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Possible causes of cracks on a bucket of an Liebherr 9350 hydraulic excavator

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Abstract

In this paper there will be emphasis on the possible causes of cracks on the loading bucket of an excavator Liebherr R9350 and the repairing method of the bucket will be propossed.

In addition, the basic characteristics of surface coal mines will be briefly presented, the conditions of surface exploitation, the characteristics of coal mine exploitation, and the basic characteristics of coal mines. Also, the importance of mechanization on surface mines will be briefly presented. Within this topic, the architecture of the mentioned excavator will be given. Vital elements in the structure of the excavator will be indicated, from which the most important is the bucket itself, which in the process of excavator operation, has the role of carrying the load - mass, during which significant damage to the bucket occurs.

This problem is evident on the bucket surface. In this paper the loads from which cracks are generated will be considered. Considering that bucket is made from high quality materials, this means that techology for it reparation must be high quality. The paper will analyze loads and stresses on the bucket and determine their influence on the formation of cracks.

Key words: excavator, bucket, material, sheet metal, steel, dimensions , forces, stress, cracks.

1. Introduction

Coal mining is thermal and raw material base of modern industry. It supplies coal for power plants for the production of electricity and heat and other branches of the economy : metallurgy, chemical industry, etc. Mineral raw materials can be obtained from the crust by surface or underground exploitation.

Mineral resources are obtained from reservoirs where concentrations of useful components are high enough to be economically viable. Surface exploitation is dominant in relation to underground exploitation, and today about 70% of the total world production of all mineral resources is obtained in this way. The following groups of solid minerals are distinguished by their chemical composition and possible type of use: metal, non-metal, energy and construction. The group of metallic minerals includes:

a. ferrous ores containing iron, manganese, chromium, titanium, etc.,
b. non-ferrous ores containing copper, tin, zinc, lead, nickel, mercury, antimony, etc.,
c. precious metal ores containing gold, silver, platinum, etc.,
d. ores of uranium and thorium containing radioactive elements,
e. ores of rare, light and scattered elements containing zirconium, tantalum, beryllium, germanium, thallium, cadmium and others.

The surface type of exploitation has been steadily growing. This method of excavation achieves high productivity, primarily due to the use of modern exploitation technologies with new machines and their large capacities. Surface exploitation is achieved by such conditions and such development primarily due to the development and construction of large, powerful complexes for the excavation, processing and use of raw materials.

2. Characteristics of surface exploitation of mineral raw materials

Surface exploitation of mineral resources is carried out directly from the earth's surface and includes two basic groups of works: works on discovery (removing of waste rock-stripping) and works on useful mineral raw materials.

Works on useful raw materials contain from : excavation, transport, handling or storage of useful mineral resources.

During the exploitation, the work on the discovery and the useful raw material is performed in synchrony, whereby the works on the discovery to a certain extent temporally and spatially overtake the work on the useful raw material.

Surface exploitation, compared to underground exploitation, has a number of advantages, of which the following should be particularly emphasized:

- more favorable conditions for the use of large and high-performance machinery;
- Wide possibilities for introducing automation and remote control of mechanisms and production processes;
- easier application of modern methods of diagnosing and maintaining mining equipment;

Surface exploitation has its drawbacks as well.

In order for production to function well, it is necessary to have powerful and correct machinery.

3. Mechanization on a surface mine

3.1. Complex mechanization of mining operations and structure of complex mechanization

The development of surface exploitation is largely based on the versatile mechanization of mining operations. Namely, as the degree of mechanization of work increases, the number of employed workers decreases, increases labor productivity, reduces costs per unit of product, and consequently increases the efficiency of surface exploitation.

The process of mechanization of mining operations takes place on a principle from simple to complex - from mechanization of individual operations to mechanization of the entire technological process.

The mechanization of mining operations on surface mines in different natural conditions is accomplished by different machines and devices, always trying to integrate individual operations in time and space into a single technological scheme. [1]

The basic principles underlying the structure of complex mechanization are: continuity of production, the ability to integrate processes, the shortest distance of material transport and the smallest possible volume of ancillary work.

On modern surface mines, it is usually more difficult to apply one-type means of mechanization, which greatly simplifies the organization of mining works, exploitation, overhaul and maintenance of equipment. As a rule, equipment of higher operating parameters and capacities is applied to the discovery works. The structure of complex machinery in general consists of a series of machines or groups of machines for performing works on: excavation and loading, transport of excavated material, disposal, reloading or storage and primary processing.

3.2. General division of surface exploitation machinery and equipment

Surface mining machines are classified by purpose, principle of operation, construction of working, propulsion and transport equipment, by control system, by capacity, power, dimensions, etc. In theory, technological feature is taken as the basic feature for classification of machines, because it is basically determines the kinematic scheme of the machine and the construction of its parts and assemblies. According to this classification, machines and devices for surface exploitation can be divided into the following classes:

- machinery for the excavation and loading of stripping and ore;
- stripping machines,
- machines and devices for transportation of stripping and ore substances;
- deep drilling machines;
- machines for auxiliary work (dosers, graders, cranes, etc.);
- mechanized tools.

The machines of each subgroup are further divided into types according to their constructive characteristics and specificities. Thus, in the subgroup of excavators with one working element, we distinguish excavators, buckets, etc.

Each machine is structurally composed of five basic groups of elements:

- the working part, the elements that directly carry out the technological operation (for example, excavator buckets, etc.),
- Transmission mechanisms connecting the working parts to the drive motor (shafts, gears and other gears, etc.),

– Propulsion device - engines, which appear as sources of energy to drive the elements of the machine
– A control system that ensures that certain machinery mechanisms are switched on and off; and
– Devices for transport or movement of the machine (tires, tracks, etc.), which as an integral part included in the general construction of moving machines.

One of the most important machines for excavation, transport and disposal are excavators, which play the most important role in surface exploitation.

3.3. Division of excavators for surface exploitation with characteristics

Excavators are self-propelled machines intended for excavation, transfer or transportation over a relatively short distance and loading of excavated masses (tailings or useful substances) into means of transport or excavation, transfer or transport over long distances and unloading of tailings onto a pile or disposal in the excavated space (internal landfill) of the surface mine. However, there are excavators, first and foremost from a large and very diverse family of universal and semi-universal single-working excavators, which can be equipped with some of the interchangeable working parts as needed.

Most often they are divided into single-working excavators and multi-working excavators (Table 1). Comparison of certain parameters for some single- and multi-working excavators is shown.

The excavator basically consists of a working, executive and propulsion device that directly performs technological operations; portable mechanisms that connect the work device and actuators to drive ones; a transport device that ensures the technological movement of the excavator during operation and transport over longer distances, supporting metal structures; control and automation systems for regulating, switching on and off certain aggregates and mechanisms.

Table 1. Comparison of excavator parameters of different types [1]

Type of excavator	Bucket Volume [m^3]	Maximum capacity in solid mass Q_{eksp}, m^3/h	Maximum digging height H_k, m	Working mass M,t	Mass coefficient, $k = \frac{M}{Q_{eksp} \cdot H_k}$
1	2	3	4	5	6
Excavator with one working element-With Bucket	1,5	155	10,1	42,6	27,2
	1,3	215	12,1	63,6	244
	13,8	1030	28,3	655	22,4
	30,6	1530	32,4	1220	24,6
	46,0	3300	27,5	2050	22,6
Excavator with one working element-Dragline	7,64	298	58	460	26,6
	15,30	900	58	1120	26,4
	23,00	940	58	1120	23,0
Excavators with more working elements	0,4	575	32,5	460	24,3
	0,65	780	26	570	28,3
	0,8	1070	40	890	20,9
	1,4	1720	36	1430	23,0
Excavators with more working elements-Rotary	0,10	330	10,5	63,3	19,4
	0,15	840	19,0	240,0	14,7
	0,25	1150	12,6	180,0	12,6
	0,35	3180	294	1290,0	13,8
	0,85	4200	304	1560,0	12,1
	140	4300	33,0	1820,0	12,6
	4,00	8500	55,0	4530,0	9,7

The excavator working device consists of a working body and actuators. The working part (the bucket) directly affects the working environment (the digging forehead) whereby the necessary movements and forces are obtained from the actuating mechanisms. The transmission mechanism is used to transfer movement from the motor to the actuators with the transformation of both the type of movement and the speed and forces (moments).

4. Technical characteristics of Liebherr r 9350 hydraulic excavator

The LIEBHERR R9350 Hydraulic Excavator belongs to the class of heavy hydraulic mining excavators and is designed to operate in the harshest conditions and in all types of mined environments. The Liebherr R9350 hydraulic excavator consists of the following subsystems:

– Power module (electric motor, gearbox, pumps),
– circular motion mechanism,
– Transport mechanism,
– System lubrication of all excavator components.

4.1 Structure of hydraulic excavator type LIEBHERR R9350 - components

When analyzing the structure of a LIEBHERR R9350 hydraulic excavator - first, its working position (Figures 3. and 4.) should be considered, during its working use, where the most common positions for the exploitation of mineral resources are given. The hydraulic excavator with its basic units is given in Figure 1.

Hydraulically powered excavators are also called excavators with a rigid working body suspension, unlike rope excavators that have a flexible working part suspension. Suspension is called solid because it allows the fixation of all elements of the working part in space.

The working equipment of hydraulic excavators can be with a normal bucket, inverted (deep) bucket and grab (grapple).

The main feature of a hydraulic excavator is the small number of pump and motor transmission elements (up to 40 MPa), which reduces the dimensions and weight of hydraulic devices. The layout and technical characteristics of the excavator are

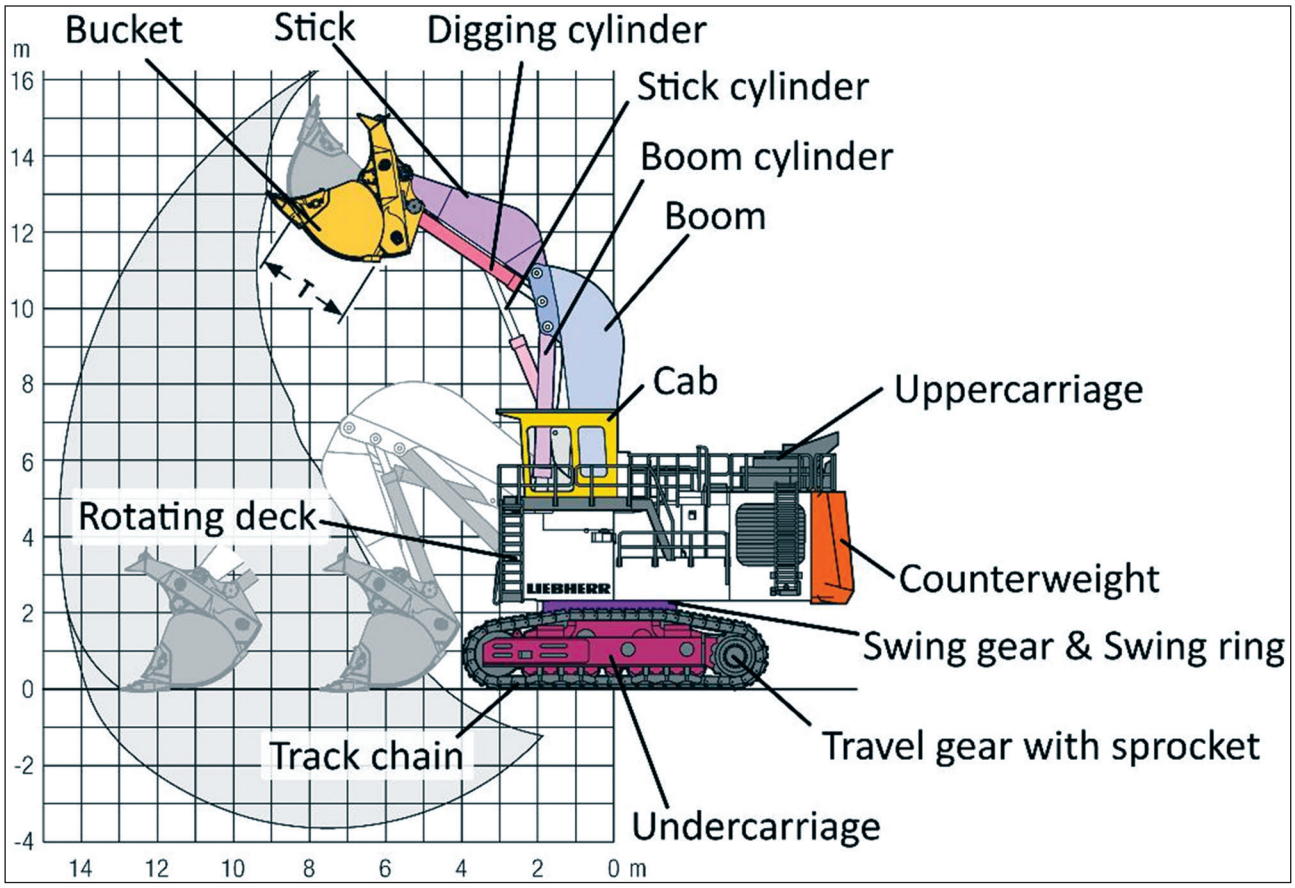


Figure 1. Main components of hydraulic excavator

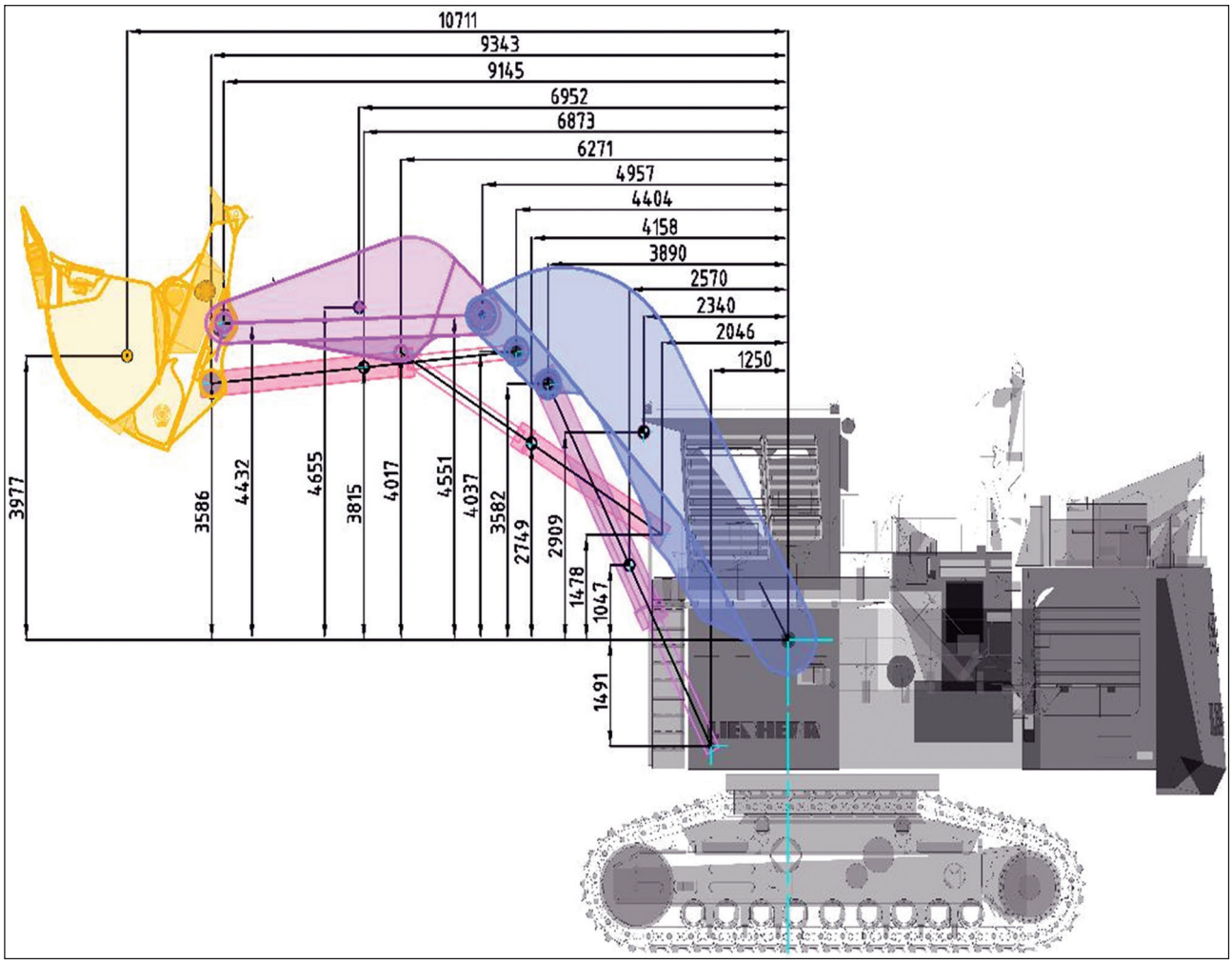


Figure 2. Main dimensions of an excavator

shown in Figures 1. and 2. The turning platform represents the basic metal structure of the excavator, to which a working device, a hydraulic drive, a cabin with a control system and a rotating mechanism are mounted.

Figure 3. Hydraulic excavator in working position

Figure 4. Hidraulic excavator Liebherr R9350

The basic goal of placing the device on a rotating platform is to achieve the best static torque, which prevents the excavator from tipping over. For this reason, a counterweight is mounted on the back of an excavator .

One of the basic tasks in the design of hydraulic excavators is to determine the development of the maximum possible forces on the teeth of the bucket and to determine the possible effective spaces of action of these forces.

Table 2. Tehnical characteristics of (contracted arm) hydraulic excavator

Drive motor	1200 kW
Bucket capacity	18 m^3
Maximum digging force	1300 kN
Maximum rip force	1060 kN
Track width	850 mm
Working mass of excavator	3225 kN
Pressure on the ground	$2,7 \cdot 10^5$ Pa
Oil Capacity	4200 litres
Hydraulic tank	3000 litres
Working pressure	$320 \cdot 10^5$
Maximum pressure in transport	$350 \cdot 10^5$
Maximum pressure in rotation	$370 \cdot 10^5$
Maximum speed of rotation	3,9 o/min
Maximum transport speed	2,2 km/h

Practical tests, as mentioned earlier, have shown that the operation of a hydraulic excavator with a normal bucket at small radius allows to achieve forces on the cutting edge of the bucket by 3 to 4 times greater than for excavators with ropes of the same mass. And the bucket capacity of this type of excavator can reach over 30 m3 of capacity.

4.2. Main elements and loads on the working part of the hydraulic excavator

Dimensions of LIEBHERR R9350 hydraulic excavator cataract. are given in Figures 5. and 6. The main elements of the catheter of the hydraulic excavator LIEBHERR R9350. as supporting structures are; front - horizontal in engineering jargon (STIK) and and sloping (BOOM) that relies on excavator structures.

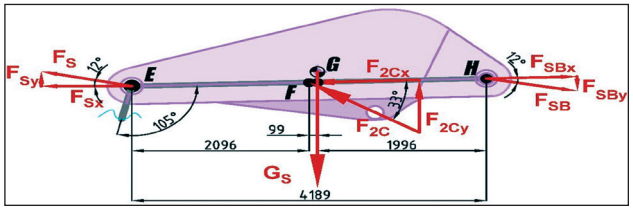


Figure 5. Stick – part of the arm of the hydraulic excavator Liebherr R9350 with load displacement and dimensions

The STIK bearing lever - the part that attaches to the excavator bucket at a smaller cross section and the larger cross section to the other part of the bucket - the dredge boom, ie. BOOM, which is attached to the excavator platform.

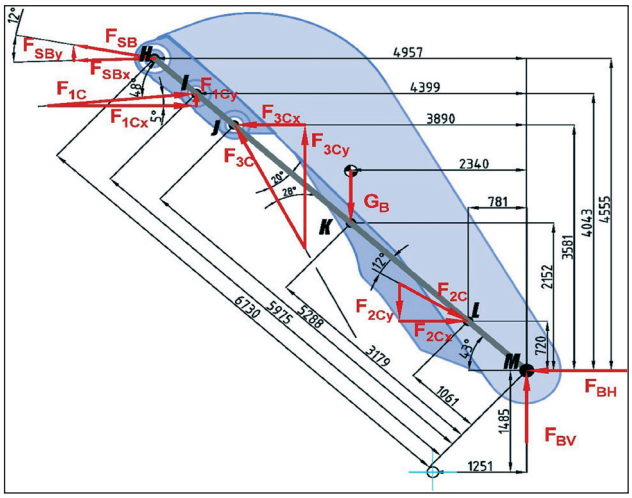


Figure 6. Boom – part of the arm of the hydraulic excavator Liebherr R9350 with load displacement and dimensions which is connected to the base of excavator

5. Technical characteristics of the bucket of an Liebherr r9350

One of the most important parts of the Liebherr R9350 Hydraulic excavator is a bucket that is shown with the load layout and dimensions in Figure 7.

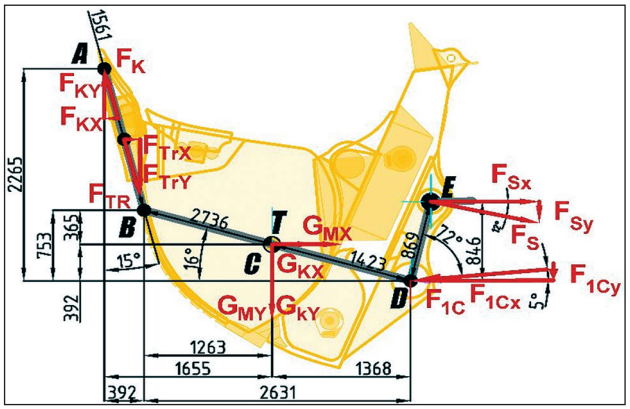
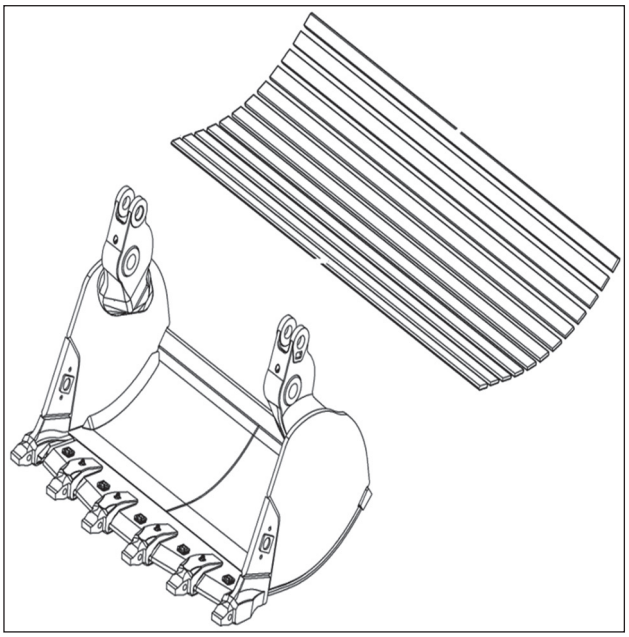


Figure 7. Bucket- With load displacement and dimensions

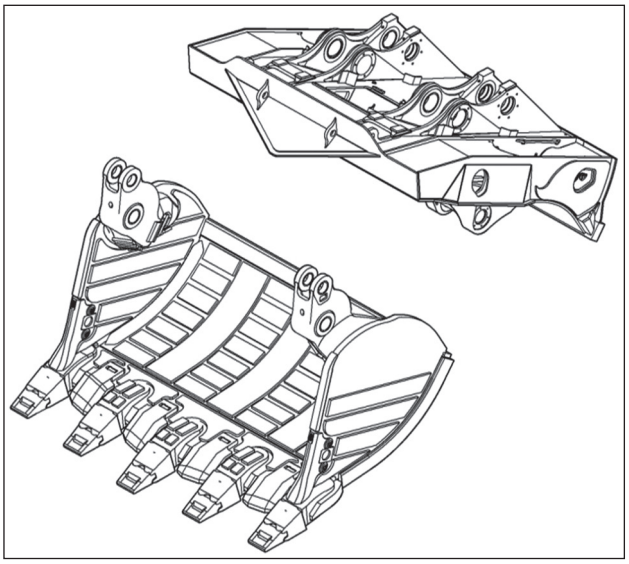
5.1 Loading bucket, dimensions and capacity

The excavator is equipped with an 18 (m3) front bucket, which is solely for digging purposes. It is made of sheet steel as a ribbed structure. The outer dimensions of the basket - buckets are given according to Table 3. [2]

The components of the bucket for a hydraulic excavator type LIEBHERR R9350 are given in Figure 8. where a) shows the back sheet and construction and b) shows the tooth of the bucket.



a)



b)

Figure 8. LIEBHERR R9350 hydraulic excavator bucket:
a.) Back of the buc
b.) teeth of the bucket

5.2 Hydraulic Excavator Bucket Loads

During operation, the bucket is loaded with two loads.

- Bucket weight 29.2 tones
- The weight of the material to be excavated is 18x2.37 = 42.7 tons. [2]

In addition to the bucket loads shown in Figure 9. the load of 880 - 1020 kN digging, the friction force, the force in the joint where it is attached to the joint and the forces from the digging cylinder and other cataract loads are given according to Figure 3. More forces occur here; digging, friction, cylinder force and joint force - contact with the Stick.

In order to enter into any serious calculation of the bucket load, it is necessary to determine the type of material, or to perform a spectrographic analysis of the material, to determine the type of material.

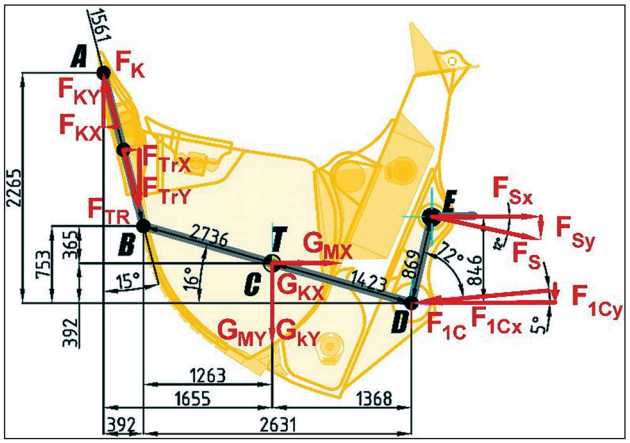
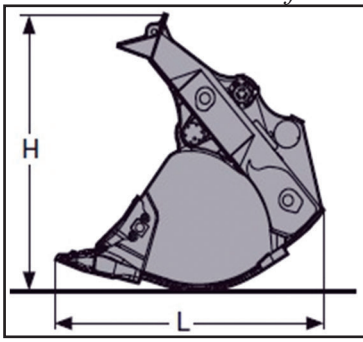


Figure 9. Loads occurring on the hydraulic excavator bucket

6. Bucket Construction Load Test - Determination of joint forces and material and damage characteristics

On this bucket, the joint force S and the components Fsx and Fsy can be determined, the total

Table 3. Dimensions of the bucket



Bottom Dump Bucket		15,30 m³/ 20.0 yd³	17,00 m³/ 22.2 yd³	18,00 m³/ 23.5 yd³
L Length	mm/ft in	3700/12'2"	3900/12'10"	4200/13'9"
H Height	mm/ft in	3800/12'6"	3800/12' 6"	3800/12'6"
Width	mm/ft in	4200/13'9"	4200/13' 9"	4200/13'9"
Weight	kg/lb	30000/66,000	31000/68,340	31500/69,450

force Fs. Based on the forces that load the bucket of the excavator, it can be concluded that the magnitudes of the forces acting on it are as follows:
Gk= 290 (kN) = 29 (t) -bucket weight,
Gm = 380 (kN) - mass of material ,
F kop.= 1050 (kN) - digging force,
Ftr.= 350 (kN) - friction force,
Fc1= ? - cylinder force,
Fs1= ? - force in the joint bucket-stick

By setting the equations for the equilibrium conditions of the system of forces along the x and y axes and the moment equation for the selected point D,
Σ X= 0; cos13° =0,9 cos16° =0,96
Σ Y= 0; sin13°=0,2 sin16°=0,27 $\Sigma M_D = 0$;

we get the following values:
Ftry = Ftr. • cos16° = 350 • 0,96 = 353 kN ;
Ftrx = Ftr. • sin16° =350 • 0,27 = 100 kN
Fky = Fk. • cos16° = 1050 •0,96 = 1020 kN ;
Fkx = Fk. • sin16° = 1050 •0,27 =283 kN
Gmy= Gm• 1 = 380 kN, - projection of material mass values on the y axis
Gmx = 0- projection of material mass values on x axis
Gky= 290 kN- projection of basket weight values on the y axis
Gkx = 0- projection of bucket weight values on x axis
The force in the cylinder is ;
Fc1x = Fc • cos13° = 4600 •0,9 = 4100 kN
Fc1y = Fc • sin13° = 4600 •0,2 = 920 kN

Applying the equations of equilibrium along the x and y axes, we obtain the values of the forces in the spoon joint and the joint Fs:
Σ X= 0;
Ftrx – Fkx + Gmx + Gkmx - Fcx – Fsx = 0;
100 + 283 + 0 + 0 - 4100 = Fsx = - 4200 kN
Σ Y= 0;
Ftry – Fky + Gmy + Gkmy - Fcy – Fsy = 0;
353 + 1020 + - 290 - 380 -+ 920 + Fsy=0
Fsy= - 917 kN

The total force in the joint of the bucket and the stick is:

$Fs^2 = Fsx^2 + Fsy^2$

$Fs = \sqrt{F^2sx + F^2sy}$

$Fs = \sqrt{4283^2 + 917^2}$

$Fs = \sqrt{19185818} = 4380$ kN

The most unfavorable condition of the bucket load is when the bucket is pulled out horizontally position as shown in Figure 10. This is because the load moments are the highest and there fore the stresses in the excavator structures are the highest.

6.1. Bucket material and spectrographic analysis of the material

In order to be able to see the further functioning of the excavator, a repair of the damaged bucket must be carried out. The excavator bucket has damage that needs to be repaired. First of all, the bucket must be repaired using the prescribed technology. In order for the bucket to be repaired, welding technology must be prescribed, and the material - the excavator bucket - must be analyzed.

Analysis of the floor material and bucket material of the LIEBERHERR excavator was performed on the surface mine itself, on 02.07.2018 by measuring instrument X-Olympus, Model DPO-2000-CC, Serial No. 543108. The test was performed on one sample spot on the prepared surface for analysis (polished and fine sanded). The analysis is based on the percentage, deviation and repeatability of the results, with the deviation ranging from +/- 0.01 to +/- 0.09 depending on the material, and as a result, the values of the individual chemical elements vary.

Back of the excavator bucket

The measurement was done on a finely sanded surface. Based on the chemical composition, the measured results classify the material in EN 1.0913 according to JUS Č3132 - Č3134.

The results of the analysis of the material of the mobile part of the excavator bucket-floor of the excavator bucket are shown in Table 4.

Excavator bucket ears

The measurement was performed on finely ground surface in several iterations. Analyzing the chemical composition to conclude that the EN standard material is the closest to EN 1.4310; JUS Č4571 with an accuracy of 65% (the deviating values are Silicon-Possible Surface Impurities and

Figure 10. Bucket in fully extended horizontal position

Manganese Steel has good mechanical properties at elevated temperatures and high toughness at low temperatures.

The results of the analysis of excavator bucket ear material material are shown in Table 5.

According to EN standard the closest material to EN 1.4310 by JUS is Č4571

Remark:

- Screen Based Analysis on Device.Results taken from photographs taken on-site for sample #1.
- The unit is calibrated to beam 1 = 30s and beam 2 = 60s for a total of 90s
- The MN match number indicates the accuracy of detecting a particular material, the MN color the less the accuracy of detecting material is greater.

MN values and accuracy of measurement results

MN = 0 recognizing the material exactly
MN < 1 very good indicator of accuracy
MN between 1 i 2 a good indicator of accuracy
MN between 2 i 3 a sufficient indicator of accuracy
MN above 3 weak indicator of accuracy

6.2 Determining the state and the conditions of the existing bucket

The existing condition of the bucket bucket is that it is still functional, but there are defects that can lead to the dysfunction of the bucket and thus the excavator as a whole. Based on the observed condition, it can be concluded that there is damage

Table 4. Elements in the structure of the material of the excavator bucket floor

ANALYSIS OF THE MATERIAL LIEBHERR EXCAVATOR, 02.07. 2018th													
Results of the analysis of the excavator bucket floor material - Č3132-Č3134													
Elements	Fe	Cr	Mn	Ni	Cu	Mo	Si	S	P	V	Material	DIN	MN (Match Number)
[%]	97,98	0,021	1,43	0,00	0,044	0,00	0,32	0,00	0,00	0,00	EN 1.0913	50Mn7	2

Table 5. Content of elements in the material structure of the excavator bucket ears

ANALYSIS OF THE MATERIAL LIEBHERR EXCAVATOR, 02.07. 2018th													
The results of the material analysis of the bucket ears - material Č4571													
El.	Fe	Cr	Mn	Ni	Cu	Mo	Si	Co	W	V	Nb	Material	DIN	MN (Match Number)
[%]	69.42	17.93	1.10	7.70	0.30	0.38	2.95	0.16	0.03	0.06	0.008	EN 1.4310	X10CrNi18 8	3

to the floor and ears of the excavators bucket as displayed on the photos, especially at the places of frequent contact of the bucket and the material.

An aggravating circumstance when it comes to monitoring the condition of an excavator bucket is a partial knowledge of the composition of the excavator bucket material.

Consequently, there are also the corresponding problems of repairing the excavator bucket.

The analysis of the materials of the bucket parts such as the floor and ears has shown that it is not possible to determine with considerable certainty the type of material of the parts mentioned.

The analysis shows that the floor of the basket is made of material that is most similar to EN 1.0913, that is, according to JUS Č3132-Č3134, while the analysis of the basket ears by analysis determined that it is approximately material EN 1.4310; JUS Č4571 with an accuracy of 65%.

The current condition of the excavator bucket with details of the damage is given in the following Figures 11. and 12.

The construction of the bucket at the place of the cracks, after repair, can take many forms, especially in the zone near welding process.

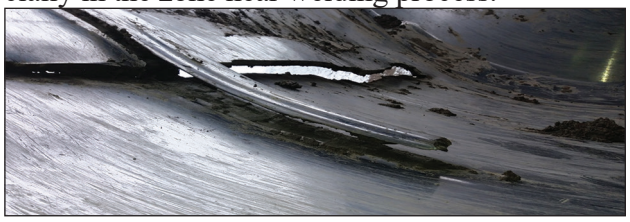


Figure 11. Characteristic damage to excavator bucket segments

Figure 12. Characteristic damage to the excavator bucket segment

6.3 Comment on the detected gamages

Damage to the bucket can be manifested mainly through damage to the floor, body, traverses, cutting edges and ears of the bucket of the excavator, as in Figures 11. and 12.

etc- Damage to the bucket. Excavator buckets are horizontal cracks caused by the effects of certain types of stress.

This is a complex stress created by forces (digging and friction, and their differences, where the components create bending moment and shear). This means that two types of stress occur here; bending and shear forming the total stress, the manifestation of which can be felt on the degradation of the basket. [3]

It can be seen that stresses are created from such structural loads. they are manifested on the cross-section of the basket floor Figure 13. which are one of the major factors in the formation of cracks with on the sheet: Figures 13. a. and b. and Figure 12. these stresses are calculated by the equations.

The total damage made by max. bending moment from the digging and friction forces for a given bucket according to Figure 14.

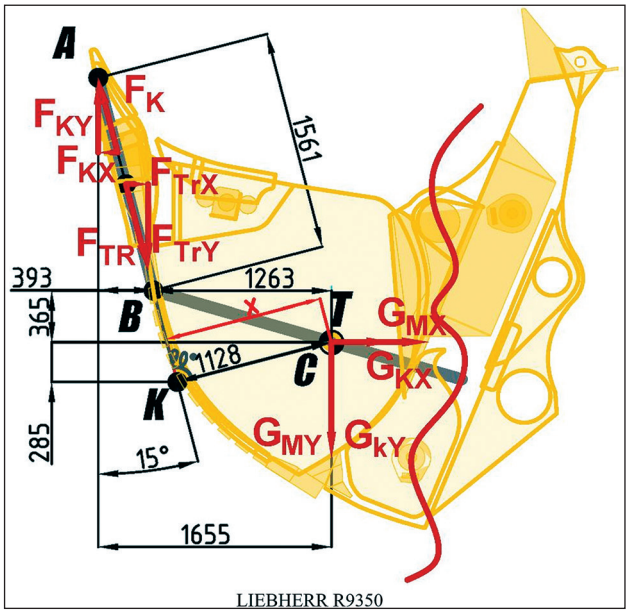


Figure 14. Position of forces relative to the center of gravity of the Mmax calculation And σs

$$\sigma_{uk} = \sigma_s + 3\tau_s ,$$

while bending stress is calculated at the points of action of forces;

$$\sigma_s = M_{smax} / w_y$$

while the shear stress is calculated according to Equation

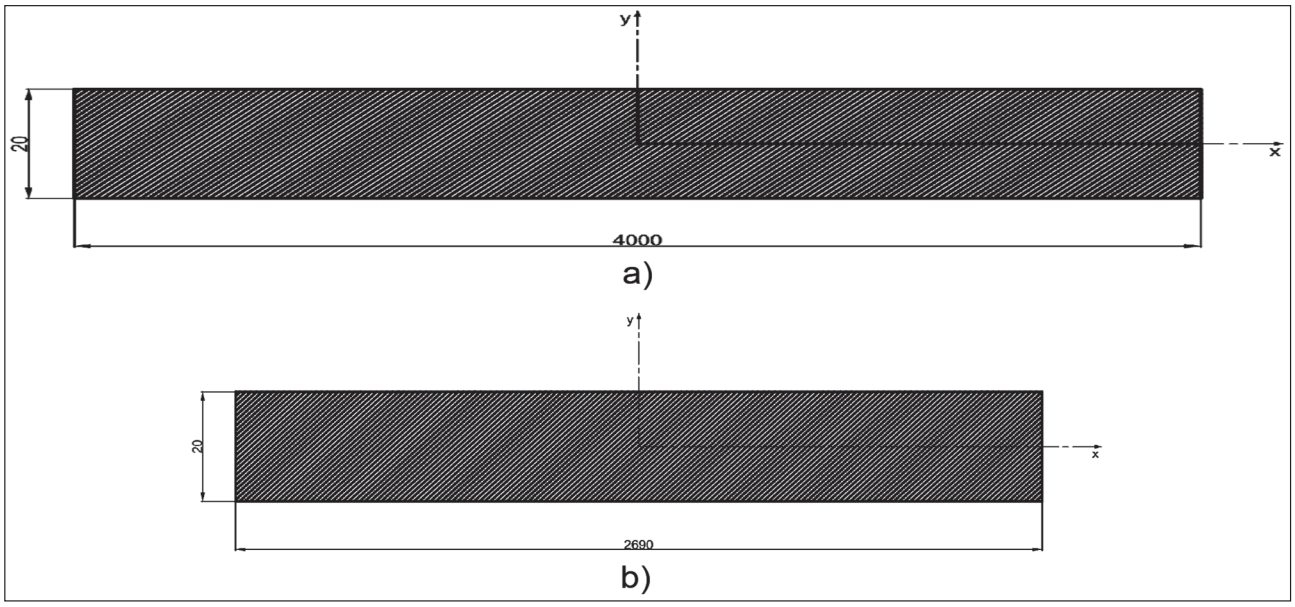


Figure 13. a) Hydraulic Excavator bucket floor cross section Profile
b) Cross-section profile of sheet metal at crack location on excavator bucket

$$\tau_s = F_{rez}/A$$

cos16° =0,96	cos 69° = 0,77	cos 21° = 0,55
sin16°=0,27	sin 69° = 0,12	sin 21^0= 0,84.

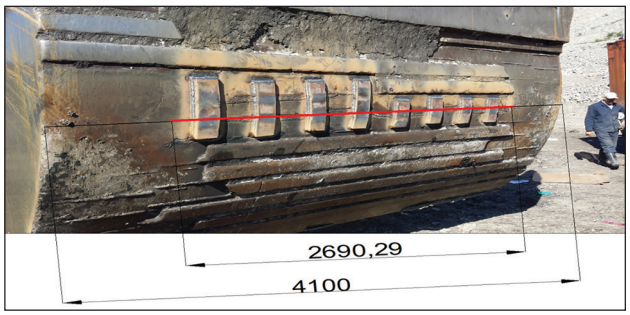


Figure 15. Cross section - location on excavator bucket, welded with vertical and vertical reinforcements (largest excavator bucket floor cracks)

The bending stress is calculated by the expression:

$$\sigma_s = M_{smax}/_{W_y}$$

W_y – *the resistance moment for a given cross – section,*

is calculated by the expression $W_y = \frac{b \cdot h2}{6}$;

while the bending moment is for digging and friction forces;

$$M_{smax} = F_{kop} \cdot \overline{TK} - F_{tr} \cdot \overline{TK} =$$

cos 21° = 0,55

$$\frac{\overline{TK}}{\overline{TB}} = cos21^0 ;$$

$$\overline{TB} = 2736 - 1423 = 1300\ mm$$

$$\overline{TK} = 0{,}55 * 1300 = 700\ mm$$

$$M_{smax} = F_{kop} \cdot (700) - F_{tr} \cdot (700) = 1050 * 700 - 350 * 700\ kNmm$$

$$F_{kop} = 1050000\ N;$$

$$F_{tr} = 350000\ N$$

$$M_{smax} = 1050000 \cdot (700) - 350000 \cdot (700)\ Nmm$$

$$M_{smax} = 735000000 - 245000000 = 490000000\ Nmm$$

$$M_{smax} = 490000000\ Nmm\ ;\ \textbf{sin 69° = 0,12}$$

$$M_{smax\ za\ sin69^\circ} = M_{smax} * \sin 69^\circ = 490000000 * 0{,}12$$

$$M_{smax} za\ sin69^\circ = 58000000\ Nmm,$$

due to the position of the structure, this moment is taken as the relevant one in the further procedure and it is

$M_{smax} za\ sin69° = 58000000\ Nmm$,

The flexural stress is calculated according to the expression [4]:

$$\sigma_s = M_{smax}/W_y$$

W_y – the torque for the given cross – section of the bucket sheet metal„

$$W_y = \frac{b.h^2}{6} = \frac{4000 * 400}{6} =$$

$$W_y = \frac{b.h^2}{6} = 266000\ mm^3;$$

$\sigma_s = M_{smax} za\ sin69°/$

Wy = 58000000 /266000 = 221 N/ mm^2

The shear stress is calculated by the expression:

$$\tau_s = F_{rez}/A$$

A =53800 mm^2,

a F_{rez}=F_{kop}-F_{tr}=1050-350=700 kN.

We obtain that the shear stress is:

$$\tau_s = 13{,}01\ N/mm^2$$

The total value of the complex stress is

$$\sigma uk. = \sigma s + 3 \cdot \tau s = 221 + 3 * 13{,}01 = 221 + 39 = 260 \frac{N}{mm^2}$$

[5,6]

The given stress also satisfies the criterion for calculating the total structural stress, and in this case the stress less than the tensile strength of the excavator bucket material was obtained, whose tensile strength is $\sigma_{doz.}$ **= 320 N/mm²** which satisfies the condition $\boldsymbol{\sigma_{uk.} \leqq \sigma}$ **doz.**

Based on the load (type and arrangement of load), it can be seen that the bucket material is fully supported - holds the function of the bucket capacity.

However, considering the working span of the basket and the conditions (high abrasion forces - friction) and the material, it is possible to reduce the cross section and, of course, to create cracks in the basket. These cracks are horizontal, probably resulting from micro-cracks that have increased over time, which has significantly damaged the bucket. As shown in Figures 11, 12 and vertical reinforcements were welded to the bucket according to the Figure 15.

7. Conclusion

Finally, it can be stated that the damage to the bucket bucket was caused mainly due to fatigue of the material and due to impact loads. When carrying out the load analysis of the excavator, the case of a fully drawn boom with fully loaded bucket was analyzed.

Checking the load-bearing capacity of the structure was performed by analyzing the forces acting on the bucket of the excavator, ie the weight of the bucket, the mass of material, the digging force, the friction force, the force in the cylinder, and the force in the joint and joint of the bucket were taken into account.

Based on the calculated values, for the forces acting on the system, we obtained that the force in the cylinder is Fc1 = 4201.9 kN, and the force in the joint and joint of the bucket Fs1 = 4380 kN. Considering the value of the tensile force Fkop. = 1050 kN, it can be clearly concluded that the structure meets all the static values and by checking the stress and comparing it with the table values

The given stress also satisfies the criterion for calculating the total structural stress $\boldsymbol{\sigma uk.} = \sigma s + 3 \cdot \tau s = \boldsymbol{260 \frac{N}{mm^2}}$; and in this case also a stress less than the tensile strength of the excavator bucket material was obtained, whose tensile strength is $\boldsymbol{\sigma_{doz.}}$ **= 320 N/mm²**., thus satisfying the condition $\boldsymbol{\sigma_{uk.} \leqq \sigma}$ doz.

From the calculation that the force in the joint is greater than the force in the cylinder, for the most unfavorable case of a completely pulled arm, which clearly shows that the force generated in the process of exploitation meets the set criteria.

It is important to emphasize, especially when it comes to such systems, that special attention must be paid to preventative maintenance of all segments of the system, in order to identify in a

timely manner the potential shortcomings and difficulties in their exploitation.

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Digital Distractions and Student Participation: The Smartphone as a learning tool in the University of Bahrain

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Abstract

As the use of smartphone has proliferated in recent years, new challenges are faced by institutions of higher education and their faculties. The aim of this Action Research is the investigation of the impact of the use of smartphone as a learning tool on the students' participation. To collect the data, different techniques were settled such as observations, questionnaires and an interview. The collected data shows positive outcomes of the smartphone use as a learning tool on the students' participation. Supported by technology, lectures become more effective, enhance student's level of participation and transform the lecture into an interactive classroom. The smartphone's use may also contribute to the improvement of the students' self-learning. It also enables the teacher to get a better feedback about the class level.

Key words: Learning process, University of Bahrain, smartphone, participation, students' self-learning, culture differences.

1. Introduction

Nowadays, mobile phones have taken an essential place in our society. It allows people to remain in touch with the rest of the world at any time. However, mobile phones are becoming an unwanted guest in our classes [1]. The increase of smartphone use for non-class purposes causes learning distraction, threatens students' reflexion skills and learning, and leads to a decrease in students' participation and academic performance [2]. Recently Pulliam [3] mentioned that "students using cell phones during class may affect more than just their individual academic performance; student cell phone use may actually have a negative impact on the entire class and the quality of teaching".

Looking closer, we can notice that students become not attentive enough, don't participate or ask questions. The students kept using the smartphone despite the policies of the university about that concern. When teachers are asked about their own experience with the digital devices, they confirmed that they faced the same problem. Usually faculties started by warning students and if they did not respond they would ask them to leave the classroom.

Several researches have studied the use of smartphones in class. Some studies have focused on the relationship between the frequency of smartphones' use and students' performance [4] such as spelling, linguistic and communicative skills [5].

New researches focus on the use of smartphones as a learning tool and its impact on the students' achievement [6]. However, only some studies show significant impact on the students' participation [7].

All the outcomes of these researches will be used at the same time as evidence and to update teaching and learning practice. Teachers have first to understand how the so called "digital natives" or "mobile addicts" [8] students learn, and then to assign appropriate methods and tools. So to be effective, teachers can take into consideration the students' characteristics and abilities. It is even unfair to the students to use old methods of lecturing. Obviously, smartphones can certainly enrich their learning and become a useful educational tool in supplementing teaching instruction [9].

To manage the students' use of the smartphone for non-class purpose, we decided in this action research, to introduce it as a learning tool to improve at the same time the teaching practice and the students' participation.

2. Research questions

Burns [10] acknowledges Action Research (AR) is an influential tool for school and classroom investigation. It can also be considered "as a means of remedying problems in specific situations or somewhat improving a given set of circumstances" [11]. In this present Study, we attempted to assess the extent to which the use of the cell phones as a learning tool can enhance students' participation.

The different cycles of this study, will try to answer to these research questions:

- How effective can be the use of the cell phone in enhancing students' participation?
- To what extend is using cell phone with pre-planned tasks helpful in reinforcing students' independent learning?
- How do students perceive the use of cell phone in their learning?

3. Action research methodology

3.1 Participants

The target population consisted of 120 students (54 males and 66 females) enrolled in 2 sections of Management and Organization (Mgt230), a second level course in the department of Management and Marketing in the University of Bahrain. The action research was conducted during the second semester of the academic year.

3.2 Data collection

To answer to the AR questions and to promote the reliability and the validity of the result [12], a triangulation data collection was used. Different techniques were settled such as observations, questioners, and interview.

Based on the review of the literature, self-assessment checklists (Smartphone use as a learning tool checklist 1 & 2) were developed. Simple criteria were chosen to assess the students' use of the smartphone and its impact on their learning, team work and participation during both cycles. The simplicity of the chosen criteria enhances the objectivity of the AR results.

At the end of each cycle, the students' feedback was collected through a questionnaire. It consisted of 2 sections: the first evaluates the utilizing of the mobile phone as a learning tool, and the second assesses the impact of the change on the participation, the team-work and self-learning process. During the second cycle, the questionnaire was adapted to allow the rate of new students' attitudes and behaviours. The students were asked to answer a formative quiz which were evaluated online for correctness, however, it were neither mandatory nor taken into account of the final course grade.

To evaluate students' perception to this method an additionally semi-directive interview was carried out with 35 students (26 girls, 9 boys) at the end of the second cycle. Data collection was stopped when the data saturation [13] has been reached. The interviews last from 6 minutes to 14. The interviews were recorded via a tape recorder and transcribed. The main goal was to answer the third research question related to students' perceptions about the use of the smartphone as a learning tool.

All the themes of the research are included in the interview guide. The selected themes are: encouraging participation, creating a good learning environment, motivating students to answer the questions correctly, and increasing retention of information.

All these techniques helped to analyse primary as well as secondary data during the different cycles, and to support the consistency of the results.

4. Research Procedures

As a part of teacher preparation for each class, a set of supplementary material (slides, notes, extra reading articles, cases studies, multiple choice questions, etc.) was created and uploaded on the blackboard. The students had to print out all the materials and to bring it with them during the classes.

During this AR students will be asked to use their smartphone to access the materiel on the blackboard instead of printing it out.

4.1 Cycle 1. The use of the smartphone under the control of the teacher

Most of the students participated in this experience. No special hardware was needed or used. Informed consent, based on university's consent forms, was obtained from all participants after being briefed about the nature of the research.

Assign tasks with the use of the smartphone	
Cycle 1	**Cycle 2**
The smartphone as a learning tool	Open use of the smartphone
Use of smartphone is under the control of the teacher	Free use of the smartphone by students

Figure 1. Features of Action Research Progress

4.1.1 Procedure and action

Students were asked during the first cycle to use the smartphone to access to the chapter materials (lecture slides & notes, extra reading articles, cases studies, questions & formative assessment) on the blackboard, instead of printing it out. The cellphone was also used to collect students' feedback. Cellphone use was under my supervising. The cycle took two weeks: first and second week of March 2018.

Most students use their own smartphones. A checklist was developed for cycle 1, to check how students react to the use of the digital device, if they are comfortable and cooperative, and how this can affect their interaction and participation. At the end of cycle 1, students were also asked to complete a questionnaire by using a Likert scale with scores ranging from 5 (strongly agree) to 1 (strongly disagree).

4.1.2 Cycle 1. Results

A number of significant outcomes were obtained during Cycle 1.

The first thing noticed was students' reaction when asked to use the smartphone to perform the tasks usually done with the old method (print out the slides and the supplementary material and bring it with them in the class). Students showed a high level of motivation and cooperation and were willing to use their smartphone in that purpose. This fact of motivating students to participate and get engaged in the class was also confirmed with results obtained from the questionnaire.

The results of questionnaire were similar to the observation and showed: 84. 7 % of the respondents were motived to use their smartphone to perform the course tasks (Figure 2).

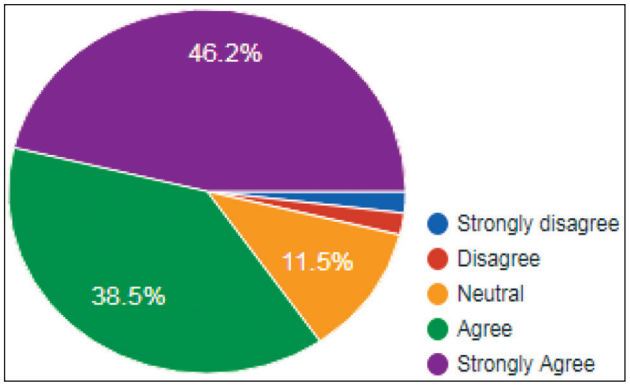

Figure 2. I am motivated you use the smartphone to perform the course tasks (checking course materials; answering questions…)

The majority of the respondents, felt comfortable when performing the tasks (Figure 3).

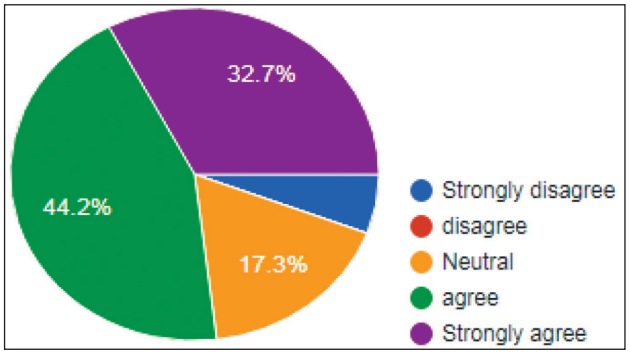

Figure 3. I felt more comfortable answering questions with the smartphone

Some of them took even the responsibility of explaining the task to their friends. A significant level of the students' participation was also observed during the first cycle. The students usually shy and inactive became more engaged with their classmates and teacher. The majority of the students (112 respondents out of 120) mentioned that their participation increased after the use of the smartphone (Figure 4).

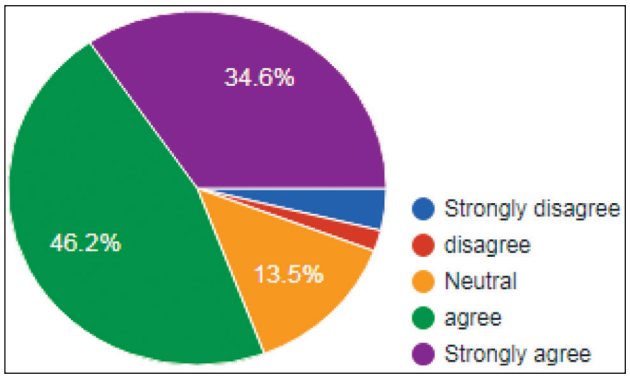

Figure 4. My level of participation was increased because the instructor asked me to respond to questions with my smartphone

96 students declared that the tasks were easier on the smartphone (Figure 5).

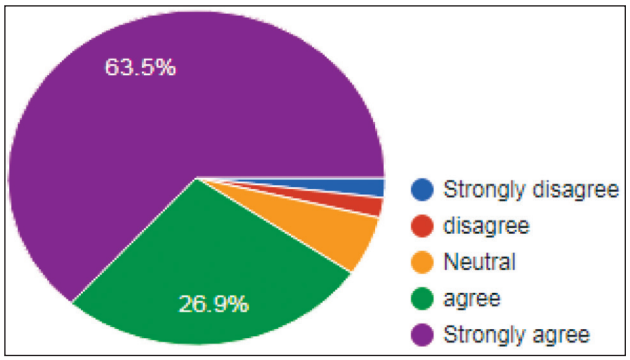

Figure 5. The tasks on the smartphone were easy to do

During cycle 1, we noticed that the majority of the students showed a high level of self-confidence when discussing the responses. At the same time students were enjoying using their cell phones to answer. The class became more attractive to them and impacted positively on the lecture and around 87 students' judge that the quality of the lecture was good (Figure 6).

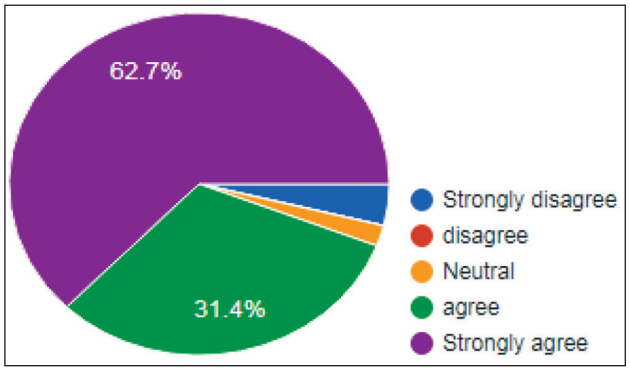

Figure 6. The quality of this lecture was good

The students mentioned also the positive impact of this method on their learning. 113 students out of 120 thought that the smartphone use can increase their learning (Figure 7).

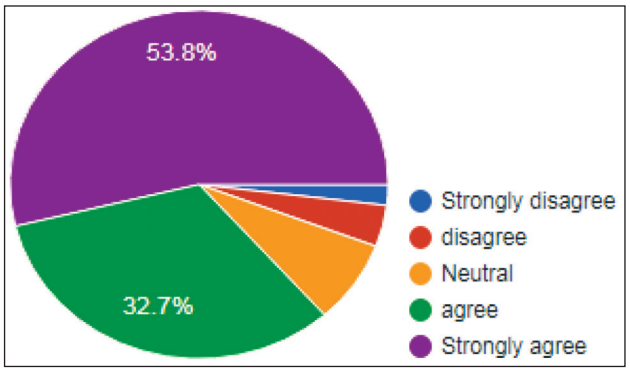

Figure 7. My learning was improved because the teacher asked questions through smartphone

Moreover 97 respondents suggested the use of the smartphone for the future lectures (Figure 8).

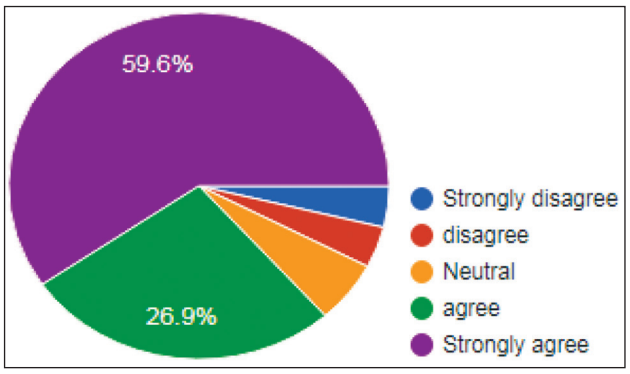

Figure 8. I would like to use the Phone during the future lectures

4.2 Cycle 2. The free use of the smartphone by the student

Based on the findings of the first cycle, and the positive impact it made upon students' performance we decided to develop this practice further.

4.2.1 Procedure and action

During the second cycle of the AR, students were responsible of the use of the smartphone. They were free to use their phone to consult the slides, to check the extra materials, to share new links, texts, graphics and videos related to the course during the lecture. A second observation checklist helped us to identify the students' new at-

titude and behavior. The students were also asked to complete a second questioner to rate their level of participation, and their attitude about the self-use of the smartphone for class-purposes. An online formative quiz was also done to evaluate the smartphone impact on the students' performance.

4.2.2 Cycle 2. Results

During the second cycle the students developed different attitudes. Students started to take the initiative of using the smartphone to find quick answers to a common and routine task. 97 students declared using independently the smartphone during the class (Figure 9).

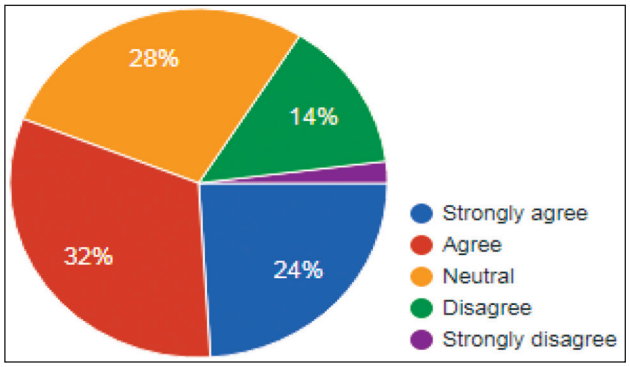

Figure 9. I act independently when it comes to use the smartphone during the lectures

The majority (111 students) of the respondents are showing a high level of responsibility when it comes to the use of smartphones for educational purposes (Figure 10).

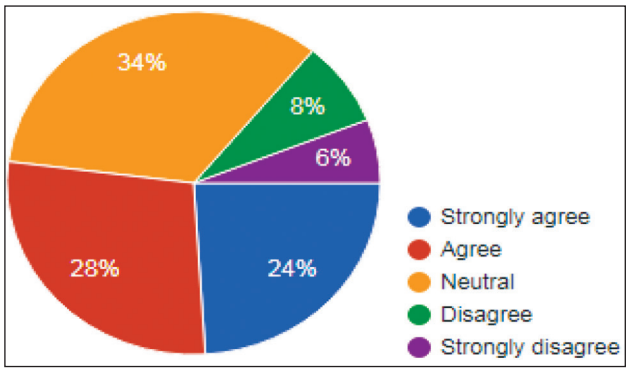

Figure 10. I only use the smartphone to check extra materials related to the course

The websites visited and the applications used are directly related to the content of the course. The effective use of the smartphone impacts positively on the level of students' self-learning and participation. The results of the third question (Figure 11), indicated that a large number of students' (115 out of 120) were able to discuss and evaluate the data retrieved from the various data platforms available through smartphones, which increase their participation.

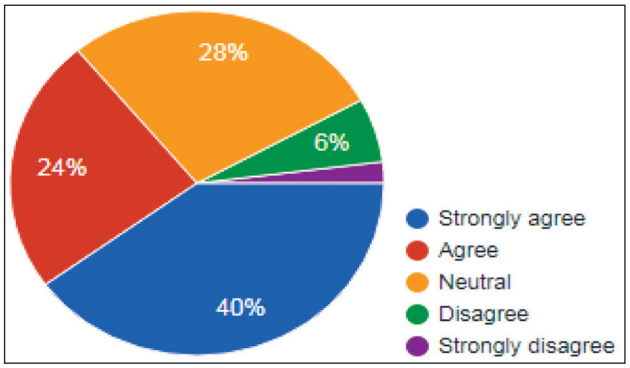

Figure 11. The use of smartphone as a learning tool should be introduced every course

The majority of the students strongly agree with the fact that the use of the smartphone increases the students' participation level (Figure 12).

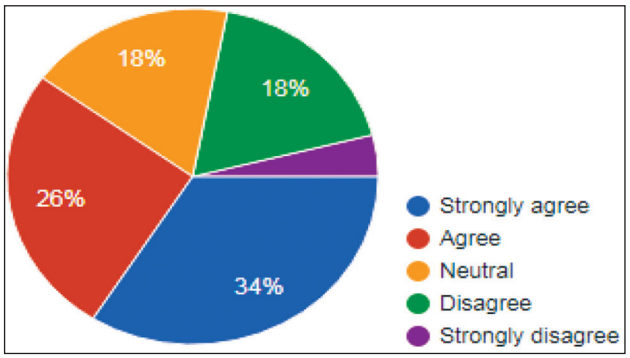

Figure 12. The use of smartphone as a learning tool should be introduced every course

We also noticed that in some specific situations, the students tend to discuss the findings and to propose different ideas and tools. Students became more enthusiastic about the use of the smartphone independently. This helps them to catch up easier the lessons (Figure 13).

During the last week of the second cycle students were given a formative quiz on the past lecture. The outcomes were improved compared to the last quiz.

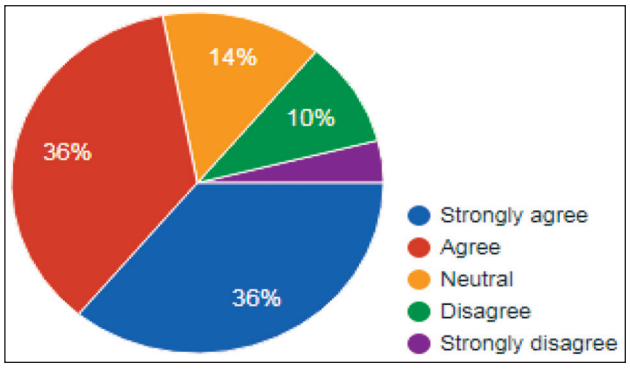

Figure 13. Using smartphone for class purposes makes it easier for students to catch up the lessons

4.3 Interview findings

The results of the interview conducted with 35 students confirm the research themes (encouraging participation, creating a good learning environment, motivating students to answer the questions correctly, and increasing retention of the information) and the outcomes obtained during both cycles 1 and 2. The majority of the students especially girls, declared that traditionally they avoid participating because they "*feel shy and scared*". They also mentioned the "*lack of self-confidence"* and the influence of the *"Bahraini culture*" which affect their abilities to communicate and participate in public. A few of them mentioned the teachers' attitude "*some doctors will not accept a wrong answer*"; "*if I give a wrong answer the doctor will penalize me and this can affect my grades*".

Introducing the smartphone as a learning tool, for the majority of the students was an excellent method to encourage participation in the class: "*I can participate without fear*"; "*I did the entire task and I decided to check my answer* ". They considered the use of the smartphone as a one of the "*best method to participate*" and to speak in public "*with a high level of self-confidence*"; "*without fear to make a mistake*". The digital device offers for the majority of the interviewees the ability to "*write and express their opinions"*. They added "*using the smartphone during class activities allows me to check my answers*".

The majority mentioned also that the use of the smartphone as a learning device makes them feel very comfortable in the classroom; which encourages them to participate: "*I feel safe when I use the smartphone to do the task*"; "*the facility of the use of the smartphone allows me to give the correct answers*"; "*I like the method*". Some of the interviewees mentioned also, the flexibility of the method: "*I don't have to print out the slides or the questions, it's very flexible*"; "*easy to manipulate* ".

Based on the responses of the majority of the students, it appears that the use of the smartphone helps them to better concentrate on the course content and to increase their memory and learning process, which in turn can affect positively their performance : "*using smartphone helps me to memorize better the information*"; "*helps me to practice and to improve my learning*"; " *you feel like you assimilate better the new concepts* "; *'it's an effective way of concentrating on the course and to improving my performance"*. The majority of the students considered it as a *"good method to be adopted during other classes"*.

5. Evaluation and reflection

This Action Research has been conducted having in mind the improvement of the teaching methods and practices. The combined data obtained seem to answer adequately to the AR questions and provide factual information to faculties about smartphone use and students' participation and self-learning. The majority of the students had positive perceptions about smartphone use as a learning tool.

The study helped to understand the real reason behind the lack of the participation of the Bahraini students during lectures. Bahraini culture as a conservative one, influence the students' abilities to communicate and participate in public. Effective teachers have to respect individual learners and diverse learning communities when they teach and design activities. To be effective, the teacher has to create a comfortable environment to the students which can in that way improve their learning [14]. Supported by technology lectures can become more effective and can be considered as a tailoring delivery method for Bahraini students in this case.

The findings of the AR gave also, the chance to show how smartphones can contribute to enhance students' communication, to promote participation and to give them equal opportunities. The use of smartphone as a learning tool can "transform the lecture from a one-way method of communication to an interactive classroom" [15]. The use of digi-

tal devices gives them the possibility to calm the fear of giving a wrong answer in front of peers.

It also provided with an extra opportunity to share things with the students. It also enabled educators an "*immediate*" feedback which can be benefic for both teachers and students. For the teacher it allows timely adjustments about his/her content delivery and the methods of instruction. As for students it allows them to improve their learning and to encourage them to communicate with the teacher and their classmates and to be at the same time responsible of their own learning. These findings can help teachers in planning to state mobile as a mean tool for their students. The smartphone can be considered as a real tool and a supplementary alternative to learning and not simply as a gadget. Many courses can be improved by re-designing appropriate activities which can be answered and discussed with the smartphone in the class.

This research has several significant contributions especially in order to fill the gap in existing literature about the use of the digital devices as a learning tool especially in Bahrain University's context. The findings can be used as the basis for motivating students to participate and use ICT during the class for learning purposes. It helped also in revisiting the old teaching methodologies and adopting new ones to enhance the students' participation and their self-learning.

This study has also some limitations, in term of the sample. All the students, in both colleges were Bahraini students. In spite of the fact that they are majority in the university, this remains insufficient to generalize the results. It could have been more beneficial to choose another college with a mix of Bahraini and foreign students to obtain more reliable findings. Another limitation could be related to the fact that the instructors were at the same time the researchers which could cause bias [16]. Therefore, using external assessors can enhance the inter-reliability of the findings [17].

This research focus on how the smartphone can increase the students participation and ignore other factor that can influence the degree of the participation such as teachers traits as mentioned by my students during the interview. Many research found that teacher communication variables play an important role in shaping classroom interaction. "Traits like being encouraging, understanding, approachable are consistent with several studies which also found that students participate more when instructors engage in behaviors that are confirming, encouraging, and supportive" [18].

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Effectiveness of comic-assisted group investigation learning model to elevate disaster awareness of the upper-grade primary school students in Jipang Village

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Abstract

The study departed from the fact that the average primary school students had a low level of disaster awareness due to several factors, including the unavailability of the relevant course, learning instrument, and emergency warning facility. Additionally, the use of conventional model also becomes the obstacle within the learning process. The study aims to find out the effectiveness of *comic-assisted group investigation* model to elevate the disaster awareness of the upper-grade primary school students in Jipang Village. It adopted a quantitative method through the *posttest-only control design.* The study included the fifth-grade primary school students in Jipang Village that consisted of 29 students from Jipang State 2 Primary School as the experimental group and 16 students from Jipang State 3 Primary School as the control group. With regards to the improvement of disaster awareness through a class-learning, the experimental group was treated by using the *comic-assisted group investigation* model, while the control group used the conventional method. The analysis signifies that the application of *comic-assisted group investigation* model is more effective than the conventional model, as the experimental group could garner higher average score by 74.31 In more detail, the *Independent-Sample T-Test* produced the value that $t_{calc} > t_{tab}$, confirming the effectiveness of *comic-assisted group investigation* model to elevate the disaster awareness of the upper-grade primary students in Jipang Village.

Keywords: effectiveness, group investigation model, disaster learning through comic-assisted media, primary school students.

1. Introduction

The landslide has frequently occurred in Bantarkawung Sub-District especially at the rainy season, due to the region's geographical condition which is surrounded by rice fields and hills. From January to February 2018, Regional Disaster Management Agency (Badan Penanggulanagan Bencana Daerah - BPBD) even recorded significant frequencies of disasters, including landslides (13 times), tornado (1 time), liquefaction (1 time), and other disasters (3 times). Therefore, Bantarkawung people, including the primary school students require the provision of disaster education as an attempt to elevate their awareness in facing such phenomena. Hyogo previously campaigned the disaster education as part of the three awareness priorities that emphasize 'the use [of] knowledge, innovation, and education to build safety and resilience at all levels" [1].

Currently, the 2006-7 UNISDR is campaigning the disaster risk reduction from the school level. The campaign aims to promote the integration of disaster risk reduction into the government's agenda for school curricula and ensure the safety of school buildings from natural disasters (UNISDR 2006) [1]. The UNISDR framework implies an urgency to provide disaster education for the students, in which the learning coverage belongs to social science. The concept is in accordance with Leleito [2] who conveyed the potentials of the education sector to grow the disaster awareness. The attempt to elevate the disaster awareness can exist in the form of cooperative learning model, in which the students will have the opportunity to form a discussion group. With regards to the idea, the group investigation is considered as one of the most appropriate cooperative learning models.

The group investigation (GI) learning model offers a student-centered approach that motivates them to play an active role within the learning process. The model implementation will encourage them to define and solve the problems, as the model also aims to grow their understanding of the subject as explained by Tabani [3].

The model belongs to the cooperative learning style that emphasizes the students' active participation to explore the subject by referring to the available instruments, such as handbooks and online sources. Sumantri [4] explained it as a learning model that classified the students into a number of heterogeneous groups in discussing particular topics. Following the discussion, they will be requested to present their analysis.

The article utilizes comic as the learning instrument. Daryanto [5] explained comic as a media that represents cartoon characters in a sequence of events and functions as an entertainment for its readers. The researchers combined the comic as the learning instrument and *group investigation* model for the upper-grade primary school students as an attempt to encourage them to grow their disaster awareness. With regards to the explanation, the article aims to answer the following problem: "Is the *comic-assisted group investigation* model effective to elevate the disaster awareness of the upper-grade primary school students in Jipang Village?"

2. Methods

The article utilizes a quantitative method, as it mainly contains numerical data and features a statistical analysis [6]. It adopts an experimental approach through a *posttest-only control design*. The design divides the subject into two major groups through a random classification, including the experimental group as part of the subject that will receive the treatment and the control group that will be excluded from the treatment [6].

The population covered all of the fifth-grade primary school students in Jipang Village that were determined through a *cluster sampling* [7]. Meanwhile, the instruments consisted of observation forms and multiple-choice test which were analyzed by the expert as the construct validation and utilized *Pearson Correlations* technique through *SPSS 16.0 for Windows.* The reliability test was only targeted for the multiple-choice test by using the *Cronbach's Alpha.* Meanwhile, the normality test used a *One-Sample Kolmogorov-Smirnov* through *SPSS 16.0 for Windows,* in which the normal data distribution is defined if *sig* > 0.05. The homogeneity test and *Independent-Sample T-Test* were also assisted by *SPSS 16.0 for Window*

3. Results and Discussion

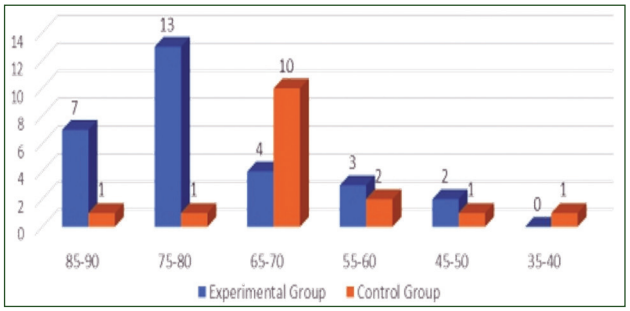
Based on the treatment classification for the experimental group that adopted the comic-assisted group investigation model and the control group that used the conventional model, the following analysis statistically explains the results.

3.1 The level of disaster awareness between the experimental (treated using the *comic-assisted* group *investigation* model) and control group (treated using the conventional model) was determined through the posttest analysis which had been considered valid and reliable. Table 1 signifies the result.

Table 1. Disaster Awareness Level of The Experimental and Control Group

No.	Interval	Frequency	
		Experimental Group	Control Group
1.	85 -90	7	1
2.	75 – 80	13	1
3.	65 – 70	4	10
4.	55 – 60	3	2
5.	45 – 50	2	1
6.	35 – 40	0	1

Source: Research Data in 2019



Source: Research Data in 2019

Figure 1. Experimental Group and Control Grup Test

Table 1 signifies seven students of the experimental group and a student of the control group at

the score interval 85-90, 13 experimental group students and a control group student at the range 75-80, four experimental group students and ten control group students at the range 65-70, three experimental group students and two control group students at the range 55-60, two experimental group students and a control group student at the range 45-50, and only a control group student at the range 35-40. The following diagram shows the details.

3.2 Normality Test

The study performed a normality test for both experimental and control group using the *One-Sample Kolmogorov-Smirnov Test* through the *SPSS 16.0 for Windows*. It referred to the 5% significance value. Table 2 signifies the normality test result.

Table 2 signifies that *Asymp Sig*. (2-tailed) > 0.05 and confirms that the samples derive from the normally distributed population.

3.3 Homogeneity Test

The study utilized a homogeneity test assisted with the *SPSS 16.0 for Windows* by referring to the 5% significance value. The test aims to determine whether the two data possess the homogeneous variance. The homogeneity test as performed above signifies that *sig* > 0.05 and confirms the homogenous data variance.

3.4 Hypothesis Test

Following the normality and homogeneity test, the *Independent-Sample T-Test* was then carried out through the *SPSS 16.0 for Windows*. The test aims to find out the average score difference between the experimental and control group. Table 3 signifies the *T-Test* result.

Table 3. Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Nilai	1	29	74.31	11.078	2.057
	2	16	64.38	10.782	2.695

Source: Research Data in 2019

Table 3 shows that the experimental group consisted of 29 students (N = 29), while the control group consisted of 16 students (N = 16). The experimental group secured 74.31 in their average score in terms of their disaster awareness, in which the standard deviation = 11.078 and standard error mean = 2.057, while the control group only gained 64.38 with the standard deviation = 10.782 and the standard error mean = 2.695.

Table 4 Signifies the disaster awareness level of the experimental (treated using the *comic-assisted group investigation* model) and control class (treated using the conventional model). The findings prove the effectiveness of the *comic-assisted group investigation* model to elevate the disaster awareness of the upper-grade primary school students in Jipang Village. The effectiveness has fulfilled the statistical requirement of $-t_{count} \leq -t_{tab}$ or $t_{calc} \geq t_{tab}$. In contrast, the treatment will be judged ineffective if $-t_{tab} < t_{calc} < t_{tab}$. Table 4 resulted $t_{calc} = 2.907$, while t_{tab} (df = n-2; 45-2 = 43) (two-tailed *sig* = 5%; 0.05/2 = 0.025) = 2.416. Therefore, the analysis confirms the effectiveness of the *comic assisted group investigation* model to elevate the disaster awareness of the upper-grade primary school students in Jipang Village, as the value of $t_{calc} > t_{tab}$ (2.907 > 2.416).

Table 2. Normality Test Result

		Posttest_Experimental_Group	Posttest_Control_Group
N		29	16
Normal Parameters[a]	Mean	74.31	64.38
	Std. Deviation	11.078	10.782
Most Extreme Differences	Absolute	.214	.273
	Positive	.133	.176
	Negative	-.214	-.273
Kolmogorov-Smirnov Z		1.155	1.092
Asymp. Sig. (2-tailed)		.139	.184

Test distribution is Normal.
Source: Research Data in 2019

Table 4. Independent-Sample T-Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Nilai	Equal variances assumed	.361	.551	2.907	43	.006	9.935	3.418	3.042	16.828
	Equal variances not assumed			2.930	31.785	.006	9.935	3.391	3.027	16.844

Source: Research Data in 2019

3.5 Discussion

Based on the implementation of the study, the researchers obtained two data related to the assessment, including the disaster awareness level of both experimental (treated using the comic-assisted investigation group learning model) and control group (treated using the conventional model). The data then proceeded to the normality test using the One-Sample Kolmogorov-Smirnov technique which was assisted by the SPSS 16.0 for Windows. The normality test confirms that both data are normally distributed.

Following the normality test, the study also proceeded to the homogeneity test for both experimental and control group in terms of their disaster awareness level. The homogeneity test which was performed through the SPSS 16.0 for Windows confirms homogeneous variant of the data as the requirement to forward the hypothesis test using T-Test parametrical statistics.

The T-Test was directed to the disaster awareness level based on the students' learning performance, in which the experimental group gained a higher mark reaching 74.31, while the control group only secured 64.38 as their average score. The difference between both groups' average score indeed has signified the effectiveness of the treatment. However, the research still proceeds to the next procedure to strengthen the initial conclusion. The calculation which was assisted by the SPSS 16.0 for Windows signified tcalc = -2.907, while ttab (df = n-2; 45-2= 43) (two-tailed sig = 5%; 0.05/2 = 0.025) = 2.416. The result of analysis concludes that tcalc > ttab (2.907 > 2.416) and confirms that the comic-assisted group investigation learning model is effective to elevate the disaster awareness of the primary school students' in Jipang Village. The current finding is in accordance with a number of previous studies, including [8] [9] [10]. The following curve explains the detail.

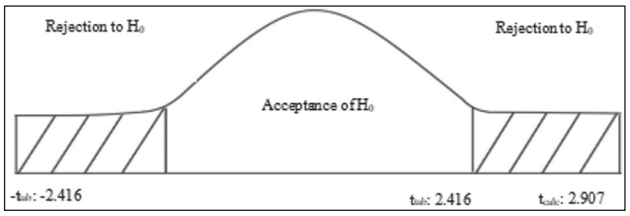


Figure 2. T-Test Curve

The article confirmed the effectiveness of the comic-assisted group investigation learning model to elevate the students' disaster awareness, as the experimental group students signified the improvement of average score through the application of the treatment, in which consecutively from the first to fifth class meetings, they got 65.21, 68.69, 75.76, 78.62, and 81.86 in their average scores. The students still needed to adjust their learning style with the new treatment at the first to third meeting. At the phase, their common problems majorly related to the activities of finding the relevant sources, proposing a number of topics, studying topics, evaluating the presentation, providing feedback, and collaborating with the teacher. They eventually could adjust themselves with the comic-assisted group investigation learning model at the fourth and fifth meeting to study the subjects related to disasters.

4. Conclusions

The experimental group that was treated using the *comic-assisted group investigation* learning model signified a higher disaster awareness level compared to the control group that only utilized the conventional method.

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Green management practices in higher education institution of U.A.E. - A case study

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Abstract

The purpose of the study is to determine the practices of green management in higher education institution of Dubai. A random sample from 523 students, staff and faculty from a small sized private university were collected using a questionnaire composing of statements on green management functions in human resources, library, training, and operational departments of higher education. The mean, standard deviation was carried out. The results showed mean score of (4.26), standard deviation of (0.848). The overall mean score for green management practices is 4.26 and is therefore at a high level of demonstration. The outcome of the research will instigate the other educational institutions to adopt green management practices. Educators need to think differently and creatively with innovative minds. Universities are obliged to play proactive role in setting goals and mission statements to instill more responsibility among students, faculty and staff. The green management practices instill promotion of green education. A few recommendations are provided for perceiving green management in academics.

Keywords: Green management, green education, green academics, green curricula, higher education, U.A.E.

1. Introduction

During the past years, environmental concerns have increasingly become popular and there are many studies focusing on environmental issues, health concerns and economies. Environmental protection is an individual and personal responsibility for all human beings since we are all part of the biosphere. We need to make environment protection a personal responsibility. That is the only way future generations can make a contribution to Planet Earth's [1]. The UAE's commercial capital and its most cosmopolitan city, Dubai, has been identified as the most attractive city in the world and the critical factor for further economic growth and sustainability by nurturing incorporate environment-friendly HR commencement and practices for sustainable use of resources that resulting in more efficiencies, less wastage, improved job related attitude, improved work/private life, lower costs, improved employee performance and retention which help organization to reduce employee carbon footprints by the means of Greening [2]. Green management has become an accepted part of business life. When companies strive for maximizing their profits, and minimizing environmental influences, higher education institutions have to make changes in their decisions about environmental protection, by implementing green management policies. Academic institutions and education services are working towards greening by incorporating awareness and adopting environmental practices in the learning process. Setting up green operations and facilities, offering green services, executing green recruitment practices, applying green training & development, introducing green education and curriculum are some specified practices observed. Green management applications in educational institutions increases the reputation and familiarity, provides competition among others, and decreases usage of energy sources. The aim of greening in educational institutions to teach the students to become responsible individuals of nature protection, to use the resources sensibly, and decrease nature destroying by recycling activities [3].

2. Literature review

Business schools is one of the fastest growing industry of economy on one hand and also they have a responsibility to train managers; provide guidance in terms of consultancy and create new knowledge. i.e. research in green management. Green Management is; "*the organization-wide process of applying innovation to achieve sustain-*

ability, waste reduction, social responsibility, and competitive advantage via continued learning and development, and by embracing environmental goals and strategies that are fully integrated with the goals and strategies of the organization" [4].

Many higher education institutions have attempted to go green and become more sustainable by signing national and international declarations in order to perceive the commitment. Many institutions have memberships in various green groups; encouraging students to join green learning and green courses, and adopting changes in curriculum. There are evidences of green campuses in relation to facilities and dorms, recycling and energy conservation, yet much more attention must be paid whether such green practices yield a competitive advantage. Effective leadership by institutions need to adopt to green management principles and green education. [5].

Human resource management (HRM) plays prime role in execution of green practices and indicates the contribution of HRM to the green performance, resulting in more efficiencies, less wastage, improved job related attitude, Improved work/private life, lower costs, improved employee performance and retention which help organization to reduce employee carbon footprints by the mean of Green HRM practices [6]. There are certain factors which contribute specific role in employee implementation of green principles [7]. These factors are recruitment, training, motivation and green pay/rewards in order to make sure that the organization get right employee green input and right employee green performance of job. Green training and development educate employees about the value of Green management, train them in working methods that conserve energy, reduce waste, diffuse environmental awareness within the organization, and provide opportunity to engage employees in environmental problem-solving [8]. Green Training & Development activities make employees aware of different aspects and value of environment management. It helps them to embrace different methods of conservation including waste management within an organization. Further, it sharpens the skill of an employee to deal with different environmental issues [9].

3. Objective

To study the green management practices observed in various departments of educational institution of Dubai, UAE.

To suggest possibilities for green management in academic field.

Institutions are obliged to set green goals and visions, so that their students can be capable and have the awareness of sustainable development [10]. Institutions must play key role in Administrative policies, planning, mission, goals, and also in operational strategies.

4. Departmental green management practices

I. Administration, mission, and planning –

a) The administration department drafts formal written statements describing the purposes, objectives, strategic planning reflecting to Green Management.

b) Appointing positions and committees responsible for Green Management to take up the Greening responsibility. For example- Green Purchasing Coordinator, Energy officer, Environmental Coordinator, Dean of Environmental Programs, etc.

c) Orientations programs are planned, and conducted for students, faculty and staff.

d) Green Management ideas and events are given wider visibility in campus by Earth Day celebration, inviting guest speakers, and conducting conferences on Green Management etc.

e) Factors that support the advancement of Green Management. Administrative leaders are sought out along with factors that resist or lack the responsiveness to Green Management.

II. Operational strategies-

Core plans are set on how to green the universities, through green operations & facilities, green products and services. Example: efforts are made to green facilities by installing energy-saving devices like changing out incandescent bulbs & installing motion sensor lights in toilets, and regulating computers and lights in classrooms and laboratories to automatically turn off when not in use. Adoption of operational efficiencies like:

A) Energy conservation practices and Installation of energy-saving devices or renewable energy sources like solar panels in lighting, heating, white roofs to keep building cool, sunroofs for natural lighting, ventilation, windows, sensors that automatically turn off unwanted lights or air-conditioning etc.

B) Waste reduction policies including making double-sided photocopying, e-communication between departments and staff etc.

C) Water conservation practices like efficient and low-flow toilets,

D) Sustainable transportation program like car pools, biodiesel projects, and public transport.

III. HR practices-

Higher Education institutions use digital processing like teleconferencing, virtual interviews through skpe, electronic job offers, and electronic agreements, paperless processing and verification. Performance and appraisal management, training and personal development, employee relations and reward systems are aligned with institutions green practices to reduce paper usage, less printing, and conservation of energy.

IV. Green Libraries-

Library has taken green initiative for dissemination of information (being main role of library) like creating digital library, sharing printer and computers for maximum use, institutional repository, creating e-archives and e-resources, assessing information through OPAC and MARC records, providing information through websites and blogs. Green management in libraries can be more effective with creating "Green team" in the library, converting unused library spaces into green spaces or maximum plantation, promoting green education by conducting short term courses on "greener libraries" selecting green topics for information literacy instruction, providing facilities for environmental video viewing or lecture presentations.

V. Accounts and Finance-

Green management factors include accounting and financial procedures by using computerized balance sheet, using excel sheet and tally software, for easy calculations thus eliminating paper work.

VI. Green cafeteria-

Self-service of food, and take-away of unused food is an eco-friendly measure to reduce wastage of food. Elimination of paper plates, plastic spoons/forks are also measure of green cafeteria followed by institutions.

VII. Faculty and staff development, trainings and rewards –Faculty and staff development programs enhances understanding, teaching and research on Green Management. Training programs are significant as they improve employee's knowledge [11]. Universities should develop rewarding system to promote green attitude which will help develop commitment towards importance of Green performance [12]. Faculty members use email, instant messaging, or short message service instead of paper to issue assignments and provide feedback. Use of Blackboard, learning management system promotes e-learning and eliminates paper work.

IX. Research and Scholarship- Promotion of faculty research or scholarly activities in disciplines of green management, renewal energy, environmental quality management etc.is necessary. Implementation of a multidisciplinary or interdisciplinary department to support research and publications and subscription to databases supporting Green education and literature plays key role.

5. Research design and methodology

Across higher education, increasing number of universities and colleges yield to growing pressures of "greening" their institutions in regards to facilities, recycling, energy conversation, and sustainability. Very limited research has been done that addresses green management practices in academic field of the United Arab Emirates. Therefore the purpose of the study is to determine the practices followed and its impact on stakeholders.

In this study the researcher aims at studying the perception of students, staff and faculty members on green management in universities of the United Arab Emirates (U.A.E). An exploratory study was done by gathering information from a small sized private university in Dubai. A simple questionnaire was distributed randomly among the stu-

dents, staff and faculty. The five point Likert scale was used to collect the data on given variables. Frequency, and Percentage, Mean, Standard Deviation were analyzed using the Statistical Package for the Social Sciences (SPSS) software

6. Data analysis and discussion

A total of 655 Questionnaires were distributed randomly in selected universities. 523 respondents responded giving a response rate of 79.8%.

Table 1: Demographic profile of participants (n=523)

Demographic variables	Frequency	Percentage
Gender		
Male	326	62.3
Female	197	37.7
Category		
Students	483	92.4
Faculty	21	4.0
Staff	19	3.6
Qualification		
Undergraduate	443	84.7
Postgraduate	63	12.0
Doctorates	17	3.3
Total	**523**	**100**

Out of 523 respondents, 326 (62.3%) were males and 197 (37.7%) were females. 483 students formed the largest number of respondents (92.4%), followed by 21 (4%) faculty members and 19 (3.6%) staff members. Most of the respondents were at undergraduate level of study. A large number of 443 (84.7%) were with undergraduate level of study; 63 were at postgraduate level (12%) and 17 respondents with doctorates.

The mean and standard deviation were calculated based on the opinions. The score ranges from 1 (Strongly disagree) to 5 (Strongly agree) on each item. A score of less than 3.0 indicates dissatisfaction; score in the range between 3.0 - 3.5 indicates an average level of satisfaction, score of 3.5 to 4.0 indicates above average level of satisfaction; while a score of 4.0 or greater, indicates a very high level of satisfaction.

Green management approaches was determined with five variables which showed the mean score of (4.26) and standard deviation of (0.848). A mean score of 4.0 or greater, indicates a very high level of Green Management adoption and practices.

In Table 2, the three statements of green management practices- Operational strategies ; Green HRM; Green library have a mean score of 4.32 which is the highest mean score among the five variables. The second highest mean score (4.20) is seen for the statement- Green Training. The third highest score is seen for the statement – Mission and Goals for Green Management with a mean score of 4.16 which indicated that Universities are obliged to play proactive role in setting goals and mission statements to instill more responsibility among students, faculty and staff. The overall mean score for green management practices is 4.26 and is therefore at a high level of demonstration.

7. Conclusion and recommendations

The study shows that Green management in educational institution is accepted whereas educators need to think differently and creatively with innovative minds so as to acquire skills, competencies and use of technology to reposition the organization for future growth. Creating Green awareness among the younger generation is a necessity to

Table 2: Mean and Standard Deviation

S. No	Green Management practices	Mean	SD
1	Mission and goals of University emphasizes for development of Green Management	4.16	0.893
2	University has implemented operational strategies through energy saving devises, lights and air-conditioning	4.32	0.797
3	University has demonstrated Green HRM while hiring, evaluating, and promoting employees	4.32	0.863
4	University has Green library projects by providing access to electronic resources	4.32	0.884
5	University deploys trainings to students, staff and faculty recycling processes and advantages of it.	4.20	0.803
	Average	**4.26**	**0.848**

raise a responsible society. When higher education goes green, it creates a high public image, creates sustainability, and a conducive environment. Younger generation need to realize how to control environmental damages and develop environment protection sense through education from schools and colleges. By introducing green management courses into the curriculum, every individual gain a consciousness that environment should be protected [13]. In comparison to conventional education, green education imposes modern pedagogy, and imparting environmental values, services and products.

Syllabus and Curriculum – Development of curricula for an environmentally sustainable future offering courses related to green management, environmental policy and sustainable agriculture, urban ecology, sustainable production and consumption, globalization and sustainable development etc.is very important. These courses maybe included in foundation level with science, math, etc. or integrated into undergraduate level. Interdisciplinary academic courses, open and distance learning system, interactive web-based syllabus eases communication amongst professionals, students to promote green management and sustainability for the future [14].

Outreach and Service- Support and encourage Green Management through conferences, faculty exchanges or internship programs, and thereby safeguard the interests of future generations. Partnerships with government, non-government organizations and industries are established to develop models and knowledge related to environmental management and sustainability.

Innovative Performances – Universities should encourage students to be innovative and develop competencies of the future that would circumvent standard routines and knowledge; provide students with specific opportunities and settings like green career fairs where employers are hiring for positions with an environmental and sustainability focus, career counselling focused on Green Management, pledge of social and environmental responsibility, student groups in campus involved in Green Management etc.

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Interactive whiteboards

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Absctract

Nowadays, it is impossible to bypass modern technologies and their use in all the segments of everyday life and work. In order to improve quality of teaching, teachers tend to use multimedia and smart whiteboards more often. Technology and Internet led to online studying which improved mastering of learning and that is not always an easy thing to do. This survey is going to show results of using interactive white boards in classrooms within two Primary schools. The survey is done in December, 2018. We have come to discover that teachers use traditional teaching materials more. By applying the instruments of research and processing the results that we got it will be shown that there is a statistically significant difference in the teachers' evaluation when it comes to use of interactive whiteboards and their impact on teaching. This research has also shown that teachers have different opinions about the idea of replacing a traditional book and classic 'green board' with the smart board.

Key words: *education, interactive board, education*

1. Introduction

Theme of this research is the use of informational – communicative technologies in schools with the special attention on the smart board and its impact on the students' motivation and the easier way of knowledge acquiring. Development of the technology imposes the need for the improvement of the technology of education on all levels. Informational communicative technology consists of informational technology, phone technology, electronic media, all types of audio and video processing and transferring as well as all the functions of surveillance and control based on the network topologies [1]. In the area of education IKT implies the use of informational technology within all the areas of education emphasizing communicational component of informational technology [2]. The presence of computers as well as the use of other teaching materials cause changes which improve the quality of the education today. The whole process of modernization of education is conditioned by possessing and using the right materials and equipment. During the acquisition of the materials, educational institutions require significant financial means. In order to make education more efficient, new multimedia is needed, the one which can meet the needs of the modern didactic- methodical principals in teaching. Having worked for nine years as a teacher consultant I have seen the possibilities for improvement of teaching by implementation of multimedia in classrooms. I have been mostly intrigued by the idea of easy and fast implementation of multimedia such as films, animations and experiments in class management without the interruption of its natural flow which would improve the dynamics and motivation with students.

This kind of approach would improve the quality of teaching and students would acquire materials easier and faster. Considering the fact that classrooms have small groups of students, multimedia would be an excellent choice for remedial and additional teaching.

The great responsibility falls on teachers who need to be capable to use the modern technologies. These kinds of teaching means improve interactivity, engagement and motivation with students which again improve the final results of teaching. Projectors (with computer and projector screen) are used today in many schools. Although they cannot replace the classic green board because they only show already prepared material so there is not enough space for additional activities, explanations or changes. Combination of the two approaches mentioned above led to invention of the electronic interactive board (multimedia white board). Using the smart board, a regular projector gets more interactive and the whole system becomes technological substitute for regular school board with loads of new possibilities.

2. Interactive board IT

Advantage of modern technologies is that they enable interactivity and multidirectional communication in the classrooms [3]. It means that teaching is based on words and pictures (animation, photography) and that there is a possibility of different levels of interactivity, simulations, graphics and finding information and also the use of strategical and didactic games which was almost impossible with old technologies. Interactive board is the newest accomplishment when it comes to digital equipment. Interactive white board is a teaching aid which enables interactivity on the project screen. Interactive board (IT) makes a mechanism of projectory surface which behaves similarly as one big touch screen. The expression *touch screen* does not apply to all white board because not all react to touch but because of the presence of touch screen mobile phones this expression is adequate to describe the behavior. What is common for all the interactive boards regardless the way of realization?

- the screen of the white board is very sensitive to actions of users. It is important to say that the white board screen is not the same as the Windows screen and we will use this term in order to describe the surface which reacts when combined with user. Whiteboard screen is the surface which shows the content that is on the computer screen at the moment and that could be part of the wall, piece of mediapan board or some other suitable surface where we could project the content from the computer screen using a projector. Besides projecting pictures using projector some models of IT can use the computer on TV screen which has big diagonal. Dimensions of the surface we work on depend on the size of the picture we need to project or on the physical size of the media where we project the picture.

- Actions of the users who use the screen result in doing a certain action on the computer which is connected to the white board and that is enabled by the software installed on the computer. In order to use the smart board we need a computer and a projector. The principle of working on such a board is very simple although it requires a bigger engagement of teachers in the preparation for the class. For students it is a special experience because it makes a classic presentation into two- or three-dimensional picture. Its most important role is to achieve visual communication through picture. Apart from the white board we also need a digital pen which is used to write on the screen although we can also use our finger to do that. Big interactive board needs to be connected to the computer and projector. The projector is going to project the picture on the board and users will use the pen or the finger to manage the computer. That is the way where demonstration of the educational materials starts to become more interesting for the students. Student will remember things more easily because of the visual effect. It is the way to include students and teachers in process teaching and learning.

2.1 Interactive boards in the process of teaching

Video projectors have been used in many classrooms over the past several years. Although they have had unimaginable value in the process of teaching, we still need the classic green board because the things we use in the presentations on the projectors are prepared in advance and cannot be changed. They do not allow further explanations, additions or changes.

Today it is already possible to input some new material such as java applets and flash animations which expanded the range of material that can be used on presentations. If we input some video as part of Windows Media Player, we get an object which can control the video in our presentations. Also, using some plug ins we can insert the whole web page into our presentation and use it from there. Although, apart from all the possibilities of Power point (PP is not the only software for making presentations but it is the most common one so we use it as an example) the simpliest operations such as *drag* and *drop* as well as object manipulation are extremely difficult to manage directly during presentation because it depends on macros and behaves unexpectedly. Those are the things which would discourage most of the beginners. PP also has the ability to make the notes in different colours. Software will suggest to save them in the presentation even after stopping the Slide Show. All this would have to be done from the computer and not directly on the board screen. The consequence of a work like this is that students might

find it confusing because they do not see the teacher whereas when the teacher is using IT student see him, they see the action because they see the teacher's digital pen or finger. Another problem is that there is not a possibility of the object manipulation. For e.g. when teacher makes a note during presentation if we wish to move it left or right, it wouldn't be possible. The reason why interactive boards were invented is the need to control the computer and direct object manipulation with all the possibilities that we had with the computer, projector and multimedia. Although the smart board is only a teaching aid used in the classrooms it has brought many novelties. If we only consider the computer manipulation directly from the screen we already have the advantage when compared to old projections because now we can use *Ball Pen* or *Highlighter* from Power Point directly on the interactive screen. If we forget PP for a moment and take a look at large number of softwares which are already in use (Geogebra, 3dCabri, MS mathematics, Sketvchup) we can be ascertained that direct manipulation of the commands of those programs is a huge advantage when compared to old projections without the possibility of interaction with the software.

All interactive boards have set of tools which ensure interactivity or so called sensitivity of the screen. These tools enable some of the following actions besides the control of the cursor:

- Writing notes on the screen, according to a content visible on the computer screen
- Making photographs from the part or the whole screen
- Making a video in steps
- Audio recording
- Recognizing handwriting
- Recognizing shapes
- Enlarging part of the screen

Some models of the smart boards integrate these tools in the flipchart softwares which are delivered with the board. It is also possible to record the whole class or just part of it in audio or video format. Each object is easily manipulated and the use of 'sponge' for deleting objects is easy.

Flipchart softwares are made in order to eliminate problems stated above and to make working on smart boards easier. In time these softwares became serious applications with great capabilities which contain huge libraries that have already installed teaching materials such as: texts, pictures, graphics, diagrams, vide, audio or interactive animations needed to work in class. Flipchart softwares enable us to organize materials through slides when using smart boards. I t can also show pages that are not visible but are easy to be shown again with or without notes done during the class with possibility of interacting multimedia. Possible problems that may occur during the use of interactive board are:

1. Wasted opportunities of the smart board because of the insufficient teacher training
2. Partly covering the board by the teacher, shadows which can cover great parts of the screen
3. Standing in front of the projector for several hours can be damaging for the teacher's eyes (this can be solved by the adequate UST projectors)
4. It is prerogative that teachers as well as student have some previous knowledge and computer skills (basic software and hardware knowledge)
5. Software are not compatible between themselves
6. Creating presentations demands a lot of time

2.2 Use of interactive boards in our schools

Use of smart board is not that difficult so it wouldn't be a problem for every teacher to learn how to. Smart board would be of most use with tasks and activities that teacher organizes for the class. Student acquire knowledge more easily through the smart board because they hear, listen, see, speak and do. Beside the activities that teachers do with students, teaching can be enriched with all kinds of animations and pictures and make the lessons more interesting. Smart board means new experience for students and teachers. It offers more exciting and more dynamic way of learning for students and gives teachers opportunity to give that experience to students. Development of motivation needs to be influenced and the most important agent for that is a teacher and his methods and tools in the classroom. Motivation for learning demands series of planned steps within the

process of learning and interaction with a teacher as well as the organization of class itself. (Lalic – Vučetic, 2016). Motivation is important for many other factors such as: learning tempo, concluding, memory, attention, quality of attention and perception, imagination and creativity. We can surely state that book is still the main tool when it comes to teaching but it is extremely important to make students hear and see what they learn and they will surely be interested to study it at home.

All this is possible on the level of satisfying the curiosity for certain contents. Interactive board makes a traditional green board into interactive tool for teaching and presentation. According to several researches it can be stated that only a small amount of our schools has a smart board. Teachers know so little about all the possibilities and efficiency of this board. The main obstacle for schools to have this board is the finance. Teachers, mostly young ones want to educate themselves and to use these boards in their classrooms. They also want to create educational materials through the software of interactive board. That way, the use of interactive boards would be intensified until it completely takes over. Equipping schools with interactive boards does not mean that it raises the quality of teaching or enriches it. It doesn't even mean they will be used in the classrooms. In order to do that, it is necessary to train teachers and make them realize that it is a must to follow trends when it comes to education.

Another problem that schools need to overcome is logistics. It means that smart boards need to be in native language as well as creating software packages which can be used with the smart boards. Some software packages already exist in our country but they are just a spack of dust in the sea of infinite online resources in the world. (e.g. Smart boards have nearly 7000 available different lessons, Hitachi has also a great number of free online resources). Oney of the problems is also when teachers are not educated enough so they cannot use all the possibilities that smart board can give them. That is why great brands in the world have educations for smart boards available at all times while in our country it is still very limited (several seminars) or superficial presentations one or two). The rest of the work is up to teachers and their motivation.

3. Methodology of research

The goal of the empirical research is to find the use of interactive boards in the classroom and the amount of their usage. Starting point of this empirical research is a research problem formulated as a question: Are the interactive boards used in the classroom and is their use good for the students' achieving better results? According to the established problem of this research, the subject of this research was: To find if smart boards are used in the classrooms.

This research is going to:

1. Determine whether there is a statistically significant difference in elementary school teachers' opinions and attitudes of the use of tools that are more used in classrooms, traditional ones or multimedia
2. Determine whether there is a significant difference in elementary school teachers' estimate of influence of the smart boards on the achieved results
3. Determine if there is a statistically significant difference in elementary school teachers' estimates of the use of smart boards in the classroom
4. Determine if there is a statistically significant difference in elementary school teachers' estimates of interactive smart board replacing the 'green board' and traditional book.

Participants of this survey are students, teachers of Primary schools in HNK/Ž. Random sample is used. The sample included teachers from two Primary schools. Schools in the sample are: Primary school Ilija Jakovljevic Mostar and Primary school Gnojnica. Statistical package SPSS is used for data analysis.

4. Results of the research and the interpretation

The first task of the research was: ' to examine opinions and attitudes of the teachers which tools are more used in the classroom, traditional or multimedia'

Table 1. Teachers' attitudes towards the use of tools in the classroom

Do you explicitly use traditional tools in the classrom?			
Yes		No	
f	%	f	%
37	86,05%	6	13,95%

In the chart nb 1. Teachers' attitudes and opinions about the use of traditional tools in the classroom are shown. Traditional tools are used by 86,05% teachers while 13,95 % of teachers said they do not use only traditional tools.

Table 2. Teachers' attitudes about the use of interactive boards in the classroom

Do you use smart board in the classroom?			
Yes		No	
f	%	f	%
3	6,97%	40	93,02%

From the chart number 2. We can see that teachers said they do not use smart board more than traditional tools. The question: ' Do you use smart board in the classroom? '6,97 % said YES while 93,02 % said NO.

According to these results we can see that teachers do not use interactive board in the classroom which we confirmed the first hypothesis: 'Traditional tools are used more'.

Second task of the research was 'to determine whether there is a significant difference in elementary school teachers' estimate of the influence of interactive boards on the achieved results '.

Table 3. Teachers' views on the impact of interactive boards on the achieved results in the classroom

Can interactive boards as opposed to traditional tools have better effects on the results in teaching?			
Yes		No	
f	%	f	%
34	79,07%	9	20,93%

The question: Can interactive boards as opposed to traditional tools have better effects on the results in teaching? ' has been answered by most of the teachers with YES,79,07%. According to this survey we can conclude that smart boards have positive effect in the classroom and that students have much better results in educational process. 9 students or 20,93 % of them answered that smart boards do not have any impact on the learning results.

Table 4. Values χ^2 – teachers' views on the impact of interactive whiteboards on classroom outcomes

f_0	f_t	$f_0 - f_t$	$(f_0 - f_t)^2$	$\Sigma\frac{(f_0-f_t)^2}{f_t}$
34	21,5	12,5	156,25	7,26
9	21,5	-12,5	156,25	7,26
Σ 43				**Σ 14,52**

Calculated value χ^2=14,52 on the level of significance of 0,05%exceeds the limit value (3,84) zadf=1 degrees of freedom, we conclude that the deviations in the frequencies of students' assessments of the impact of interactive whiteboards on classroom outcomes, expressed in the empirical frequencies of expected ones, are not accidental. At the significance level of 0.01, the calculated value of χ^2 = 14.52 is greater than the cut-off value (2.71), zadf = 1 degrees of freedom, which means that the difference between the empirical and theoretical frequencies is also statistically significant at this level, indicating that there are significant discrepancies in teacher evaluations of whether the use of interactive whiteboards , as opposed to traditional tools, can better influence teaching outcomes.

By processing the results of the teachers' assessment, we came to the conclusion that: by calculating the values of χ^2 we found that there were significant deviations of empirical from expected frequencies, that is, there were statistically significant differences in the students' assessment of the impact of interactive whiteboards for better teaching results, unlike traditional tools.

The results of the teacher assessment confirm the second hypothesis, which was stated by the use of research instruments and the processing of the obtained results, it will be established that there is a statistically significant difference in the assessment of primary school teachers regarding the impact of interactive whiteboards on the achieved results.

Our third research assignment was: "to determine whether there is a statistically significant difference in primary school teachers' estimates of the use of interactive whiteboards in teaching.

Table 5. Teachers' views on the use of interactive whiteboards in teaching

Is it easier for you to manage classes using the interactive whiteboard?			
Yes		No	
f	%	f	%
32	74,42%	11	25,58%

More than half of the respondents, 74.42% of teachers, stated that it was easier for them to teach using the interactive whiteboard while 25.58% said no. Based on the results we can conclude that the use of interactive boards in the teaching process is very important, and that the use of interactive boards should be increased.

Table 6. Values of χ2 - teacher attitudes about the use of IT in teaching

f_0	f_t	$f_0 - f_t$	$(f_0 - f_t)^2$	$\Sigma\frac{(f_0-f_t)^2}{f_t}$
32	21,5	10,5	110,25	5,12
11	21,5	-10,5	110,25	5,12
Σ 43				**Σ 10,24**

The calculated value of $\chi^2 = 10.24$ at the significance level of 0.05% exceeds the threshold value (3.84) zadf = 1 degrees of freedom, we conclude that the deviations in the frequency of teacher assessments of the use of multimedia in teaching, expressed in empirical frequencies are not random

At the significance level of 0.01 the calculated value $\chi^2 = 10.24$ is greater than the threshold value (2.71), zadf = 1 degrees of freedom, which means that the difference between the empirical and theoretical frequencies at this level is statistically significant, which indicates that there are significant discrepancies in teacher evaluations of the use of interactive whiteboards in teaching.

By processing the results of the teacher assessment, we came to the conclusion that: by the calculated values of χ^2, we found that there were significant deviations of the empirical from the expected frequencies, that is, there were statistically significant differences in the teacher's assessment of the use of interactive whiteboards in teaching.

By processing the results of the teacher assessment, we confirm the third hypothesis which said: using the research instruments and processing the obtained results it will be established that there is a statistically significant difference in primary school teachers' estimates of the use of interactive whiteboar ds in teaching.

Our fourth research assignment was: "to determine whether there is a statistically significant difference in primary school teachers' assessments of whether an interactive whiteboard can replace a green board and a traditional textbook."

Table 7. Teachers' views on whether the interactive whiteboard is sufficiently accepted in teaching

Is the use of the interactive whiteboard still under-accepted and has many difficulties			
Yes		No	
f	%	f	%
23	53,49%	20	46,51%

When asked "whether the use of the interactive whiteboard is still under-accepted and has many difficulties", 53.49% of teachers answered that the use of the interactive whiteboard is still under-accepted and has many difficulties, and 46.51% said that the use of the interactive whiteboard is sufficiently accepted and there are no difficulties. From the results presented above, we can see almost identical responses of teachers, when it comes to accepting the use of interactive whiteboards in teaching.

Table 8. Values of χ2 - Teachers' attitudes about interactive board acceptance and many difficulties

f_0	f_t	$f_0 - f_t$	$(f_0 - f_t)^2$	$\Sigma\frac{(f_0-f_t)^2}{f_t}$
23	21,5	1,5	2,25	0,10
20	21,5	-1,5	2,25	0,10
Σ 43				**Σ 0,2**

The calculated value of $\chi^2 = 0.2$ at the 0.05% significance level does not exceed the cut-off value (3.84) zadf = 1 degrees of freedom, we conclude that the frequency deviations of the teachers' assessments are still insufficiently accepted.

The use of interactive panels, expressed in empirical frequencies as expected, is random.

At the significance level of 0.01, the calculated value of $\chi^2 = 0.2$ is smaller than the limit value (2.71), zadf = 1 degrees of freedom, which means that the difference between the empirical and theoretical frequencies is not statistically significant at this level either, which indicates to us that there are no significant discrepancies in teachers' evalu-

ations. There is still insufficient acceptance of the use of the interactive whiteboard

Table 9. Teachers' attitudes about applying IT instead of traditional textbooks in the teaching process

Can the use of interactive whiteboards replace the green board and the traditional textbook?			
Yes		No	
f	%	f	%
39	90,7%	4	9,3%

Table 9 clearly shows that teachers, 90.7% of them, have stated that the use of interactive whiteboards can replace the "green board" and the traditional textbook. Only 9.3% of teachers answered the opposite.

Table 10. Values of χ2 - students' attitudes about using interactive whiteboards instead of "greenboards" and the traditional textbook

f_0	f_t	$f_0 - f_t$	$(f_0 - f_t)^2$	$\Sigma\frac{(f_0-f_t)^2}{f_t}$
39	21,5	17,5	306,25	14,24
4	21,5	17,5	306,25	14,24
Σ 43				**Σ 28,24**

The calculated value of $\chi^2 = 28.24$ at a significance level of 0.05% exceeds the threshold value (3.84) zadf = 1 degrees of freedom, we conclude that the deviations in the frequencies of teachers' assessments of the use of interactive whiteboards instead of "green boards" and traditional textbooks, reported in the empirical frequencies from expected are not random.

At the significance level of 0.01, the calculated value of $t\chi^2 = 28.24$ is greater than the limit value (2.71), zadf =1 degrees of freedom, which means that the difference between the empirical and theoretical frequencies is also statistically significant at this level, which indicates to us that there are significant discrepancies in teacher evaluations.

By processing the results of the teacher assessment, we have come to the conclusion that: by the calculated values of χ^2 we have found that there are significant deviations of the empirical from the expected frequencies, that is, there are statistically significant differences in teachers' assessment of whether the interactive whiteboard can replace the "greenboard" and the traditional textbook in teaching. By processing the results of the teacher assessment, we partially confirm the fourth hypothesis which said:

Applying research instruments and processing the results will establish that there is a statistically significant difference in primary / secondary teachers' assessments of whether the interactive whiteboard can replace the 'greenboard' and the traditional textbook.

5. Conclusion

Today it is impossible to bypass modern technologies and their use in all segments of life and work. In order to increase the quality of teaching, teachers are increasingly using multimedia teaching aids and therefore an interactive (smart) whiteboard. Interactive whiteboar is a multimedia didactic tool that combines a computer, projector and projection surface into one device. The topic of this paper is the use of modern information and communication technologies in teaching with special reference to the smart board. It is the teacher who, in elementary school, needs to develop a preference for modern technologies. It can only do good work, which implies quality, but at the same time, interesting presentation of teaching content to students. The use of the interactive whiteboard and its use in teaching certainly leads in this direction. There are no restrictions on the use of software applications.The biggest drawbacks are cumbersome calibration and limited movement of the teacher (should not stand between the remote controller and the desktop).

The conducted reasearch was intended to examine the teachers of the two primary schools (N =43) on the use of interactive whiteboards in teaching. The survey was conducted in December 2018.

Teachers are informed about the survey, aware of the form and purpose of it, and that the survey is completely voluntary and anonymous. It was intended to influence the increased use of multimedia tools and interactive whiteboards in teaching.

In this research we came to the following conclusions:

- Traditional means are used more in teaching
- Applying the research instruments and processing the results, it will be found that there is a statistically significant difference in

the assessment of primary school teachers on the use of interactive whiteboards in teaching.
– Applying research instruments and processing the results, it will be found that there is a statistically significant difference in the assessments of primary school teachers on whether the interactive whiteboard can replace the "green board" and the traditional textbook.

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Influence of laser apparatus currency and laser radiation time on welded geometry of tools steel

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Abstract

The reason for laser welding came because currently this technique largely "neglected" in relation to other processing technology laser. According to the plan of making a master work, will be explained the concept of the laser, the formation of the laser beam, the advantages and disadvantages of laser introduced technology in general. After which work will be focused exclusively on laser welding tool steels.

Worked as influencing factors in the process of welding, or the quality of surface layer. The above described method and the quality control of surface layer, and to methods of non-destructive and destructive methods. And based on that, given the conclusion of the possibility of welding tool steels. In addition to technology, a brief review is made about the tool steels. The definition and properties, chemical composition and use in the industry.

In the experimental part, welded layers the tool steel X38 CrMoV5-1 (Č.4571) 6 thick. Welding is performed by a laser facility type HEROLASER 200 W laser power of 200 [W]. The laser beam is guided by the optical fiber the focal optics 110 which provides the point for the present 0,6 diameter. To create an experiment, according to the methodology of planning the experiment was carried out a total of 27 experiments. The variables that were changed in the process were:

- Laser power of 165, 180, 190,
- Heat input of 8, 10, 12,
- Laser frequency 6, 8, 10.

Each of experiment repeated three times for statistical data analysis. After processing, carried out is a visual inspection the quality of cladding, after which the quality control is accessed destructive. In the laboratory, samples were cutting, polished, and the determined heat affected zone, microhardness test and the degree of mixing of the base material with an additional.

Key Words: Laser Technologies, Tools for plastic injection, welding.

1. Introduction

When it comes to the processing of materials using laser technologies in the former Yugoslavia, it can be stated that this is an area that is currently in transition, that is, an area that is developing and whose effects are still being studied. The processing of concrete metal materials is represented in various forms of processing. Most often it is material cutting with considerable limitations, welding, engraving and welding. The advantage of cutting metal with a laser is reflected in the narrow cut, high quality and precise cutting seams, but also a relatively high cutting speed. The productivity of this process is at a high level. The ability to cut complicated shapes is in this sense unlimited. The disadvantage of the process is the inability to cut out all the materials, which is especially true of materials with a high degree of reflection. Laser welding, engraving do not have significant limitations, but the basic processing parameters must be taken into account in order to avoid side effects after processing. Laser technologies are also used for the thermal treatment of metallic materials. Foreign literature is abundant in research on materials processing using laser technologies, while the B&H literature is scarce with this type of data. Laser welding is the application of layers of additional material to the base material, by the impulse action of the laser rays, which the additional material mixes with the base material due to the influence of thermal energy. In addition to being the most productive type of machining, it is also one of the highest quality methods of machining metal materials. The work will cover the

repair of plastic injection molding tools, that is, filling the crater on the surface of the material formed by the abrasive and temperature mechanisms of tool damage. These are high alloy tool grade X38 CrMoV5-1 (Č.4571) steels used solely for the manufacture of plastic injection molding tools. After a certain amount of time spent in work, they are susceptible to wear and need to be repaired using appropriate methods. Reparations include: removal of tools from the machine, preparation for welding, the welding process and ultimately finishing, super finishing and placement of tools on the machine. The high density of laser welding power allows welding with a narrow zone of heat input into the material, resulting in high cooling rates. This causes a large increase in the hardness in the heat affected zone. It has been shown that the change in mechanical properties with respect to the base material does not unduly affect the mechanical properties of the welded layer. This is due to the narrow zone of influence of heat, the small size of the deposits and the fine-grained structure. This significantly differentiates laser welding from conventional welding procedures. Plastic injection molding tools are further heat treated and polished. Literally, the tools increase the hardness in the surface layers, followed by the polishing and polishing operations according to the requirements of the quality of the surface of the product. This processing process makes it difficult to predict the microstructure of the layer, which is also the carrier of the mechanical properties of the deposits. The quality of the weld layer is determined in several ways. The first contact with the welded layer is visual inspection, that is, the operator is the one who determines whether the weld is satisfactory or not, whether it contains certain deformities visible to the eye. Additional determinations, if required, of the quality of the precipitated layer are determined by non-destructive and non-destructive methods. Non-destructive methods are the most common test with ultra-sound, penetrants, magnetic powder, etc. The methods with fracture include the excision of specimens, microscopic observation and determination of the zone of influence of heat, determination of microhardness, etc.

Advantages of laser welding technology over other types of welding:

- High power density;
- Narrow zone of heat influence
- low degree of deformation
- High degree of the process productivity
- High welding speed;
- Process flexibility;
- Small or unnecessary post-processing of tools;
- High quality welds.

Disadvantages of laser welding technology compared to other types of welding:

- High investment costs;
- Increased costs of material preparation;
- Trained workforce;
- Plant maintenance.

2. Tool steel

Tool steels are iron and carbon alloys with a carbon content of 0.6% to 2.06%. In addition to the basic element's Fe and C, other alloying elements, such as Cr, Mn, Si, Ni, W, V, are included in the alloy composition, which depends on the purpose and desired characteristics of the product. The basic requirements that these types of steel must meet are the wear resistance (high-carbide martensitic structure) and the corresponding impact resistance. In addition to these characteristics, it is important that steels do not change their dimensions during heat loads because they operate under conditions where temperatures reach a value above 200 °C. The requirements for this steel group are:

- Possibility of processing by methods of separation of shavings;
- High proclivity;
- Slight change in dimensions during operation;
- Corrosion resistance;
- Wear resistance;

The most commonly used alloys are high alloy steels with a basic alloying element content of Cr> 5% with a combination of other alloying elements such as: W, V and Mo, which give the steel an adequate temperature stability.

According to their chemical composition, tool steels are divided into:

- carbon (non-alloy) tool steel;
- low alloy tool steel;
- high alloy tool steel.

According to the operating temperature and application conditions, tool steels are divided into:

- tool steel for cold work (<200 ° C),
- tool steel for hot work (> 200 ° C),
- high speed steel.

2.1 High alloy tool steels for cold work

The main alloying element of this steel group is chromium (> 5%) with possible additional alloying with vanadium, molybdenum and / or tungsten. By increasing the degree of alloying and austenitization temperature, the proportion of residual austenite in the hardened microstructure increases, which can reduce the appearance of deformations after quenching. Considering the chemical composition, microstructure and properties, high alloy cold work tool steels can be divided into 3 subgroups:

- Steels with ~5% chromium (X100CrMoV5-1). Its main application is for the manufacture of scissors and sheet metal forming tools, measuring tools, drill bits, threaded drill bits, nuts, complex shape dies, polymer processing tools, etc.;
- High carbon ledeburite steels with 12% chromium (X210Cr12, X210CrW12, X65CrMoV12, X55CrVMo12-1). The most common application of this group of steels is the production of tools for cold forming, embossing, deep drawing, and other elements of punching and sifting tools;
- Martensitic stainless steels (X42Cr13, X45CrMoV15, X5CrMo14, X1CrMoV18). They are used for medical instruments (scalpels, scissors, dental pliers, tweezers, etc.), cutlery (knives), razors, razors, tailoring scissors, etc.;

2.2 High-alloy steels for hot work

Tool steels for hot work are used to make tools that are heated to a temperature higher than 200 °C during operation. The most important feature of tool steels for hot work is the resistance to cracking. Crack resistance includes the phenomena that can occur during exposure to elevated temperatures (hardness reduction, micro-structural changes, and thermal fatigue). In addition to resistance to loosening, tool steels for hot work also have additional requirements such as resistance to wear, high temperature corrosion, plastic deformation, impact load (toughness).

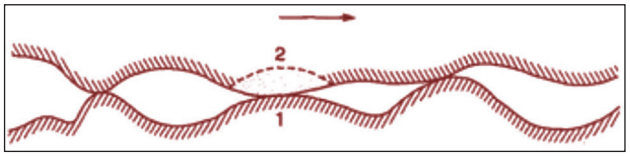
Tool steels for hot work can be divided into three main groups:

- Tool steels for forging (56NiCrMoV7, 55NiCrMoV6 steels);
- High alloy steels with ~5% chromium and 1 - 3% molybdenum, intended for injection molding molds (X32CrMoV3-3, X38CrMoV5-1 steels);
- High alloy W-Cr-V steels for injection molds (steels X30WCrV4-1, X30WCrV9-3).

2.3 Wear of tools in material processing

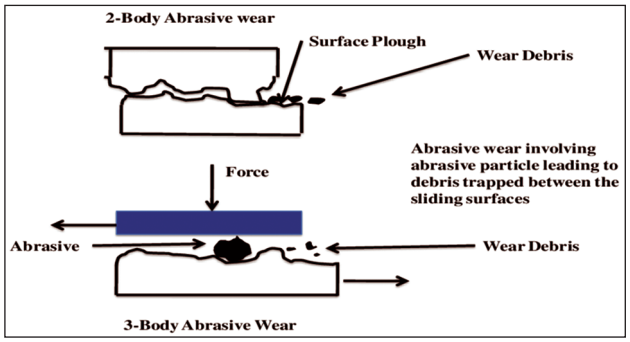
Damage may occur sooner or later when tools are used in production facilities. Damage is an occurrence caused by wear on certain tool surfaces. Depending on the type of material, the operations they perform, and the operating conditions in which they are exploited, different mechanisms of tool wear occur. The basic wear mechanisms are: abrasion, adhesion, surface fatigue and tribocorrosion. All mechanisms, except fatigue, lead to slow removal of the material. Wear is, as a rule, initiated by one mechanism, and proceeded by another. [1] In order to determine the mechanism of tool wear, the components of the damage are determined and subsequently the mechanisms responsible for the damage. Appropriate tribological research apparatus and equipment are worth mentioning tribological analytical balances with a measurement accuracy, (mass loss) of 0.0001 grams, and devices for measuring surface roughness. [1]

Adhesive wear occurs in places in contact with each other. Surfaces moving relative to one another, with or without lubrication. It occurs when the slides that slips due to contact slip, resulting in the separation of the uneven surfaces on the contact surfaces and their adhesion to other surfaces.



Picture 1. Schematic illustration of adhesive wear [1]

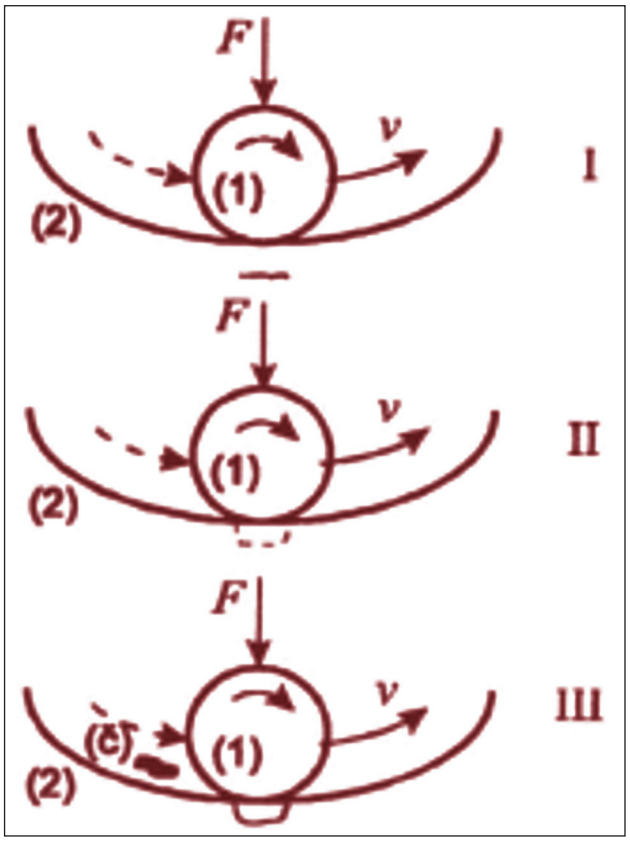
Abrasive wear occurs when uneven parts of a rough hard surface or hard particles slip on a softer surface and damage the surface by plastic deformation or fracture. The adhesion and abrasion wear mechanisms are generally effective during direct physical contact between the two surfaces. Due to the movement of one surface towards the other, the hard surface makes grooves on the softer surface. This causes damage in the form of a crater, and the separation of particles that are plastically deformed at the surface contacts. Of great importance in this type of wear are the maximum heights of uneven surfaces (the degree of quality of the treated surface). If the surfaces are roughly machined, a greater degree of abrasive damage will occur and vice versa. If a lubricant is used, this is negligible.



Picture 2. Schematic representation of abrasive wears [1]

Surface fatigue is the separation of particles from the surface due to oscillating changes in stress - repeated rolling or repeated sliding. A single three-phase surface fatigue event is shown in Picture 3. Phase I - microcrack formation, mainly below the surface, Phase II - microcrack progression, Phase III - wear particles, usually in the form of a tile or chipboard. [1]

As a result of body-to-body movement, a flaw occurs that does not immediately erupt to the surface but propagates in the inner layers. With further movement of the body, the cracks progress to the surface layers, resulting in material separation and damage.



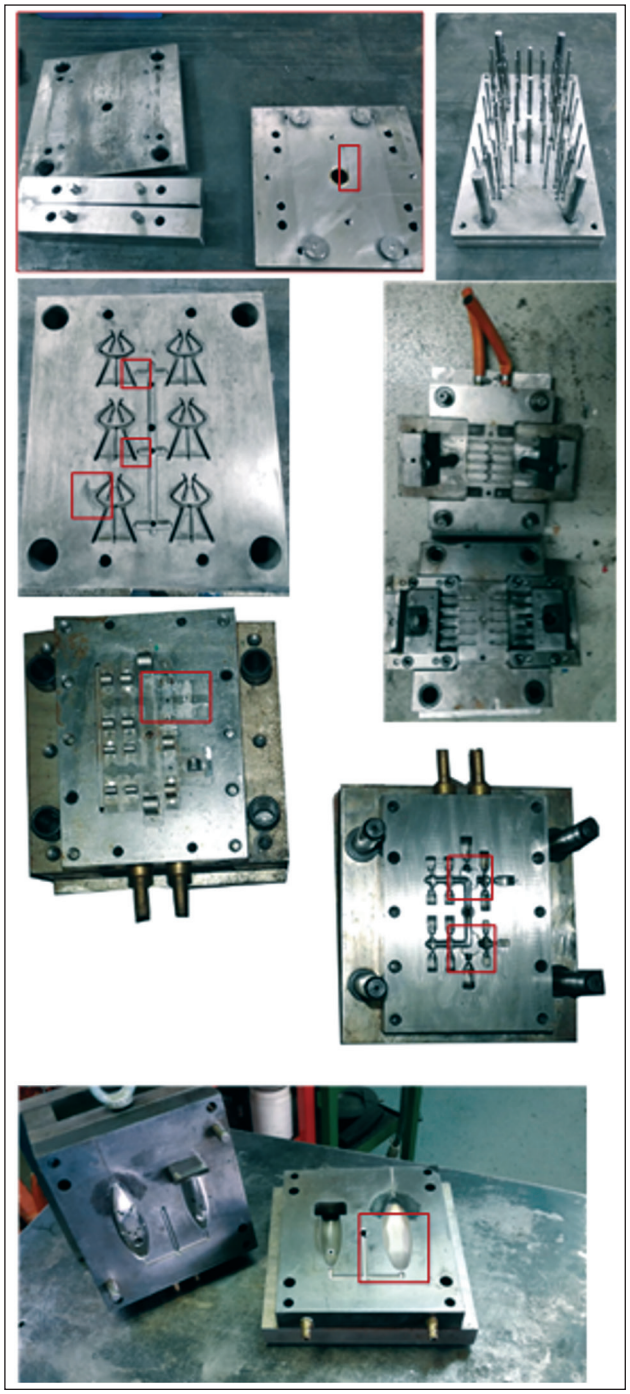
Picture 3. Schematic representation of fatigue wears [1]

2.4 Wearing of plastic injection molding tools

During operation of the plastic injection tool, damage to the parts in contact with each other occurs. Primarily guides that are used to center and properly position the tool parts. It is often the case that the tools are large in size, and therefore the massive and centering parts are loaded with high intensity forces. In these parts, wear and tear occurs first. The geometries are simple, they are not repaired but re-made on machine tools, after which they are heat treated. To avoid production downtime, toolboxes have a stock of tool guides.

Injection molds are generally coated with agents to extend their life. The aforementioned agents prevent adhesion of the melt to the tool walls, as well as easier separation of the part from the walls of the mold cavity. Wearing occurs on contact surfaces and the site of first impact of the molten mass. With the highest impact pressure and elevated temperature, the lubricant and the surface layers of the tool are removed. Due to the large number of duty cycles and the removal of the upper layers of the mold cavity, there will

be a deviation of dimensions on the object being injected. Increasing the dimensions of objects is the first indicator of tool wear, and activities are being undertaken to assess the degree of wear and proper repair measures of tools. If the tool cannot be repaired, it must be replaced with a new tool, which sometimes entails high costs. Costs are reflected in the cost of tooling, transportation and system failure time.



Picture 4. Reparation tools [2]

3. Experimental work

The problem of research is the influence of laser welding parameters of tool steels on the characteristics of the welded layer. It is necessary to determine the change in the geometry of the welded layers and mechanical properties when performing the machining process. The primary goal is to define the values of the input parameters so that the subsequent processing of the tool is minimal or completely necessary. In order to conduct research, it is necessary to perform an experiment according to a fully orthogonal experimental design with three parameters in three levels. Input parameters are defined based on a set of output quantities:

- Geometry of the welded layer:
- Height of the welded layer
- Width;
- Fusion depth
- The surface of the welded area

Plastic injection molding tools are required to increase the microhardness of the surface layers for better wear resistance and product surface quality. In addition, one of the goals is to repair the tool in the shortest possible time with the best possible weld quality. Experimental studies were performed on an ND: Yag ruby laser of type "ML-200W" with a maximum laser power of P_L = 200 [W]. The manufacturer of the laser device is Shen Zhen Herrolaser Co. The machine configuration is given in Table 1.

Table 1. ML-200W laser system specifications [3]

Laser type	Nd: YAG laser
Laser power	200 [*W*]
Impact energy	75 [*J*] / 150 [*J*]
Wavelength	1064 [*nm*]
Dimensions	1000 x 600 x 1500 [*mm*]
Monitor	Semiconductor CCD Camera
Laser beam diameter	0,2 – 1,5 [*mm*]
Laser Frequency	0 – 50 [*Hz*]
Pulse	0,3-20 [*ms*]
Weight of the appliance	200 [*kg*]
Laser distance from weld location	110 [*mm*]

Picture 5. Configuration of the ML-200W laser machine

The base material is high alloy tool steel X38 CrMoV5-1 (č.4571) with the chemical composition shown in Table 4. The tensile strength of the material is 775-850 [MPa] while the hardness has a value of about 240 HV. Tools made from the above material are often used in conditions where the temperature reaches 200 °C and above. They are creep resistant and retard their mechanical properties under these conditions. The additional material is a wire of 0.4 [mm] diameter with a length of 300 [mm] with the characteristics listed in Table 2. At the same time, the additional material is recommended by the welding material manufacturer.

Chemical composition:

Table 2. Chemical composition of additional material

C	Si	Mn	Cr	Mo	Fe
0,1	0,4	0,6	6,5	3,3	--

Table 3. Chemical composition of base material

C	Si	Mn	Cr	Mo	V	Fe
0,38	1	0,4	5,3	1,2	0,4	--

Experimental pilot studies were performed to analyze and identify the parameters of the processing process. It has been found that the output values of the laser welding process are influenced by: current, frequency and time of laser beam. One of the pre-set goals is to achieve correct welding by experimental testing, continuous without interruption, and preferably without scattering material from the required weld site. When choosing the values of process parameters, the manufacturer's recommendations, technical and technological limitations of the machine, characteristics of basic and additional material were taken into account. Assuming that the mathematical dependencies of the process factors are complex and nonlinear, three levels of variation were chosen for each input size.

Table 4. Input process sizes and levels of variation

Process factors	Unit of measure	Level		
		1	2	3
Current	[*A*]	165	180	195
Frequency	[*Hz*]	6	8	10
Runtime	[*ms*]	8	10	12

The parameters of the laser welding process whose values did not change during the experimental studies are shown in Table 5.

Table 5. Constant work input factors

Processing subject	Material	X38CrMoV5-1 (č.4751)
	Material thickness	100 x 100 x 6 [*mm*]
Additional material	Wire diameter	0,4 [*mm*]
Laser	Laser type	Nd:YAG
	Wavelength	1064
	Processing Conditions	Pulse mode
	Auxiliary Gas	Argon
	Distance of laser head from work piece	110 [*mm*]

The laser welding experiment was planned and realized using the experimental design theory. In order to minimize the number of experimental trials without losing data quality, the Taguchi experiment planning method was used. An experimental matrix with 27 parameter variations was constructed based on the identified input quantities and corresponding levels of variation. This covered the entire experimental space.

Table 6. Experiment plan matrix

Number	Current [A]	Frequency [Hz]	Runtime [ms]
1	165	6	8
2	165	6	10
3	165	6	12
4	165	8	8
5	165	8	10
6	165	8	12
7	165	10	8
8	165	10	10
9	165	10	12
10	180	6	8
11	180	6	10
12	180	6	12
13	180	8	8
14	180	8	10
15	180	8	12
16	180	10	8
17	180	10	10
18	180	10	12
19	190	6	8
20	190	6	10
21	190	6	12
22	190	8	8
23	190	8	10
24	190	8	12
25	190	10	8
26	190	10	10
27	190	10	12

3.1 Impact of process input parameters

The identification and selection of input sizes was performed based on the type of process, experiment and modeling objective and on the configuration of the laser device. Since laser welding is one of the thermal treatments of the material, the amount of heat input is the most important factor in the process. 200 - 400 [W] lasers are used for welding. Increasing the power of the laser instead of welding would result in complete combustion of the material at the laser beam. This would result in engraving or, in a more difficult form, cutting the material. In laser processing, power per unit area defines the thermal input during a time interval. All machining processes are of thermal character, including cutting. This implies a sufficient amount of heat necessary to heat the material to the melting temperature, and then by further intake of heat it reaches the evaporation temperature. On the other hand, if the power of the laser system were reduced, the surface layers of the additional material would be melted, but not mixed with the base material. The combination of frequency and thermal input is the second most important factor when welding tool steels. In this short interval of laser beam action, the base material with the auxiliary material melts and mixes with each other. Thereafter, the cooling and re-action of the laser beam shifted by the distance traveled in the direction of the air action. Sudden cooling causes a phase transformation of the structure in the heat-affected zone and an increase in the hardness in those zones. The occurrence of impurities and inclusions inside the weld occurs mainly due to the oxidation of the weld or the burning of certain metal components. Negative occurrence can be avoided or reduced by the use of auxiliary gas during welding. Ancillary gas has two basic protection functions. The first, as already mentioned, to protect the precipitate from oxidation, that is, from impurities coming from the air. Another crucial feature is to protect the optics and nozzle of the laser plant from metal evaporation. The nozzles are designed in such a way that they emit a laser beam through the central part and, through the beam, discharge Argon or CO_2 depending on the system used.

4. Results and discussion

Statistical analysis is based on the analysis of larger groups of observed data, that is, complex orthogonal arrays. Such complex systems are called statistic assemblies, or in short, populations. The number of elements of a statistical set or population defines the size of that set. When solving specific tasks when there is a small amount of data available, it is very possible to obtain models that will not represent a system with sufficient reliability, so it is advisable to increase the number of data in order to increase the statistical reliability of the indicators. The statistical unit is the bearer of information on the qualitative and quantitative characteristics of the statistical set. Each statistical unit can be characterized by a statistical set, i.e. can manifest her own personality. On the other hand, each statisti-

cal unit must be precisely defined by the following components: substantive or essential, spatial or territorial, and temporal or chronological. [4]

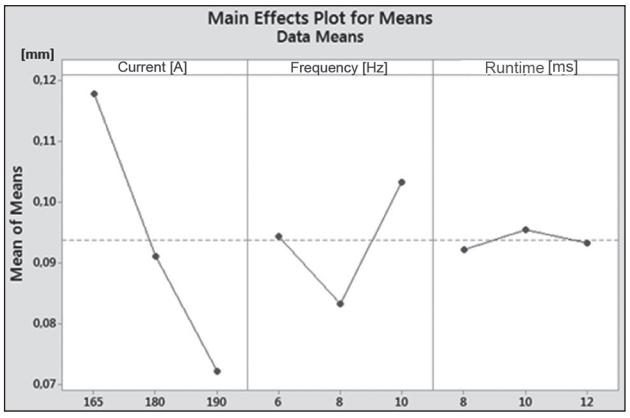
Influence of parameters on the height of the deposited layer

Table 7 shows the results of the measured values of the heights according to the experimental design. In order to determine the legality of the change in height, it is necessary to perform statistical data processing and to define a regression model.

Table 7. Influence of input sizes on weld height

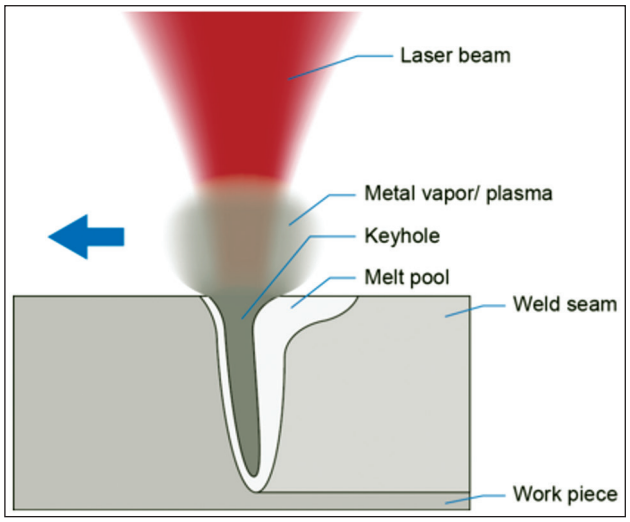
Current [A]	Frequency [Hz]	Runtime [ms]	Welded layer Height [mm]
165	6	8	0,10
165	6	10	0,10
165	6	12	0,11
165	8	8	0,10
165	8	10	0,12
165	8	12	0,13
165	10	8	0,12
165	10	10	0,15
165	10	12	0,13
180	6	8	0,10
180	6	10	0,09
180	6	12	0,09
180	8	8	0,08
180	8	10	0,10
180	8	12	0,08
180	10	8	0,09
180	10	10	0,09
180	10	12	0,10
190	6	8	0,10
195	6	10	0,08
190	6	12	0,08
190	8	8	0,04
190	8	10	0,08
190	8	12	0,02
190	10	8	0,10
190	10	10	0,05
190	10	12	0,10

A variance analysis was performed in the data processing software package to determine the influence of laser welding input sizes on the height of the welded layer. Picture 6 gives a graphical representation of the influence of the input quantities on the laser welding process.



Picture 6. Effect of input sizes on the height of the welded layer

The diagrams show how the variation of the input magnitude of the laser welding affects the height of the welded layer. The maximum values in the diagrams represent the desirable values of the input sizes to give the maximum welded layer value. When the value of current is at the lower level, the height of the welded layer is greatest. By increasing the value of the current, the height of the weld will decrease (Picture 6). In addition, the amount of heat that the laser beam exerts on the material will be greater by increasing the value of the current. The molten alloy in the mixing zone of the base and auxiliary material will remain in the liquid state for a long time. The action of the laser beam on the metal surface also causes the appearance of metal vapor pressure acting on the molten material. With Nd: YAG lasers, metal vapor is thought to be just a "hot gas", thermally excited, consisting of neutral atoms. The vapor temperature of laser welding of tool steel is between 1700 and 2700 ºC. [4] At processing speeds of less than 1 [m / min], the laser beam has more time to interact with the metal vapor cloud, and its attenuation is greater. In addition to absorption, the beam is also dispersed and defocused, that is, the power density at the workpiece surface is reduced. [4] The use of different shielding gases does not affect the temperature of the metal vapor, but does affect the amount and size of the metal vapor cloud. The size of the metal vapor cloud is very important as it determines the particle density inside it and so does the beam attenuation due to absorption and scattering. [4]



Picture 7. Influence of metal vapor on the weld

The formed droplet of metal tends to be in equilibrium, that is, to take a spherical shape. Due to the action of the laser beam, melting of the base and additional material occurs; the so-called melting zone of the material is formed. The zone formed in this way is, according to Picture 7, pressurized by metal vapor which reduces the height of the precipitates. By increasing the value of the current, the heat input is increased, the material remains in the molten state for a longer time and, consequently, the vapor pressure has more time to deform the weld.

The empirical form demonstrating the above has the form:

$$Q = E \cdot I\ [W] \quad \text{..... (1)}$$

In order for the material to melt and to form deposits, the exact value of the heat brought into the joint is determined by the relation:

$$H = \frac{Q}{v} = \frac{f_1 \cdot f_2 \cdot E \cdot I}{v} \quad \text{..... (2)}$$

Where is:

E - Voltage of electricity;

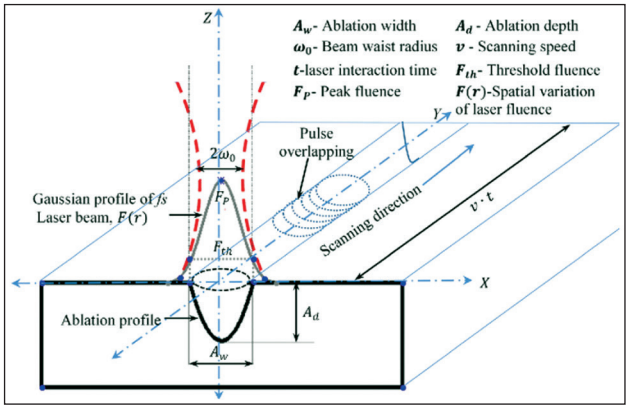
I - Current;

Q - The amount of heat required to melt a material;

f_1, f_2 - Thermal energy transfer efficiency factors;

v - Welding speed.

The current is directly proportional to the heat input. In this way, increasing the current increases the heat input and vice versa. Considering the influence of frequency on the height of the welded layer, the situation is more complicated. With the increase of the frequency value from the lowest to the middle value, the height of the precipitated layer decreases. Then, from increasing the frequency to its maximum value, there is an increase in the height of the welded layer. The impulse nature of the frequency causes the previous and subsequent laser beam to partially fold in the direction of the laser head. The overlapping effect of the laser beam is also shown in the following Picture 8 in the corresponding direction of the laser head.



Picture 8. Effect of laser beam on the object being processed [5]

The impulse action causes the material to cool, after receiving instant melting, and receive its final properties. Regardless of the variation in the action time, the height of the welded layer remains almost identical. For this reason, his devilishness to the height of the overlay may be neglected.

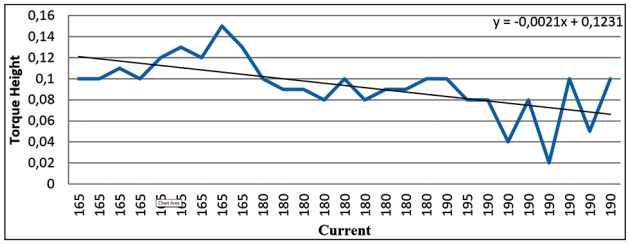
Table 8 shows the statistical data processing according to which the influence of laser welding inputs on the welded layer height was analyzed. The DF (degrees of freedom) designation is a degree of freedom that shows how many squares are based on independent notifications. The degree of freedom for all input laser welding sizes is DF = 2, while for the interactions between input sizes, DF = 4. Distortion factor P (significance threshold) is an indicator by which the influence of the input magnitude on the response of the system is distinguished. If the value of the parameter P <0.05 then the input value is significant to the response. If P>

Table 8. Analysis of variance of mean values on the height of the welded layer

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Current (A)	2	0,00943	0,00943	0,004715	13,99	**0,002**
Frequency (B)	2	0,001807	0,001807	0,000904	2,68	0,128
Action time (C)	2	0,000052	0,000052	0,000026	0,08	0,927
A*B	4	0,002593	0,002593	0,000648	1,92	0,20
A*C	4	0,000815	0,000815	0,000204	0,60	0,671
B*C	4	0,001637	0,001637	0,000409	1,21	0,376
Residual Error	8	0,002696	0,002696	0,000337		
Total	26	0,01903				

0.05 then the input size is declared as random, i.e. its effect is not significant for the system response. Significance factor for the current intensity is P = 0.02, on the basis of which it is concluded that this is an input size that is important for changing the height of the surges, while the influence of other input quantities is of a random nature.

The adequacy of the linear regression model is tested using the Fisher test based on the degree of freedom $v_{rez} = 2$, $v_{uk} = 8$, and the significance threshold α = 0.05. The Table value of Fisher's criterion for the given case is $F_{(0,05;2;8)} = 4,458$. Since the Table value of the Fisher test is less than the value obtained for the influence of the current strength on the height of the welded layer F = 13.99, it is concluded that the linear model will be adequate.



Picture 9. Linear dependence of the height of the welded layer in relation to the current strength

$$H = -0,0021 \cdot I + 0,1231 \quad \text{..... (3)}$$

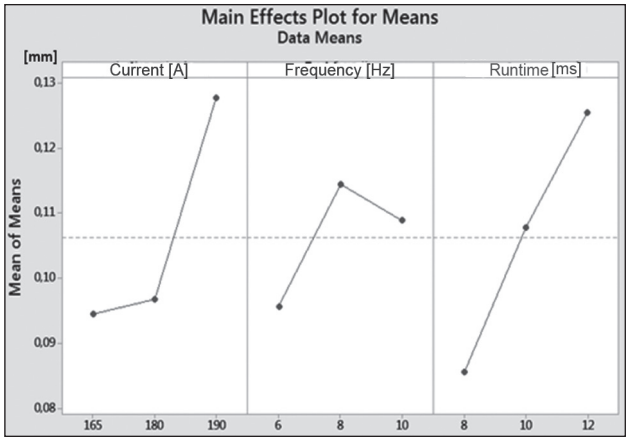
Influence of Laser Welding Parameters on Welding Depth

Measured values of the depth of slopes depending on the variation of the input sizes of the welding process are given in Table 9.

Table 9. Influence of the input sizes of the welding process on the depth of the weld

Current [A]	Frequency [Hz]	Runtime [ms]	Welded layer Depth [mm]
165	6	8	0,07
165	6	10	0,09
165	6	12	0,11
165	8	8	0,08
165	8	10	0,09
165	8	12	0,10
165	10	8	0,09
165	10	10	0,11
165	10	12	0,11
180	6	8	0,01
180	6	10	0,11
180	6	12	0,11
180	8	8	0,09
180	8	10	0,11
180	8	12	0,13
180	10	8	0,09
180	10	10	0,12
180	10	12	0,10
190	6	8	0,10
195	6	10	0,11
190	6	12	0,15
190	8	8	0,18
190	8	10	0,09
190	8	12	0,16
190	10	8	0,06
190	10	10	0,14
190	10	12	0,16

Picture 10 shows how the input sizes work on the depth of the welded layer. Therefore, by increasing the value of the current and the laser beam, the depth of the welded layer increases. The amount of heat exerted by the laser beam on the weld site increases in proportion to the current strength (Form 1) and, in interaction with the longer operating time at one site, increases the depth of the weld.



Picture 10. Influence of parameters on depth of crack

Table 10. Analysis of variance of mean values on the depth of the deposited layer

Source	DF	Seq SS	F	P
Current (A)	2	0,005267	4,07	0,06
Frequency (B)	2	0,000556	0,43	0,665
Action time (C)	2	0,004689	3,62	0,076
A*B	4	0,001044	0,4	0,801
A*C	4	0,001578	0,61	0,667
B*C	4	0,003156	1,22	0,375
Residual Error	8	0,005178		
Total	26	0,021467		

On the basis of the significance factor, no input size can be declared significant for changing the depth of welded layer. Therefore, all three input quantities represent random values and are not sui Table for the mathematical model. In case it is necessary to define input sizes that would have a significant impact on the depth of the welded layer, it is possible to:

– Increase the rank of already existing input sizes and perform experimental tests according to the experimental plan defined in this way;
– Perform new experimental tests with new values in a set of input quantities to determine process parameters using correlation analysis.

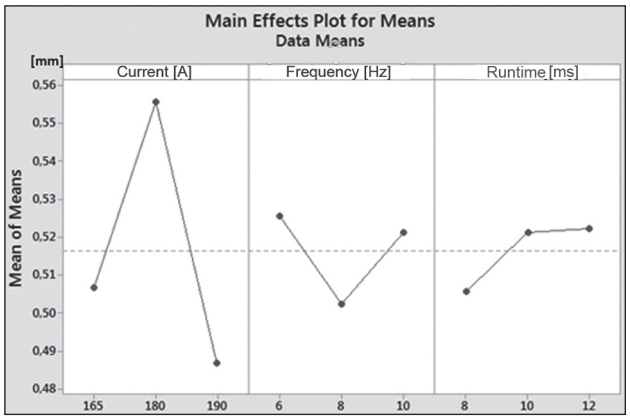
Influence of laser welding parameters on the width of the welded layer

In order to describe the mathematical dependence of the change in the width of the weld with respect to the input sizes of the laser welding process, Table 11 shows the measured values of the weld layer widths. On the basis of these data, an analysis of variance was performed to determine the influences of the input sizes of the width of the welded layer and to perform statistical data processing.

Table 11. Effect of laser welding process input sizes on the welded layer width

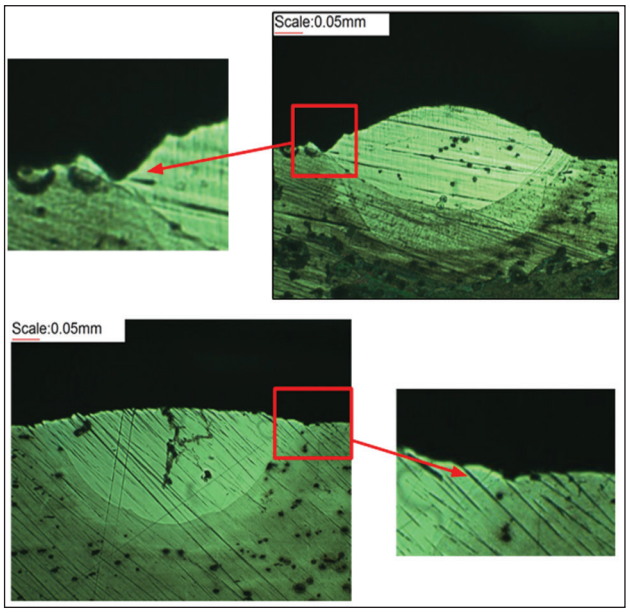
Current [A]	Frequency [Hz]	Runtime [ms]	Welded layer width [mm]
165	6	8	0,46
165	6	10	0,50
165	6	12	0,52
165	8	8	0,49
165	8	10	0,50
165	8	12	0,51
165	10	8	0,50
165	10	10	0,53
165	10	12	0,55
180	6	8	0,56
180	6	10	0,55
180	6	12	0,56
180	8	8	0,54
180	8	10	0,56
180	8	12	0,57
180	10	8	0,54
180	10	10	0,56
180	10	12	0,56
190	6	8	0,55
195	6	10	0,57
190	6	12	0,46
190	8	8	0,44
190	8	10	0,47
190	8	12	0,44
190	10	8	0,47
190	10	10	0,45
190	10	12	0,53

As the current increases from the smallest value to the mean value of 180 [A], the welded layer width increases. After increasing the current to 180 [A] to 190 [A], the width of the welded layer decreases to lower values. The increase in the width of the weld layer is due to the action of the metal vapor pressure, which by reducing the height of the weld increases the width of the weld. In this way, the height of the welds and the width of the welds are closely related quantities that can define the cross-sectional area of the welds.



Picture 11. Effect of input sizes on the width of the welded layer

Picture 12 shows that by increasing the current strength above the mean, the width of the welded layer decreases. The molten metal, pressed with metal vapor, is pushed towards the ends of the welds and in thin layers covers the area above the base material. This makes it difficult and almost impossible to measure their values. The spillage of the weld layer over the surface of the base material is shown in the Pictures shown and occurs under conditions where the input sizes are at the highest levels.

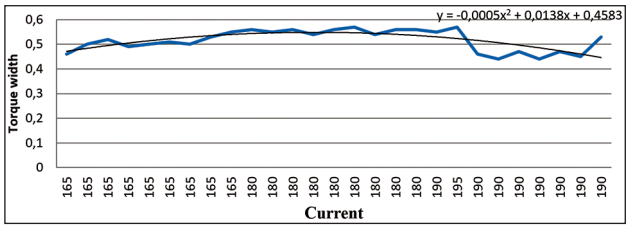


Picture 12. Spillage of thin layers over base material

Statistical processing of the data presented in the Table 12 shows that the current intensity significantly affects the width of the welded layer. Since indicators of influence of frequency and time of action are greater than the significance threshold P = 0.05, it is concluded that they have no significant influence on the width of the welded layer. The regression model is formed on the basis of current strength. The simple linear regression model is not adequate due to the nature of changes in the width of the welded layer. It therefore resorts to nonlinear regression and the use of a second-order equation.

Table 12. Analysis of the variance of the mean values for the width of the welded layer

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Current (A)	2	0,022607	0,022607	0,011304	11,48	**0,004**
Frequency (B)	2	0,002763	0,002763	0,001381	1,40	0,30
Action time (C)	2	0,001563	0,001563	0,000781	0,79	0,485
A*B	4	0,007993	0,007993	0,001998	2,03	0,183
A*C	4	0,002326	0,002326	0,000581	0,59	0,679
B*C	4	0,003304	0,003304	0,000826	0,84	0,537
Residual Error	8	0,007874	0,007874	0,000984		
Total	26	0,04843				



Picture 13. Dependence of the width of the welded layer in relation to the current strength

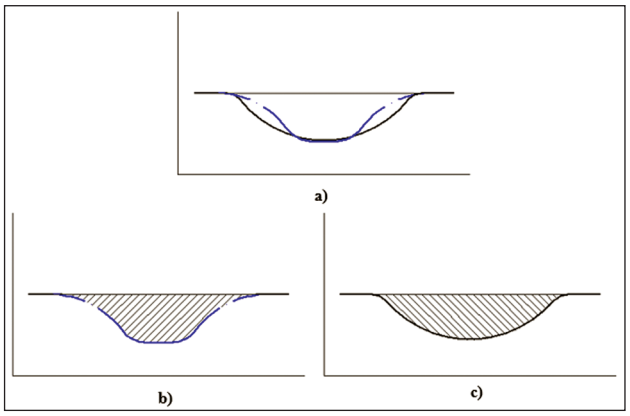
Based on Picture 13 and the statistical data processing, a second-order nonlinear pattern was formed that describes the change in the width of the welded layer with respect to the current.

$$L = -0{,}0005 \cdot I^2 + 0{,}0138 \cdot I + 0{,}4583 \quad \text{..... (4)}$$

The adequacy of the nonlinear regression model is tested using the Fisher test based on the degree of $v_{rez} = 2$, $v_{uk} = 8$, and the significance threshold $\alpha = 0.05$. The Table value of Fisher's criterion for the given case is $F_{(0,05;2;8)} = 4{,}458$. Since the Table value of the Fischer test is less than the value obtained for the influence of the current strength on the height of the welded layer F = 13.99, it is concluded that the nonlinear model will adequately describe the dependence of the width of the welded layer on the current strength.

Influence of laser welding parameters on the surface of the welded area

The analysis of the obtained results of the survey, which was carried out, revealed that none of the specified input values influence the change in the depth of the deposits. Even more, the depth of the weld does not change significantly. However, it is clear that the surface of the welded area changes depending on the change in input sizes. Although the depth of fit is approximately the same for each test, the surface changes its shape. It increases and decreases depending on the input size level. Picture 14 shows two surface shapes obtained after the welding process.



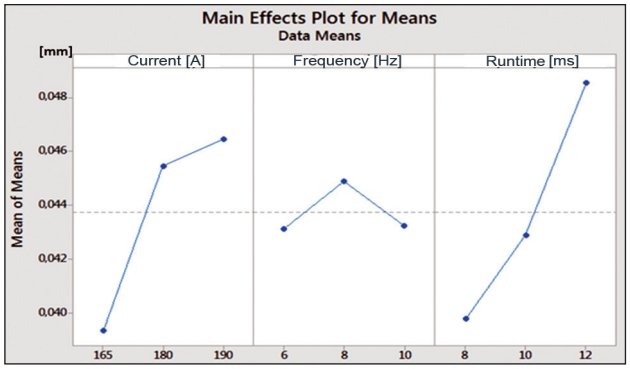
Picture 14. Characteristic shapes of welded area
a) folding of two holes;
b) narrowed type of welded area;
c) concave type of welded area

Table 13. Influence of laser welding inputs on the surface of the welds

Number	Current [A]	Frequency [Hz]	Runtime [ms]	Surface area [mm²]
1	165	6	8	0,027
2	165	6	10	0,039
3	165	6	12	0,043
4	165	8	8	0,033
5	165	8	10	0,038
6	165	8	12	0,040
7	165	10	8	0,042
8	165	10	10	0,041
9	165	10	12	0,051
10	180	6	8	0,037
11	180	6	10	0,043
12	180	6	12	0,046
13	180	8	8	0,040
14	180	8	10	0,046
15	180	8	12	0,054
16	180	10	8	0,041
17	180	10	10	0,053
18	180	10	12	0,049
19	190	6	8	0,046
20	195	6	10	0,053
21	190	6	12	0,054
22	190	8	8	0,073
23	190	8	10	0,027
24	190	8	12	0,053
25	190	10	8	0,019
26	190	10	10	0,046
27	190	10	12	0,047

Image J software was used for the purposes of the work so that the surfaces could be scaled and measured. The measured values of the crack surface are shown in Table 13.

A variance analysis was performed in the statistical data processing software package. That is, an analysis of the effect of the laser welding inputs on the surface of the weld was performed.



Picture 15. Influence of individual parameters on the surface of a crack

Increasing the value of the current increases the cross-sectional area of the bumps. It is because inside the material the heat input according to the forms (1) and (2) increases. The processing temperature reached is over 1700 °C which is much higher than the temperature required to reach the metal grain transformation. The material melts, cools, and at the same time changes its structural properties. The effect of metallic vapor has no significant effect since the change occurs inside the material and below the zone of height; however, the time of action of the laser beam is a significant factor. With the increase of the laser beam, the cross-sectional area of the welds increases. Considering a certain amount of heat for a longer period of time it is necessary to expect a larger surface that has transformed.

Table 14. Fisher test and parameter significance threshold coefficient

Source	DF	F	P
Current (A)	2	11,48	**0,0453**
Frequency (B)	2	1,4	0,971
Action time (C)	2	11,04	**0,0247**
A*B	4	2,03	0,449
A*C	4	0,59	0,977
B*C	4	0,84	0,516
Residual Error	8		
Total	26		

The current and operating time have significant effects on the surface of the welded area. Both factors have values of significance threshold less than 0.05 and values of Fisher coefficient greater than the spreadsheet. Increasing the current strength and increasing the laser beam's time at the metal surface implies a greater amount of heat that affects the metal's transformation. Consequently, the mechanical properties of the welds, as well as the repaired portion of the plastic quick-release tool, change.

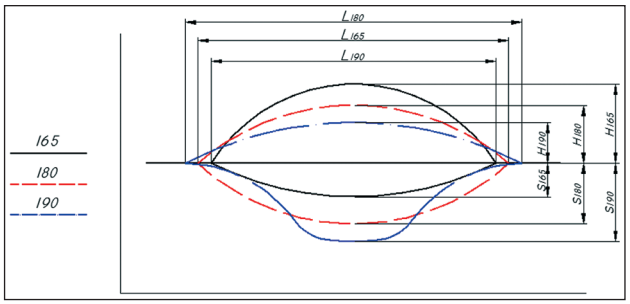
Diagrammatic representation of the influence of parameters on the geometry of the welded layer

Diagrams of the influence of the input parameters on the geometry of the welded layer are constructed in order to show more closely the changes in the geometry of the welded layers. Different levels of input sizes have resulted in a change in the geometry of the welds to some extent.

The influence of current strength on the change in the geometry of the welded layer

Picture 16 shows the change in the geometry of the current under the influence of the current. By increasing the current from the minimum to the maximum value, the following occurs:

- Height of the welded layer decreases;
- Width of the welded layer increases;
- Depth and surface of the boils increase.



Picture 16. Effect of current strength on geometry of the welded layer

Increasing the current brings more heat into the material, which causes it to remain in the molten state for a longer time. Due to the melt and the pressure of the metal vapor on the weld, the height decreases and the width increases due to the spill

of the melt over the weld surface. The occurrence of a spill occurs until the moment the molten mass solidifies. When the current reaches its maximum value, the laser's concentrated energy flow (KTE) is amplified. A side effect is the reduction in the diameter of the laser beam and, consequently, the narrowing of the surface. Picture 17 clearly shows that under these conditions the depth of the welded layer is greatest; however, the surface of the welded layer is narrowing. The laser beam tends to take the form of Gaussian normal power distribution with a single central mode. The distribution of energy flow can be displayed:

$$q_2 = q_{2max}^{-kr^2} \left[W/_{mm^2} \right] \quad (5)$$

When is

$$Z = \sqrt{x^2 + y^2} = 0; \; q_2(0) = q_{2max} \left[W/_{mm^2} \right]$$

where:

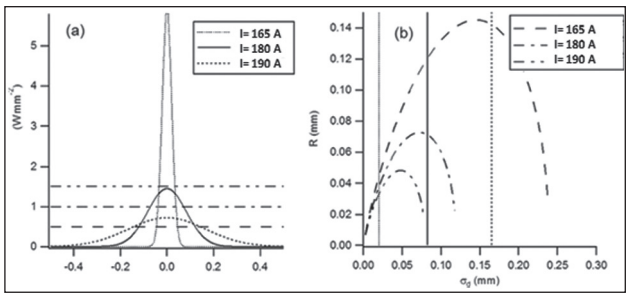
q_2 - Density of heat flow at any point of the heated surface. Index 2 indicates the two-dimensional flow distribution on the surface;

q_{2max} - Maximum heat flux density;

k - Coefficient of concentration of heat flow. The higher the k, the more concentrated the source, the higher the maximum heat flux density q_{2max} and the smaller the heating circuit.

$k = \frac{1}{2\omega^2}$; ω - laser beam diameter

The power of the laser beam over the current can be expressed by the expression $P = U \cdot I$ [W]. Consequently, by increasing the current strength, the value of the laser radiation power is also enhanced.

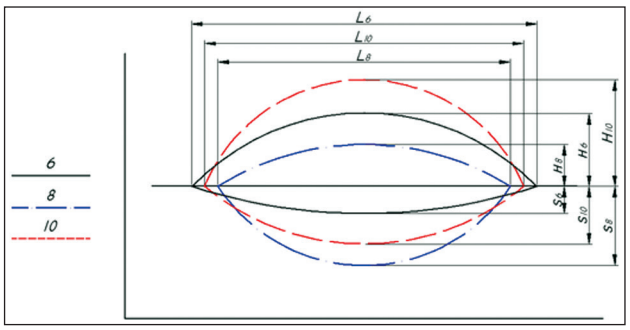


Picture 17. Change of KTE depending on current strength [5]

The laser radiation flux density is defined based on the power per unit area. The smaller the surface area, with the increase in current intensity, the higher the density of flow is. For this reason, in Picture 16, at I = 190 [A], the cross-sectional area narrows and takes on an oval shape. Certainly, Picture 17 shows the narrowing of the laser beam, which ultimately led to the narrowing of the surface of the beam.

The influence of frequency on the change of the geometry of the welded layer

The action of laser beams in a unit of time is the direct input of thermal energy of a given intensity into the site of action. Because energy is typed at a certain time interval, the thermal input inside the material is defined. Due to this, the basic and auxiliary materials are melted and mixed. But also, the phase transformation of the alloys on which the mechanical properties depend. In particular, three frequency levels are changed in the paper, which are differences of 2 [Hz]. There is no significant difference, but in practical terms they are mostly applied. Higher beats would mean the dissipation of molten material due to too much thermal input. The material would instantly heat up to such an extent that the pressure of the metal vapor and the new beats would spill it over. Consequently, no welding would occur because the welding height would in fact be zero.



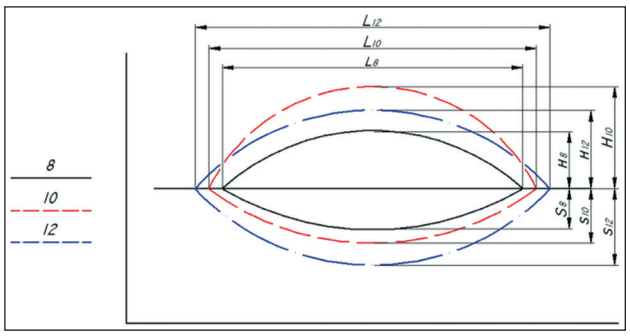
Picture 18. Effect of frequency on the geometry of the welded layer

The lowest value of the pitch is obtained by applying the middle frequency level. Due to the large number of beats per unit time, the material melts rapidly, repeatedly in the same place and is suppressed by the action of the metal vapor

pressure. Due to the repeated impact of the laser beam at the same location, the metal vapor pressure increases. Under these conditions, the width of the weld is minimal. In terms of height, it is the highest at maximum frequency. The assumption is that the vapor pressure of the metal vapor is not as great as in the previous case and the melt tends to be spherical, that is, in the form in which the metal reaches equilibrium. In addition, by using the minimum frequency value, the maximum width of the weld layer, the minimum depth of slopes and the height of the slopes between the minimum and maximum values are achieved. According to Picture 18, if a narrow crater with minimal damage is to be repaired a laser beam with a mean frequency level of 8 [Hz] will be implemented. Reparation of the widest and deepest crater will be performed using minimal fc frequency, while for the most adverse damages the highest frequency level of 10 [Hz] will be required.

The influence of time of action on the change of the geometry of the welded layer

According to the statistics on the influence of input quantities on the process, the action time is the second most important influence on the geometry of the welded layer. Effect time is the time at which the laser beam acts on the material and absorbs thermal energy inside it. As in the previous case, three levels of action time were adopted based on experiential indicators.



Picture 19. Effect of time of action on the geometry of the torque

If the laser beam operating time was too short, there would be no melting and mixing of the base and auxiliary materials, while increasing the effect, certain layers would begin to melt and dissipate around. Instead of welding, engraving or even cutting would occur due to too much energy input. The strength of the current has the greatest influence on the height of the welded layer, so the action time has the most influence on the depth of the welded layer. Increasing the value of the action time happens:

- Increasing Depth of Wear;
- Increasing the width of the welded layer;
- Increase in cross-sectional area of bumps;
- Increasing the zone of influence of heat.

Therefore, the action time is of the greatest importance when it comes to the mechanical properties, especially the microhardness and bands of the material transformation zones. The most significant is certainly the zone of influence of heat, whose value is increased by the increase of the laser beam's time of action on the material. The additional material cannot completely alloy the base material however the energy implemented by the laser is expended in increasing the temperature of the base material above 782 °C. High cooling rates and a wide heat dissipation zone are manifested by the transformation of the material and the crystal lattice, which results in a change in microhardness.

5. Conclusion

Due to the specificity of the process, laser welding is part of unconventional machining processes and is integrated in production conditions that require the repair of tool steels due to wear. Its main advantage is the narrow zone of influence of heat and high-quality welds due to the use of shielding gases. The paper covered several factors that are crucial for repairing tool steels. Testing and statistical processing of the results showed that the geometry of the welded layer is most influenced by the current, then the thermal input and the frequency. Data processing is divided into three parts, namely testing the effect of parameters on:

- The height of the weld layer;
- Width of welded layer;
- Depth of the welded layer.

For all three cases, maximum geometries were determined to be cases due to load-bearing capacity, manufacturing competitiveness, manufacturing

time, and quality of welds. The height of the surge decreases with the increase of the current. The reason is a linear increase in heat with an increase in current. This effect results in a longer unit of time for the material unit to cool down after the effect of the air beam. This is precisely why the molten material is left. That is, the height of the welded layer is less with the increase of the current.

As expected, by increasing the current and thermal input, the depth of the torque increases its value. Again, the reason is the amount of heat that is introduced into the material, alloys the base and additional material, and expands the zone of influence of the material. Frequency depends on the impact time of the laser beam and this is its only influence on the effect on the output parameters.

The effect of the parameters on the width of the welded layer is more complicated because the width increases with the increase of current to a value of 180 [A], and then decreases with the increase of the current strength up to 190 [A]. Again, the reason is the temperature and the influence of temperature on the thin layers of the material. This results in the material draining and its dispersion and combustion in thin layers. Statistical data processing shows that the current and thermal input are parameters that have a significant influence on the geometry of the welds and consequently patterns have been formed which can approximately determine the values of the height of the welds according to the current:

$$y = ax + b = -0.0021x + 0.1231$$

$$y = -0.0005x2 + 0.0138x + 0.4583$$

Where x is the current in [A] and y is the width [mm].

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