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Role of education in developed society

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Abstract

The conducted research represents the impact of the education on developed society. Due to adequate level of knowledge individual is able to follow and manage broad roles of society development. Nowadays technology is taking place in every sphere of man development, hence the education has important influence on technology development. Technology plays important role in education sector. It is helping the students to obtain the knowledge in better and easier way. The students in the class can do much more in their courses due to developed technology. At the same time technology in education leads the students educated and ready for developed society. Individuals those who poses a good knowledge contribute to the development of the society. From that way, we can say that investment in the education will positively impact on the individuals and society. Individuals are ranked differently according to the knowledge and education they possess. Developed society valued education and the educated individuals are highly paid. In this way education will have positive impact and contribute more to educated society in the term of its development.

Key words: education, developed society, knowledge, technology.

1. Introduction

Developed society focuses on the knowledge, and therefore knowledge and competences are basic assumptions of its development. Developed countries empower individuals to become actively involved in society and participate in different social roles. This implies continuous learning and improvement (adoption and ability) applying new knowledge, values and acquiring skills different skills. Individuals those are tightly integrated into society, they are equipped with new knowledge and skills to represent a valuable human resource. They contribute to the development of society improving material position and quality of life.

It is therefore essential that knowledge and education should be recognized in all societies as important levers of development. Government should play important role in supporting the education. It should provide funds, to establish close links between educational institutions, in particular, higher education with the labor market, and the cooperation of various social actors (educational institutions, businesses, social partners, etc. Human development resources should be pursued in the direction of identifying capabilities, capabilities interest and needs of individuals, and to get through the educational process they direct and train them for different social roles. Knowledge (science, education, creation) has always been a powerful driver of social development. However, knowledge has become a widespread that is needed in modern society. It has economic, political and cultural significance that facilitates employment, social cohesion, economic wealth creation and development of diverse needs. Individuals and social groups are "positioning" in a society with the knowledge at their disposal. It advances all areas of man life and work. Investment in science, research and education in developed countries is not treated by consumption but by investment. We could see the effects of the current global economic crisis have been felt much less by countries investing in science and research and making educational changes in line with technological change. The widespread benefits to society are borne out by the research findings of highly educated people in all scientific fields. All of these societal benefits are the reason for funding education from public funds. In most developed countries, knowledge-based industries (high technology, education and training, research and development, financial and investment sectors) had a large share in the achievement of business results. New technologies are pushing the boundaries in education (electronic communication, the exchange of various learning activities, etc.), leading to changes in jobs

and types of jobs. Technology nowadays is existing in all levels of education, which makes it possible for greater availability of knowledge and learning for all. This should further result in the reduction of class differences and divisions in society. However, not everyone has equal access to new technologies, so information poverty is a serious problem and an obstacle to reducing class differences. In developed countries, the functional literacy rate is high (with differences in gender, age, social background), but this is not the case in underdeveloped countries. The aim of education in developed society is, above all, to acquire knowledge and skills that are in line with the needs of business and to encourage the development of people's creative abilities. However, the humanistic goals of education, in terms of the attainment of virtue, the realization of moral and cultural values, as pointed out to us by Plato and Aristotle, and by what means many contemporary theorists agree.

2. Education as basic of developed society

In every society, institutions are tailored to their needs, so individuals through educational institutions and their activities are prepare and trained to contribute to the development of society. Since the beginning of the 19th century, the processes of industrialization have largely had their educational systems and urbanization, which required an educated and able worker strength (functional literacy, general knowledge, skills, etc.). Nowadays, synchronous technologies such as webcam, interactive video content and chat rooms provide an approximate learning experience, while at the same time allowing students to learn at their own pace [1]. The development of science and technology in modern society is changing significantly the concept and role of education. Modern education does not just mean functional literacy and encyclopedic knowledge, socialization, but also the development of creative potential individuals, their abilities and ambitions, gaining practical and applicable knowledge. Today is impossible to imagine life without knowledge. Knowledge can be defined as relationship between object and subject, in which subject is trying to connect itself with a being an object. [2]. We can say that knowledge is found in all segments of modern society, because work and business activities in this society require educated and complete persons. Thus, through the education process, individuals are trained to professional and other roles. Knowledge is treated as a basic resource of economic and every other development. It is inextricably linked to education. Like an immediate result of science and scientific research, knowledge drives and directs all social flows, raises the overall level of development of society, because it produces innovation and new information. It is constantly changing and progressing. Therefore, education cannot be limited to formal schooling, but has to take place throughout life. In order to follow the rapid changes in society, it is necessary to constantly acquire new knowledge and skills. As family life has an importance in modern society, developed or modern society invest a lot to educate its family members [3]. Knowledge is in contemporary include critical thinking, innovation, the ability to solve complex problems, the ability to cope with and respond to unforeseen situations, information use, analysis, synthesis, independent and team work, developing different skills and competences, which should be acquired through educational process.

The knowledge (totality of facts, information and skills acquired through education and experience) should be developed from self-involvement of the individual in the educational process to higher and lifelong education. So, in modern society the term education is being 'transformed' into a broad concept learning in and out of formal institutions. Lifelong learning should, and it must play a role in the transition to a knowledge society. Learning should not be education in the narrow sense of a well-trained, motivated workforce, but one system viewed in the context of broader human values. In the modern age "global knowledge" (a set of multitudes of individual knowledge) do not depend on the character of nation-states, welfare, cultural and local characteristics. Education makes it easier for people to cope, adapting, understanding, and participating in mundane social processes taking place globally, as well as a willingness to respond to different challenges (terrorism, crime, separatism, division, etc.) Science and new technologies have an impact on all spheres of modern society. Sociologists talk a lot about the way that new technology change and impact a society [4]. It pushes the classic

working class and many other outdated professions, experts, scientists, etc. In contemporary world the structure (in economic, scientific, technological and class) has undergone due to changes of the development of new technologies. The proportion of the intellectual is increasing work in developed economies, so the basic criterion for class division it is no longer productive labor (the direct consumption of physical labor). Electronic commerce, communication and computer literacy are greatly influenced by changes in work and it increases productivity and efficiency of society "The modern stage of economic developments characterized by the realization of the third scientific and technological revolution. The modern stage of economic development characterizes the accomplished third scientific and technological revolution. Increase in the development of informatics, robotics and biotechnology necessarily changes the way of production, labor and capital relations, and helping people adopt the new technologies. However, the new knowledge and economy require learning throughout life. Given the new economy, needs a computer education and the workforce is becoming increasingly aware that education can and must play a crucial role in meeting important needs of the society. Economic growth in the developed society is led by education process blended by the innovation and changes. In all strategies and plans for the development of modern society, education occupies a central place.

Investing in education or educated people as an important resource of society, is part of the politics of all developed countries. Regarding to the investment in education private returns are much higher than social return [5]. People with their intellectual and creative potentials represent strategic basis for the development of society, because they are the bearers of ideas, knowledge and information. All developed countries and those striving for it have recognized the importance of knowledge and its applications for developing and overcoming the crises.

Investing in science, research and education should be seen as an investment because it undoubtedly contributes to the development of society as a whole. In most developed countries, knowledge-based industries (high technology, education and training, research and development, financial and investment sectors) had a significant share in the business performance. Developed countries are investing heavily in the knowledge economy, that is, in the public education, in research, development and computer development software. Their example should be followed by less developed countries in order to achieve a satisfactory level of development. We can gain insight on the level and directions of development of a society based on how it relates to human resources and what conditions and opportunities are provided for their development. Top experts only with their knowledge contribute to an increase in the country's development rate and population standards. Therefore, their departure inevitably causes a slowdown or even a setback the economy of the home country, that is, the progress of the economy of the country to which they are gone. To resolve or mitigate this problem, it takes, in between among other things, a system of education that fosters favorable development opportunities of a human being throughout life, all for the purpose of personal participation in the intellectual, emotional, physical, moral, and spiritual actions in order to achieve highest quality of life. Such society makes use of acquired knowledge and skills after school. Working conditions and salaries of persons with special professional skills are stimulating, so that society strives to achieve optimal relationship between the population of the country and the employment rate. Yet, apart from these practical educational goals, we should not neglect its other dimensions, purposes and goals. The values of a society should be rooted in the entire education system. Promotion of these values in the society is achieved by their planned inclusion in national educational plans and programs.

3. Important issues in the financing education in modern society

The development of a welfare state that has taken on the financial burden of education, it has provided massed access to higher education from the middle the last century [6]. By its weakening and shifting the financial burden of education individuals, households, educational institutions and other organizations, it has stopped this process, Public funding for education in many countries is significantly reduced.

Investing in education results in realization of the quality of human capital, on which the success of using the available ones depends on a country's natural resources, technology and cash. Because its population is the largest wealth of developed countries today. Return on investment in education mostly depends how do we use our resources efficiently [7]. Reducing the allocation of public funds for higher education, it implies that universities themselves should take care of their sustainability, that is to provide for themselves sources of income, above all, by their place in the market, by increasing tuition fees for local students and attracting foreign students. Shifting the burden of educational funding to students and their families (especially, increasing tuition fees) is a social problem and can slow down development of the society (prevents continuation of schooling and consequently leads to the decrease in a quality of human resources). Universities have always been part of the worldwide knowledge network, participated in international interaction with the mobility of teachers, researchers and students. In the global society, there is increase in the demand for higher education and its professionals. However, the universities and educational institutions need to be prepared for new challenges. Society raises their level of economic development, by developing their higher education system that responds to social demand for higher education. Today, through the mobility of scientists, lecturers, students and self-service are realized by the internationalization of education, but at the same time, of the education market.

4. Education and society

Education is a key factor for effective citizenship [8]. Educational status is one of the significant causes that put individuals and social groups in a state of social exclusion. It significantly influences their social status, and therefore society as a whole education has a positive impact on society its social and cultural forces [9]. The educational structure and educational status of any social group, group or stratum significantly influences the ability to perform a variety of social roles, from economic to political and social. These personal, group also affect the possibility of social promotion, as well as lifestyles, social interactions and relationships, and involvement in various forms of social life in community rankings. Educational achievement is related to the social mobility of individuals. The research results show that as the level of education of an individual increase, the risk of poverty decreases. The number of people with low levels of education at risk of poverty in 2011 was the lowest in the Netherlands (12%) and the highest in Bulgaria (44%), while the least exposed was a person with secondary education in Malta (8%) and most in Lithuania (21%). In the case of highly educated persons, the least were at risk of poverty in Romania (2%) and most in Spain and Portugal (10% each). In terms of the at-risk-of-poverty exposure between those with the lowest levels of education and higher education, the differences are most noticeable in the following countries: Bulgaria (44% for the low-educated and 4% for the higher-educated), Romania (35% vs. 2%), Cyprus (29 % vs. 4%). These differences are least noticeable in the Netherlands (12% vs. 6%) and Denmark (17% vs. 9%). Although there is a tendency in modern society for young people to continue their education beyond the period of compulsory education, there are also a number of individuals who drop out of the educational process before or shortly after reaching the lowest level of education (compulsory education). This is a big problem because they can hardly find a job, which puts them at increased risk of poverty. The reasons for early exclusion from the educational process can be cited as: social origin, ethnicity, unjustified absence from school, delinquency, etc. All this entails exclusion from other segments of society: economy, organization, culture, etc. The social origin of children should not be an obstacle to the achievement of educational attainment, that is, the acquisition of qualifications recognized in the labor market. Still, early school leaving is more about social origin than about school success. However, in terms of literacy, the literacy rate of young women is increasing - they are increasingly able to acquire the skills they need to participate in daily life and find a job. In the total population, three-fifths of young women do not know how to read and write. The literacy rate of young women is still extremely low in underdeveloped countries - a result of continuing education. Youth literacy is increasing at a much faster rate in economi-

cally developed countries. The results of the study show that an increase in literacy rates is associated with a decrease in the number of people living in poverty, especially among young people. The development Education is variable that leads to the economic development of the society and it is one of the millennium development goals. Education is the core part how individuals, community and nations develop [10]. The per capita GDP growth is related to the rise in youth literacy rates as children in more developed societies have a greater opportunity to attend school.

5. Conclusion

The intensive development of knowledge and modern technologies gives dynamics to the development of society, introduces changes in all its spheres - education, interests, work, etc. Therefore, it is necessary for us to monitor their changes and improvement, and this requires that we constantly acquire new knowledge and skills, and that we know how to use them. New knowledge and technologies allow us to orient ourselves more easily in professional and daily life. Acquiring new knowledge, mastering skills - gaining the necessary qualifications can best be achieved through the educational process, but, now, transformed into a broader concept of learning that is not limited to institutional, physical and time frames. So, we are required to learn throughout our lives in and out of the physical classroom environment, and this is possible by modern information technologies (online learning: online courses, distance learning, self-study and research, electronic universities, etc.). By spreading knowledge and interest, the complete development of an individual (professional, social, psychological, etc.) can be achieved, which is imperative in modern society. Equipped with new and diverse knowledge and skills, people represent a significant resource and they are basis for the development of society.

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Damages and welding of the teeth on the toothed rack of Excavator Marion M201 used for coal exploitation

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Abstract

This article will present reparation of teeth on the toothed rack on main machine for coal mining in opet pit coal mine Banovići. Method for reparation of the rack welded to carrier will be presented, as well as the bucket of the escavator, also mounted to the lower end of the carrier. Escavator M201 is American made and it presents one of main machines used for coal mining in coal mine Banovići in Bosnia and Herzegovina. In this paper, structural analysis will be presented of this excavator and main elements of its structure. One of main elements is toothed rack and rod carrier on which it is welded (Boom). Boom, as said before has a bucket mounted on its lower end and during operation, the weight of the bucket causes damage to the teeth of the rack. Methods for reparation of those teeths will be shown in this paper. Considering that materials that rack is made of are very important and have high quality, then reparation method and welding technology is specific and very important.

Keywords: Material, rod carrier, boom, gear rack, teeth, technology, welding, excavator

Introduction

The choice of methods of coal exploitation, technical means and technologies of management of mining works depends on a number of factors: the angle of inclination, prospecting, the physical-mechanical characteristics of stripping, qualitative and quantitative indicators, market value of mineral resources, hydrogeology and climate of the region where the coal deposit is located, transport, communication, work and material resources, etc.

To achieve a valid production it is necessary to use a powerful and appropriate equipment. One of the most important coal mines in Bosnia and Herzegovina with the characteristics of powerful and appropriate machinery is brown coal mine in Banovići.

Machines that are used in this mine are mostly American made and the machine Marion M201 is one of those whose capacity of loading is 20 m3. In the process of its operation specific damage is made on its moving parts.

This paper will present the impact of the forces that occur in the work of the excavator on the main elements, as well as the implications that occur on these elements in the process of digging coal or removing the stripping ratio, especially in the rack and technological procedures will be presented for the reconstruction and reparation, in order for the machine to get back to good working condition since the bucket of this excavator is in a direct connection to Boom on its lower end. Toothed rack is welded to the Boom and it is restrained with two gears mounted to the main structure of excavator and through which it achieves the movement so that where damage to the teeth occurs it is necessary to perform certain repairs of the teeth. Method for reparation and welding technology will be displayed in this article.

1. Complex mining machinery equipment and structures of the complex machinery

Development of surface exploitation in a large degree is based on a type of machinery used for mining works. In fact, with the increase of mechanization in the mining process number of required employees is lower, work productivity is increased, the cost per unit of the product is reduced and the efficiency of surface exploitation is increased. The process of mechanization of mining works takes place according to the principle of simple to complex mechanization of individual operations to the mechanization of the total technological process.

Mechanization of mining process in open pit coal mine in different natural conditions is accomplished by different machines and devices, considering the fact that individual operations must be part of one unique technological system. Behind operation of one machine there is another one that must operate depending on first one, since they are connected in one technological process in order to have continuity of mining works. This organization of technological process corresponds to the principles of complex mechanization of production processes.

According to this, under the complex machinery mining works goes the high degree of mechanization in which heavy manual work is dispensed not only from basic but also from a secondary process. In modern mines usually one type of machinery is applied which significantly simplifies the Organization of mining works, exploitation, repair and handling of equipment. Regarding the works of stripping removing machines with larger capacity are usually used.

The structure of complex machinery in general case is made of machine or group of machines for performing construction works on: excavation, loading, transport of excavated material, deposition and storage. Depending on the type of material that is excavated and adopted technology of mining work, the structure of the complex machinery can contain all or some parts of the structure. The structure can be simple, single line, parallel and branched. To achieve the best technological and economic indicators of open pit coal mining, primarily high productivity, machinery must be complex and its structure is selected and positioned so that all the elements (machinery and equipment) and structures in the production processes meet the following requirements: only the machines with consistent capacity are included and those that are adapted to physical-mechanical characteristics of the material, they must match the mining-geological, hydrogeological and topographical conditions of prospecting and possess a certain flexibility of technological processes in the case of changes to these terms and conditions: the shape, size and capacity of the open pit coal mine, construction period, period of exploitation need to matched, as well as the capacity and equipment of the processors or consumers of useful materials. They should contain, as much as possible, a smaller number of individual machines and devices that are required to perform a specific scope of work, should contain same type or at least machines and devices from same series so their eventual replacement can be easier and faster.

Coefficients of power reserves and technical capacity of individual machines in comparison with average indicators of their work, in accordance with the character of the mining production, should be not less than 1.2 to 1.3 (during exploitation of soft material), and no greater from 1.5 to 1.7 (during exploitation of solid rock material). Structure of the complex machinery should preferably be equipped with machines of continuous operations.

The best economic effects are achieved in terms of the full use of the strength and capacity of machines that are part of the structure; preferably advantage should be given to the larger machine in relation to several machines of the smaller capacity.

Structure of the complex machinery with the lowest participation of difficult and incomplete mechanized auxiliary processes and operations are more effective.

Each structure of complex machinery should fully meet the requirements in terms of safety performance of mining works.

The basic principles on which the structure of complex machinery is based are: continuity of production, the possibility of merging processes, the shortest distance to transport materials and the smallest possible volume of additional mining work. The choice of the structure of complex machinery can be influenced by: natural factors, technical factors, organizational factors and economic factors, more or less.

Each of these factors can have a decisive or secondary importance. It is certain, however, that in the restricted size coal deposits and relatively small reserves of useful materials, it is irrational to strive for large capacity digs with the use of heavy machinery, and vice versa, with the exploitation of vast coal deposits in large open pits. The application of equipment of small capacity is irrational. Of course, to even contemplate on any kind of problem in the domain of machines for exploitation of coal it is necessary to look at their classification and architecture.

2. The classification and architecture of an excavator

2.1 The classification of machines and devices for open pit coal mining

The appearance and development of excavator with a single working element relates to the construction of railways and waterways in the United States. The first excavator with the one operating element was built in 1836.

Electric powered excavator was applied the first time in 1903 year, and the first engine with internal combustion engines to drive an excavator is applied in 1914 year.

Side-by-side with developing propulsion devices, grew the weight and power of an excavator with one working element and increasing their capacity. In approx. 40 years, the volume of excavator bucket was increased by almost 15 times, from 6 m3 to 88 m3, and engine power from 800 kW to about 10,000 kW.

In the United States in 1961, first excavator on four tracks was made with capacity of 88 m3, weight 8,160 t and radius of digging up to 64 m.

Machines for surface excavation of coal mine are classified by purpose, the principle of the production, construction of operating and transport devices, by the system of governance, capacity, power, dimensions, etc.

In the textbooks, as a basic feature for the classification of machines, the technological characteristic are considered, because they basically determine the kinematic scheme of the machine and the construction of its parts and assemblies.

According to this classification, machines and devices for open pit coal exploitation can be divided into the following classes: machines for excavation and loading of stripping and Rube substances, stripping Disposal Machines, machines and devices for the transport of stripping and Rube substances, depth drilling machines, machines for auxiliary works (Dozers, graders, cranes, etc.), mechanized tools. Each group of machines is divided into subgroups, which differ between themselves in the construction of the working parts. Frequently used classification of excavators depends on: function, purpose, type of working part, volume of bucket, degree of turning, the type of the transport device applied, kinematic type, per type of drive device, the ISL management system. Therefore, for example, in a group of excavators, excavators can be distinguished as with a single working element and excavators with multiple working elements. The machines of each subgroup are divided into the types according to their constructive characteristics and specificities. Within a subgroup of excavators with one working element, there are bucket excavators, dragline, etc. The machines of each type are divided into models, which differ in technical characteristics (capacity, working dimensions, Mass etc.). For example, among the bucket excavators there are dredgers with a bucket of small, medium and large volume.

As previously stated, also significant is classification of machines for surface exploitation under operating mode. The basis they differ on is the following:

a) machines with periodic (cyclical) effects, in which work operations are performed one after the other, alternating in a specific order and repeated after a certain period of time.
b) machines with continuous operation, all operations performed simultaneously.

As an example, for the machines of the group, the classification of machines for surface exploitation by mobility is also significant because it includes not only the classification into stationary and movable machines, but also the further specificity of this mobility by moving devices (on tracks, pneumatics, stepping device, etc.). Each machine is constructively composed of five basic groups of elements:

1. Working parts, i.e. The elements that directly achieve the technological operation (for example, the Bucket of excavator, etc.),
2. Transfer mechanisms connecting the working part with the drive motor (shaft, serrated and other transmits etc.),
3. Drive device – engines, which appear as energy sources for initiating machine elements,
4. Management system, which ensures the inclusion and exclusion of individual machine mechanisms and
5. Device for transport, movement of the Machine (pneumatics, Crawler, etc.), which is included in the general construction of moving machines as an integral part.

The working part and the transmission mechanisms are specific to individual machines or a group of machines, and they are determined depending on the purpose of the machine. The drive device, the transfer mechanisms and the management system can be discussed as one group. When using machines, it is important to achieve: economic efficiency to achieve productivity (capacity) of machines and devices for surface exploitation, use the working hours of the machine, evaluate utilization of the machine, maintain the machines in a good working condition and to perceive indicators of degree of mechanization in open pit coal mine.

2.2 The main elements in the architecture of the Marion M210

When it comes to the architecture of the excavator, Marion M20 consists of: engine installations-propulsion devices, upper carriage, lower carriage with counterweight and bearing ring, steering cabin-control system, bucket carrier (boom) in the function of the working part, bucket of excavator (mounted on boom), ropes for lifting bucket – in function of working parts, ropes for holding (hanging) boom – in the function of working parts.

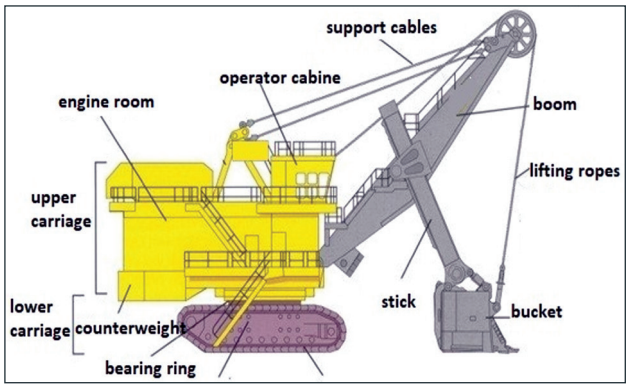

Figure 1. Parts of M201 Excavator

All of the elements in the architecture of the excavators have their own significance. Cancellation of any element would result with the fact that excavator could not function normally. However, it is necessary to emphasize, that in the work of the excavator, elements that have a dynamic function in achieving the process of digging have a very important role. This process takes place via gear rack with a bucket of the excavator. The stability of the excavator (holding the Boom), lifting and transferring is realized through the ropes. So, these elements have a significant role and their maintenance must be done with great attention. All these functions are carried out through specific mechanisms, the mechanism of digging, the mechanism of achieving circular movements and lifting mechanism.

3. Loads on gear rack carrier of the excavator Marion M201

For any kind of load calculation of the excavator or its components in terms of excavator operation one must come from the facts of function of excavator to assess the most characteristic position of excavator or to see the impact of these loads on their construction and to look into the safety of structures at different positions of working parts when operating an excavator. Emphasis will be at the loads and their influence at the most exposed position of gear rack in relation to the boom, which is under constant angle of 45 °.Gear transmissions are vital parts of machines, and their reliable operation is required in order to prevent machine damage and fracture. [1]

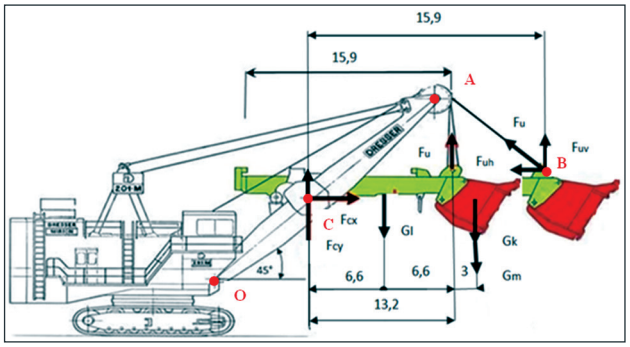

Figure 2. Display of the loads on the gear rack in a horizontal position with partially and completely extracted rod [2]

According to the figure 2 the individual segments of the load on the excavator Marion 201, can be displayed:

$$G_{(k+l)} = 421{,}68\ (kN);$$
$$G_k = 205{,}94\ (kN);$$
$$G_{lz} = 29{,}42\ (kN);$$
$$G_l = 219{,}67\ (kN)$$
$$G_m = 392{,}27\ (kN);$$
$$G_m + G_{(k+l)} = 865{,}93\ (kN)$$

According to figure 2:

$$\sum x = 0;\ \sum y = 0;\ \sum M_c = 0$$

$$\sum x = 0;\ F_{cx} = F_{uh} = F_{ux}$$

$$\sum y = 0\ ;\ F_{uv} + F_{cv} - G_k - G_m - G_l = 0$$

$$F_{uv} + F_{cy} - 205{,}94 - 392{,}27 - 219{,}67 = 0$$

$$\sum M_c = 0;$$

$$G_l * 7{,}5 + G_k * 16{,}2 + G_m * 16{,}2 - F_{uv} * 16{,}2 = 0$$

From these equations the forces at C, in the point of coupling of drive gears and the gear rack. Simplified scheme of the loads on the excavator that affect gear rack can be shown in Figure 3. Pressure at the point C (p → N/mm2), which loads the gear rod supporter is caused by horizontal force Fn.

$$F_c = 1686{,}74\ (kN) = Fn,$$

and that is the normal force that affects the sides of the teeth.

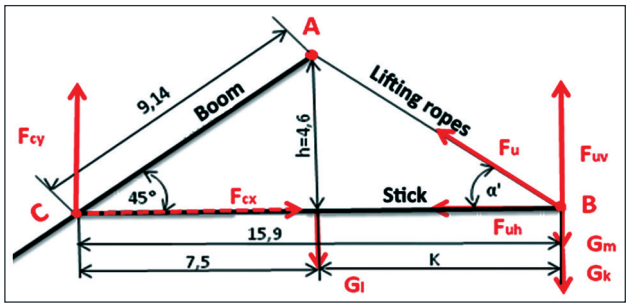

Figure 3. Display of the loads on the gear rack in a horizontal position with partially and completely extracted rod

The pressure on the sides of the toothed rack rod which causes the damage of the teeth, as well as other problems, like change of the hardness of tooth, can be determined from the relation:

$$P = \sqrt{0{,}35Fn * \frac{E}{l * \varrho}}$$

The force that occurs at the side of tooth is;

F_c – is the force on the side of the teeth.

$$F_{cx} = 1686{,}74\ (kN)$$

Characteristics of tooth gear rack (figure 4.) are from (figure 5). the cross-section of the gear rod with carrier.

$$L = 216\ mm;$$

length of tooth on one side.

Teeth's are on both sides of the gear rack so we must take two pairs of teeth

$$L_{sum} = 2 * L = 216\ mm * 2 * 432\ mm$$

$\varrho = 29.1$ mm is visible from the the tooth profile (figure 5.) with the dimensions, and the module of elasticity is;

$$E = 210000 \frac{N}{mm^2}$$

Using the equation for the stress due to the forces of F_{cx}, we can calculate strain kneading teeth forces;

$$P = \sqrt{0{,}035Fn * \frac{E}{(l * \varrho)}}$$

$$= \sqrt{0{,}035 * 1686740 * \frac{210000}{(432 * 29{,}1)}}$$

$$= \sqrt{59035{,}9 * \frac{210000}{(432 * 29{,}1)}} =$$

$$= \sqrt{59035{,}9 * \ 16{,}7048} =$$

$$= \sqrt{986185{,}8};$$

$$P = 993\ (\frac{N}{mm^2})$$

This strain corresponds is in limits of the allowable stresses is according to ISO EN [3].

3.2 Display cross-section beams – gear rack carrier-and-pinion steering [2]

Cross-section of the carrier – boom and the toothed rack can be displayed in Figure 4., because they are one unit where the power from the drive motor is transferred to the carrier which is one unit

Table 1. For steel gear tooth profile for 34CrNiMo6 dimensions that are smaller than 100 mm

Material No.	**1.6582**	**34CrNiMo6**					
Material Group	**Steel for quenching and tempering acording to DIN EN 10083**						
Chemical Composition	C	Si	Mn	Cr	Mo	Ni	other
	0,34	0,25	0,50	1,50	0,25	1,55	(Pb)
Diameter d / mm	≤16	≥16-40	≥40-10	≥100-160	≥160-250		
Ultimate tensile strength Rm /N/mm2	1200-1400	1100-1300	1000-1200	900-1100	800-950		

with the toothed rack and from the carrier force is transmitted to the working part – bucket of the excavator which carries the material (coal). Welding gear rack on the boom of excavator is done by manual arc welding 111 (SMAW) ISO 4063 (EN ISO 4063) [4].

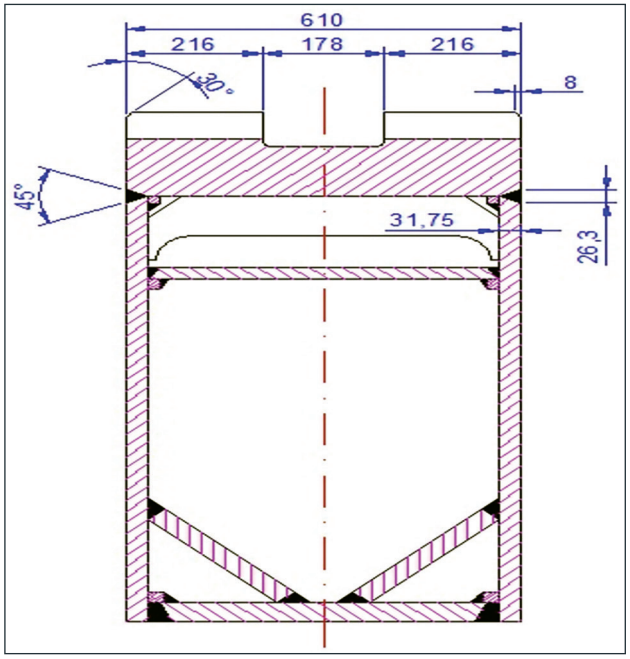

Figure 4. The cross-section of the gear rod with rack carrier with dimensions

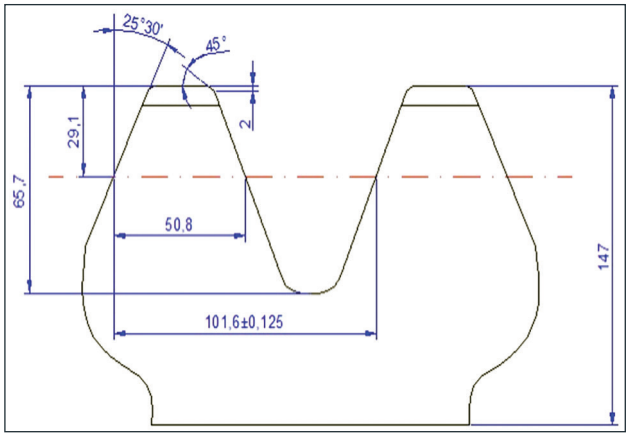

Figure 5. Tooth profile with dimensions

4. Defining current state of toothed rack

4.1 Damages on the toothed rack [5]

The existing state of toothed rack is that it is still functional, but can cause an extremely large problem with the state in which it currently is. The existing damage that can lead to dysfunctions of the toothed rack rod and thus the excavator will be presented in this paper. Based on this condition, it can be concluded that there has been damage to the teeth on the toothed rack, especially in places of frequent contact of the toothed rack and driving gears, and it refers to the central part of the toothed rack. Before mounting toothed rack on the boom, hardness of the teeth was measured and it was 235 HB. [6]

Figure 6. The left side of the visible damage to the gear rod

Damage to the gear rod can be manifested mainly through damage to the teeth, first on the driver gears, and later comes to the damage on the teeth of the gear rod, mainly in the middle of the toothed rack, as in Figure 8. Visible damage to the toothed gear rod is the change in the microstructure of the material, due to work activities.

Figure 7. Visible damage to the gear rack along the entire length

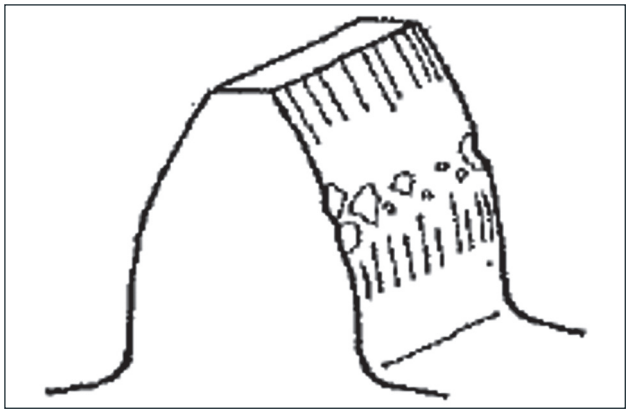

Figure 8. Damage to the side of the teeth-contact surfaces

Damage to the teeth first appears at the drive gears, and then on the teeth of the toothed rack of a similar intensity as shown in Figure 8.

Tearing parts of the tooth is result of work (digging) – where friction leads to warming and changes in microstructure of materials and thus changes to the hardness of teeth material. The teeth hardness is increased as well as brittleness that causes damage to the teeth, which is shown in figures 6, 7 and Figure 8.

This is also confirmed by the fact that there has not been a change in the hardness of teeth at ends of toothed rack according to the table 2. which displays the tooth hardness before installing on the excavator and after 10 years working period.

It is significant to note that large damages of the toothed rack may appear. Such damages are:

a) bending of the tooth– which occurs mostly due to the reduction in the hardness of the tooth, which is a consequence of the changes in the microstructure)
b) The occurrence of cracks on the outer surface of the teeth due to the occurrence of thermal influence– what also causes changes in the microstructure, which leads to reduction in hardness and toughness. It is sufficient to conclude that Russian gear rack was (308-360) HB, when mounting the hardness, and of course there was a strain of teeth and changes in the microstructure of the material because of the working activities as shown in figures 6 and 7.

5. Spectrographic analysis of the gear rack and steel profiles

If further functioning of an excavator should be considered damage on the toothed rack must be repaired. There is a visible damage of the tooth of gear rack that must be repaired before further functioning of the excavator.

First of all, repair of the teeth must be carried out, with determined technology. To perform a repair of the teeth on gear rack, proper welding technology must be chosen and the analysis of materials to performed (of the toothed gear rack), and if needed replacement of gear rack after which analysis of material of the gear rack carrier must be performed in order to determine proper welding technology for teeth of the gear rack.

In order to execute the reparation of the gear rack welding technology must be determined (re-welding) for the:

– Technology for separating the gear rack from boom
– Technology for merging gear rod and boom

Table 2. The tooth hardness before installing on the excavator and after working period of 10 years

Teeth Hardness berfore mounting on excavator [6]	Teeth Hardness before mounting on excavator (midle of rack) [6]	Teeth Hardness before mounting on excavator (ends of rack) [6]
233HB	233 HB (277 HB root of teeth)	233 HB (277 HB rot of teeth)
Hardness of teeth (After reparation)	Teeth Hardness After reparation (midle of rack)	Teeth Hardness After reparation (ends of gear rack)
500 HB	500 HB	233 HB

5.1 The analysis of material for the toothed rack

This analysis for determination of welding technology of teeth of toothed rack must be conducted and re-welding of toothed rack to boom. The analysis was conducted at the Institute of welding in Tuzla in the year of 2010 and based on the analysis results are shown in tables (3. And 4.)

These results are obtained by analyzing samples of the toothed rack material at the Institute of welding in Tuzla on 30th of July, 2010 (Table 3.).

The contents of the elements in the structure of the toothed rack material, with the German equipment and EN standards, (that are given in to the Protocol – documentation) in the coal mine RMU – Banovići in Banovići.

There are limitations of the individual content of elements in structure of a material according to International standards for materials used for creating responsible segments of the machines used for exploitation of coal. This especially applies to the excavator structure.

5.2 The standard limit values for the elements in the structure of the material 34CrNiMo6

For gear rack of the excavator Marion M 201, for material 34CrNiMo6 (Č.5431), those restrictions were given in (Table 4.).

In comparison of test results in analysis of materials at the Institute of welding in Tuzla and table values – standards small deviations can be observed, which can't particularly affect normal functioning of the excavator.

6. Welding of teeth on the toothed rack

In reparation process of the toothed rack, teeth are very important issue, since they are welded on the base of the toothed rack carrier (boom). The biggest damage was observed in the middle of the toothed rack, because that part is in contact zone with the drive gears and re-welding technology for teeth is based on type of material from which toothed rack is made (Table 3. - a high-quality alloy steel 34CrNiMo6), where damage craters appear (Figure 9.). [7]

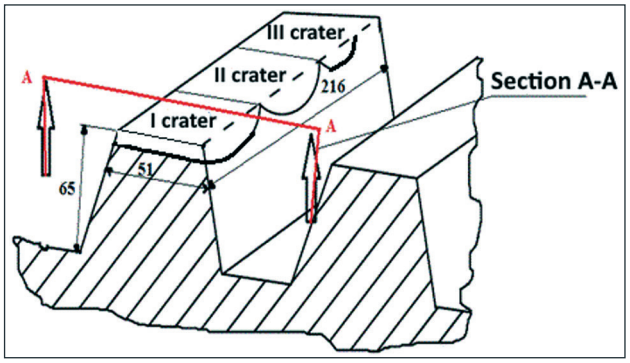

Figure 9. Damage to the tooth – craters

Depending on the type of the material, the type of electrode is chosen as well as the type of re-welding process of teeth. Selected electrode is shown in (Table 5.) and is used for:

- Welding of the middle area (most damaged);
- Welding of the sides (less damaged);

Table 3. The tooth hardness before installing on the excavator and after working period of 20 years

ANALYSIS OF THE WELDING INSTITUTE, TUZLA 30.7.2010.								
Analysis results of the gear rack: 34CrNiMo6 (Č.5431)								
Elements	C	Si	Mn	P	S	Cu	Al	Cr
%	0,38	0,31	0,6	0,01	0,01	0,18	0,041	1,39
Elements	Mo	Ni	V	Ti	Nb	Co	B	
%	0,2	1,73	0,02	0,03	0,007	0,04	0,005	

Table 4. Limit values for material of the gear rack - Steel 34CrNiMo6 (Č.5431)

STANDARD LIMIT VALUES								
Limit values for material of the gear rack - Steel 34CrNiMo6 (Č.5431)								
Elements	C	Si	Mn	P	S	Cu	Al	Cr
%	0,3-0,370	0-0,4	0,5-0,6	0,01	0-0,035	0	0	1,3-1,7
Elements	Mo	Ni	V	Ti	Nb	Co	B	
%	0,15-0,35	1,3-1,7	0	0	0	0	0	

Table 5. Electrodes for welding of teeth gear rack (34CrNiMo6)

Electrodes for welding of teeth gear rack (34CrNiMo6)			
Electrode	**Dimensions / mm**	**Electric current I / A**	**Type**
EZ 70 B Midle part	Ø 4 x 450 Ø 2,5x300	120-140 65-80	ECrMo1B42
EVB 2 CrMo Two side fields	Ø 4 x 450 Ø 2,5x300	150-180 70-95	E2CrMoB20
CASTOLIN CrNiMo	Ø 4 x 450 Ø 2,5x300	90-150 40-80	EC 33788
DURASEL 21 P	Ø 4 x 350 Ø3,5 x 350	150-200 90-120	EN499
Electrode	Impact energy KV (J)	Tensile Strength Rm (N/mm²)	Yield Strength R_{eL} / $R_{p\ 0.2}$ N/mm²
EZ 70 B Middle part	110 / 20°C	570-700	470
EVB 2 CrMo Two side fields	95/20°C	620-720	550
CASTOLIN CrNiMo	65/20 °C	770	550
DURASEL 21 P		700	600

The size and position of the crater is very important (figure 9. damage to the tooth). Each crater is made of three parts (fields), two on the sides and one in the middle. For welding of these fields the following materials can be used (Table 5.). [8]

The possible good materials for welding on toothed rack (chosen electrodes are meant to be used for tough part – the middle part of the tooth, and for side parts according to the table)

The biggest damage is on places with 3 craters on tooth, and every crater in this case can be divided into 3 fields (Figure 10.)

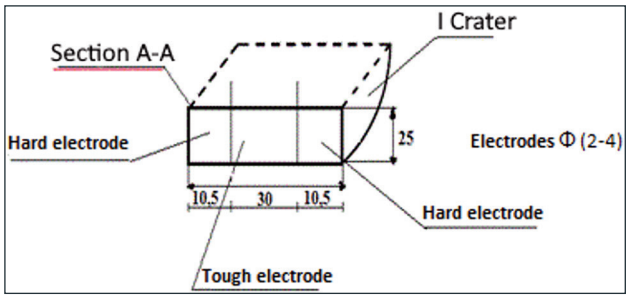

Figure 10. Cross-section of the crater is divided into 3 parts – ready for filling

Middle field needs to be done with EZ 70 B, while two sides with EVB 2 CrMo. After that, filling of the weld needs to be done. When the tooth is approximately half built up it is sometimes better to revert to a one-size smaller electrode in order to avoid overheating because the area that needs to be filled becomes progressively smaller. [9]

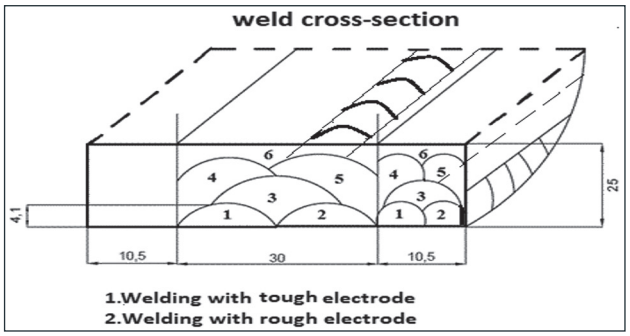

Figure 11. Cross section of the crater is divided into 3 parts – ready to fill in according to the instructions from the previous text

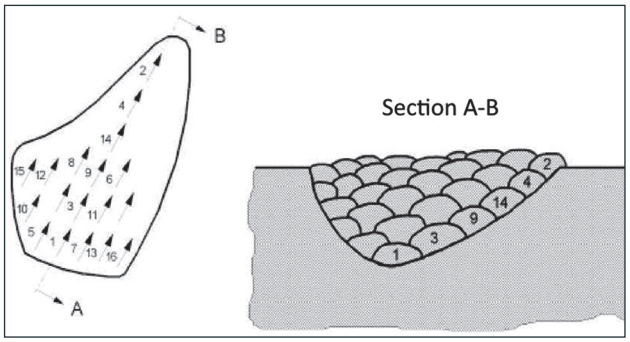

Figure 12. Possible process of applying layers in weld [10]

7. Conclusion

In conclusion, it can be reported that damage to the toothed rack is mainly caused by fatigue of the material and partly from the inefficiency of the work of the supervisory staff and inefficiency of the excavator operator staff. It can be concluded that it is possible to weld gear teeth on boom of the excavator Marion 201 with the proposed solution and put the excavator in its normal function. Selected additional materials and parameters of the re-welding are appropriate for reparation of gear rack and prolonged use of excavator. Supervisory personnel can contribute to prolonged use of this excavator with proper maintenance and use.

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Influence of processing parameters of environmental-friendly cooling/lubrication strategy (MQCL) in turning of X5CrNi18-10 stainless steel

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Abstract

This paper mainly focuses on a experimental investigation into the minimal quantity cooling and lubrication (MQCL) turning process due to enhance the machinability of X5CrNi18-10 steel with the objective to investigate and select the optimal MQCL parameters on the surface roughness parameters and cutting forces. The effects of the selected MQCL parameters such as vegetable-based cutting oil and water flow rates, aerosol impact point to the cutting tool, number and stand-off distance of the selected nozzles, and the physical properties of the cutting oils were investigated using a new class of experimental design – definitive screening design (DSD) along with graphical analysis. As a final point, the desirability function approach has been used to find out the suitable combination of MQCL application parameters.

Key words: MQCL, surface roughness parameter, definitive screening design, factor optimization, desirability function.

1. Introduction

An important factor in preserving and improving the competitiveness of the metal processing sector on the local and international market is the permanent improvement of existing production capacity. Scientific achievements in the metal processing sector are important factors that need to be harmonized with the technical and technological development that is unattainably advancing, but also with the current requirements of the industrial environment. One of the future directions of modern production, is reflected in the trend of developing solutions and applications of sustainable manufacturing. Although the idea of sustainable production is becoming more defined and understandable, many manufacturers are still not taking the necessary steps to implement newer and proven technologies. The direction of movement of modern production is in the trend of sustainable production towards the preservation of the human environment, health, and ultimately the survival of the planet and human existence on it. In modern machining industry, the key elements lie in the requirements for reducing component dimensions, improving the quality and accuracy of processing, tight tolerances, reducing costs and weights, etc. Higher values of cutting parameters offer the possibility of achieving higher productivity, but at the same time they pose a risk of deteriorating the overall integrity of the machined surface, the tool life, energy consumption, etc. In this context, strategic directions lie in the development of machine tool constructions and thus in the development of new and more advanced cutting technologies. In recent years, great importance has been attached to highly productive processing procedures as a way to raise productivity levels, reduce production costs, and improving the product quality are the effective ways to strengthen the competitiveness of enterprises.

Semi dry, or minimum quantity cooling and lubrication (MQCL) machining refers to the use of a small amount of cutting fluid, and has achieved noticeable attention in academic and industry research area. This is because the usage of minimal quantities of fluid in MQL machining can definitely reduce the cost of using cutting fluids and the auxiliary equipment [1].

In addition, the available publications indicate that under certain experimental conditions, the MQCL machining strategies showed better performances than dry machining, and is comparable to the con-

ventional flood cooling machining [2-5]. Therefore, it seems that the implementation of MQCL machining as an alternative to traditional machining strategies is an important research area. A large number of formulation and processing variables influence the overall performance of MQCL assisted machining. Thus, it becomes extremely difficult to study the effect of each parameter and interaction among them through the conventional approach. Therefore, one of the most important tasks in the MQCL assisted machining process is to evaluate the most dominant parameters in order to obtain maximum efficiency in the manufacturing process.

In this study, unlike similar publications in which MQCL parameters were investigated in the same time as the cutting parameters, the scope was widened and only the main cooling/lubrication parameters affecting the efficiency of the system were tested at the same time. For these purposes, a new class of experimental designs, the DSD (definitive screening design) were used for the experimental plan. Cutting forces and surface roughness parameters were measured through the external turning of X5CrNi18-10 steel.

2. Experimental setup

2.1 Material and measurements

A large number of recent scientific studies dealing with the issue of comparative analysis of MQL/MQCL machining procedures with conventional processes mainly describe the variation of cutting parameters and material types of cutting tools when machining difficult to machine materials with constant MQCL system parameters [2-5].

Looking at the problem on the other hand, the question arises, what would be the effects of varying only the process factors of the MQCL system on the results of the process?

Of course, it is important to note that by observing only the cooling and lubrication systems and not including the cutting parameters in terms of the continuity of the process, does not serve the purpose of cutting completely. This statement is argued by research in the field of dry machining, which in special cases has proven to be a good alternative for processing difficult to cut materials. In this regard, one of the main goals of this study is to examine and identify the dominant factors of the observed MQCL cooling and lubrication system on the conditions of the process at constant cutting parameters.

The experimental studies were performed on a conventional lathe machine *Potisje PA 501A*. This machine meets all the necessary requirements for the research objectives, ensuring sufficient rigidity, accuracy and precision of turned parts. All tests were conducted under constant settings of cutting speed, feed rate and depth of cut, by using an advanced MQCL system, produced *by Daido Metal - Japan*. This MQCL system has the ability to independently adjust oil and water delivery rates which are in the range of 10-50 ml/h and 300-1800 ml/h, respectively. Thus, there is a possibility of delivering atomized aerosols of variable volumetric concentrations. According to that, the atomized MQCL mist in this study was delivered to the interface of workpiece-cutting tool at different oil-to-water mixture ratios using a vegetable based cutting oil.

The summary of experimental conditions are listed in Table 1.

A commercial *Iscar* IC807 grade with TiAlN + TiN coated carbide insert of CNMG120408-WG and PCLNR 2020K-12 tool holder were selected for the turning tests. In order to minimize the in-

Table 1. Machining parameters and their levels

Symbol	Parameters	Notation	Unit	Level values		
				1	2	3
A	Oil flow rate	*OFR*	ml/h	10	30	50
B	Water flow rate	*WFR*	ml/h	300	1050	1800
C	Spray distance	*SD*	mm	30	75	120
D	Oil viscosity	*OV*	mm^2/s	Castrol (39)		Menzel (95)
E	Nozzle stand-off distance	*NSD*	mm	Flank face (F)		Rake face (R)
F	Nozzle number	*NN*	/	One		Two

fluence of cutting tool wear on the investigated quantities, each set of turning experiments was conducted using a new insert edge.

A quenched and tempered X5CrNi18-10 austenitic stainless steel was used as the workpiece material. All machining tests were carried out on a bar of 70 mm diameter with separated 15 mm long segments for each cutting test. The cutting forces were measured using a *Kistler 5070* dynamometer connected to an amplifier and a computer equipped with manufacturer's *DynoWare* software.

Figure 1. shows the experimental setup for the turning experiments at the Faculty of Mechanical Engineering in Zenica.

In the context of qualitative description of the condition of the treated surface as an indicator that is closely related to the cutting process, in preliminary tests, the integrity of the treated surface was measured using a contact profilometer. Therefore, a mobile device of the *Mitutoyo Surftest SJ-301* type was used to measure roughness parameters, in the laboratory at the Faculty of Mechanical Engineering in Tuzla. Before the measurement, the device were set for the planned measurement of parameters according to DIN 1990 (DIN EN ISO 4287: 1998) standard. The adopted reference test length for all measurement tests was 4 mm for the selected profile filter lc = 0.8mm × 5. A total of five measurements were performed for each processed segment at different locations, and the arithmetic mean was adopted as a reference value for data processing.

An example of roughness measurement and printed measurement report is shown in Figure 2.

2.2 Definitive screening experimental design

Definitive screening designs (DSD) are the new class of experimental designs that have three levels, which provide superior properties as compared to the traditional experimental design techniques such as Placket-Burmann, standard central composite design in response surface methodology, etc. [6].

DSDs are alternative one-step approach that is more reliable, efficient and cost effective than the conventional designs for problems involving up to 12 factors. These designs efficiently estimate the main effects, two factor interactions, and quadratic effects that are not confounded at minimum number of experiments [6].

DSDs have the following advantage and desired properties over the classical experimental designs [6]:

- (Two-factor interactions are not confounded with higher order interactions.
- DSDs have distinctive feature that it is a self- fold over.
- The number of required experiments is only one more than double (2k+1) the number of factors.
- With more than four factors, the DSDs provide higher level of statistical efficiency and able to conduct sensitivity analysis.

Vegetable-based cutting oil type (viscosity), oil and water flow rates, nozzle stand-off distance, nozzle number and aerosol impact point were

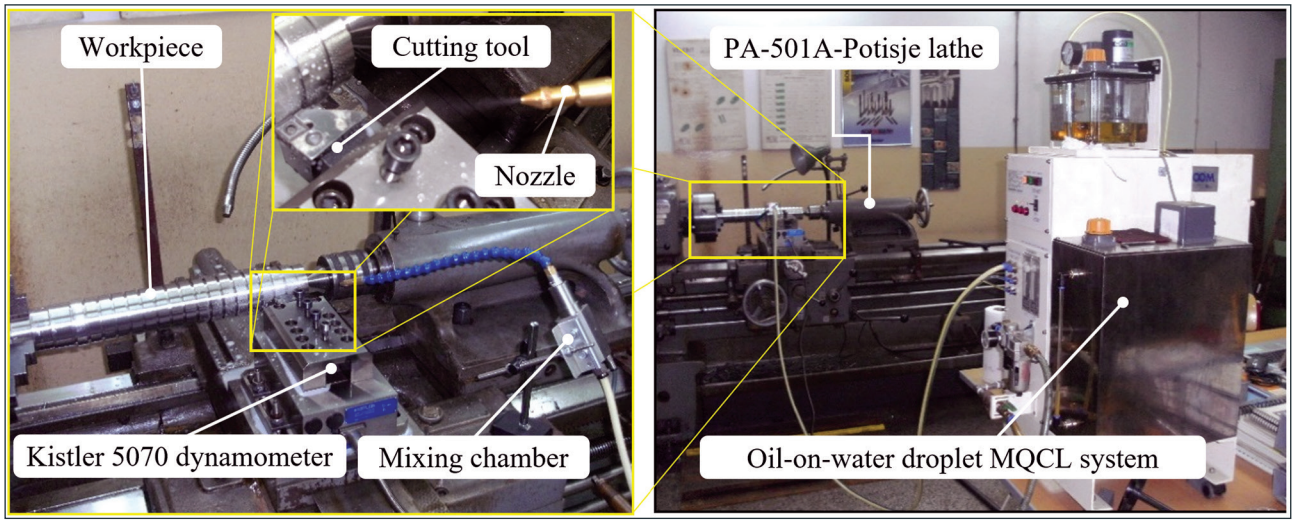

Figure 1. Experimental setup for the MQCL assisted turning test

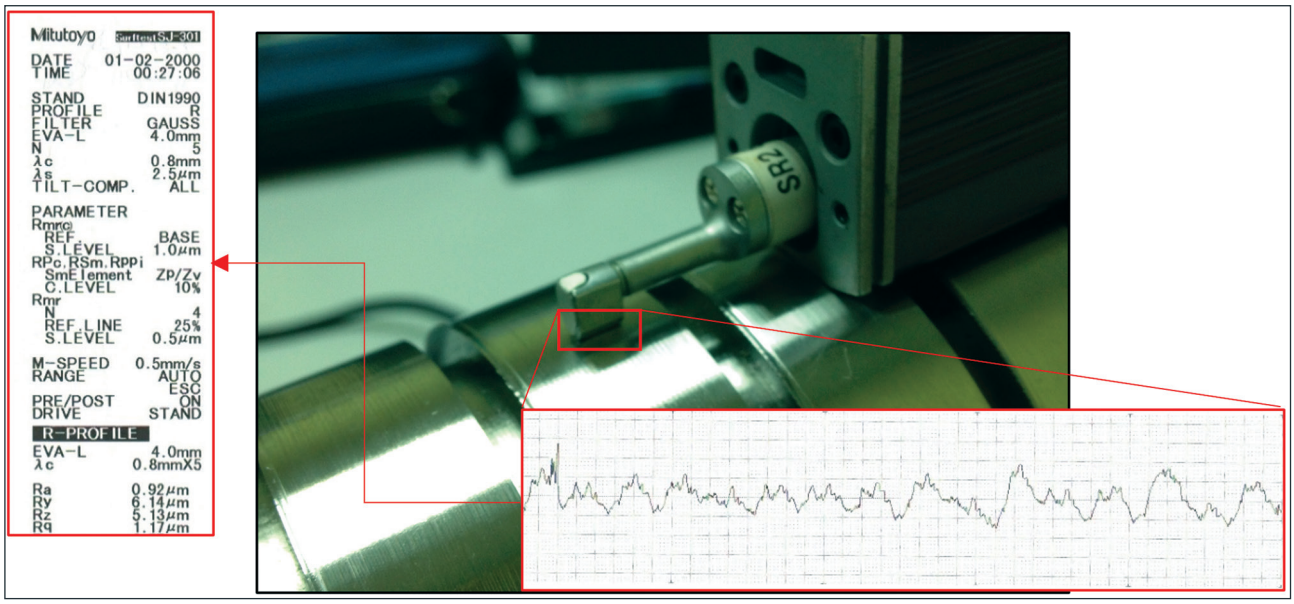

Figure 2. Surface roughness measurement of the treated surface using the Mitutoyo SJ-301

selected as control factors for the turning experiments, and their levels are given in Table 1.

Therefore, 14 runs including two center points were needed to study the impact of the six process factors on the output variables. However, DSD matrix was improved using two additional center points, resulting in a total of 16 runs. This helps to increase the power of DSD matrix. Table 2. shows the augmented DSD matrix for cutting forces components.

The cutting speed 113 m/min, feed rate 0,195 mm/rev and depth of cut 1 mm were based on the recommendations of the cutting tool manufacturer for medium cutting conditions. These parameters were kept constant in all experiments in order to investigate only the effect of MQCL control factors on the machinability of X5CrNi 18-10 stainless steel.

Table 2. MQCL control parameters and their levels for cutting forces

A	B	C	D	E	F	Fx (N)	Fy (N)	Fz (N)	Fres (N)
30	1800	120	Menzel (95)	Rake face (R)	Two	307,8	243,4	567,9	690,286
30	300	30	Castrol (39)	Flank face (F)	One	293,4	230,9	576,0	686,421
50	1050	30	Menzel (95)	Rake face (R)	One	283,5	224,8	562,2	668,563
10	1050	120	Castrol (39)	Flank face (F)	Two	298,7	235,4	567,5	683,148
50	300	75	Castrol (39)	Rake face (R)	Two	272,5	223,6	538,5	643,611
10	1800	75	Menzel (95)	Flank face (F)	One	306,3	266,5	603,0	726,946
50	1800	30	Menzel (95)	Flank face (F)	Two	292,5	224,4	567,4	676,649
10	300	120	Castrol (39)	Rake face (R)	One	277,0	258,5	556,6	673,316
50	1800	120	Castrol (39)	Rake face (R)	One	287,8	222,2	565,7	672,472
10	300	30	Menzel (95)	Flank face (F)	Two	297,5	227,6	568,2	680,558
50	300	120	Menzel (95)	Flank face (F)	Two	282,0	227,4	557,8	665,113
10	1800	30	Castrol (39)	Rake face (R)	One	296,3	228,2	590,1	698,632
30	1050	75	Castrol (39)	Flank face (F)	One	291,6	227,8	577,4	685,795
30	1050	75	Menzel (95)	Rake face (R)	Two	319,9	253,1	592,1	719,012
30	1050	75	Castrol (39)	Flank face (F)	One	293,0	229,0	580,0	688,978
30	1050	75	Menzel (95)	Rake face (R)	Two	320,4	251,7	585,0	712,905

3. Analysis of experimental results

3.1 Cutting forces

Graphical interpretation of the measured results on the resultant cutting force given in Table 2. can be presented in means of main plot for all investigated MQCL control parameters according to Figure 3.

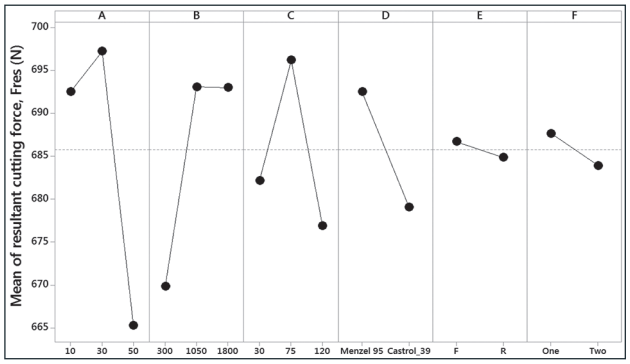

Figure 3. Main effect plot for the resultant cutting force

Analyzing the formed diagram, it is clearly seen that the amount of oil and the amount of water have the largest impact on the variation in the size of the cutting force.

This statement certainly makes sense since these two are the main elements of conventional coolants and lubricants. On the other hand, a variable change in the character of the nozzle stand-off distance to the cutting forces are noticeable, which indicates that this parameter does not have an unambiguous influence.

Other analyzed parameters (kinematic viscosity index, aerosol impact position and number of nozzles) that are categorical in nature, can be ranked behind the previously described with respect to a smaller impact on the variation of the measured cutting forces. Although, it turns out that the oil with lower kinematic viscosity sprayed with water and applied on the rake face of the tool (through two nozzles) resulted in less load on the cutting tool.

Preliminarily, it can be stated that one of the possible reasons for the more favorable action of oils with lower viscosity is closely related to the possibility of proper formation of water droplets covered with an oil film. On the other hand, not wanting to get too involved in fluid mechanics and mass transfer, it is considered that the formed oil-on-water droplets (appropriate ratio), with oil of lower kinematic viscosity have a better fluidity effect on the tool-chip interface.

The impact of the selected MQCL control parameters on the resultant cutting force can be investigated using a Pareto chart which is shown in Figure 4. This chart orders the bars from largest to smallest. It can be noticed that the oil flow rate (A), oil viscosity (D), and the interaction between the nozzle number and aerosol impact point (E×F) are statistically significant control factors on It can be noticed that the oil flow rate (A), oil viscosity (D), and the interaction between the nozzle number and aerosol impact point (E×F) are statistically significant factors on the resultant cutting force. Insignificant factors are eliminated from the model using the *Bayesian Information Criteria* (BIC).

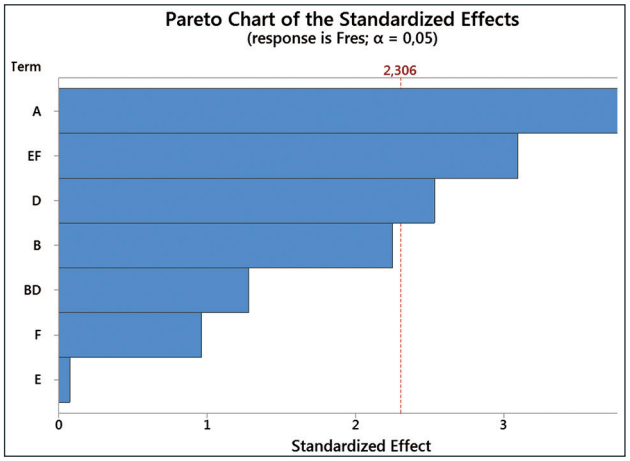

Figure 4. Pareto chart for resultant force, Fres

In this study, the analysis of variance (ANOVA) was used to analyze the effects of the selected MQCL control factors on the resultant cutting force. The results of ANOVA for the cutting force values obtained from the experimental measurement is carried out to find the significant control factors of the investigated cooling/lubrication strategy are given in Table 3.

According to the BIC criteria, the analysis was made at 95% confidence level. A p-value of less or equal than 0,05 meant that the effect of the factor on the output was regarded as statistically significant. Thus, it can be said that the oil flow rate and its viscosity have a certain influence on the cutting force. The F- values in the table were taken into consideration (contribution ratios). It can be no-

Table 3. ANOVA results for the resultant cutting force, Fres

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Model	7	5535,87	82,84%	5535,87	790,84	5,52	0,014
Linear	5	4154,13	62,16%	4154,13	830,83	5,80	0,015
A	1	1854,84	27,76%	2036,90	2036,90	14,21	0,005
B	1	1344,80	20,12%	726,56	726,56	5,07	0,054
D	1	820,93	12,28%	918,97	918,97	6,41	0,035
E	1	1,58	0,02%	0,77	0,77	0,01	0,943
F	1	131,99	1,98%	131,99	131,99	0,92	0,365
2-Way Interactions	2	1381,74	20,68%	1381,74	690,87	4,82	0,042
B*D	1	8,13	0,12%	234,18	234,18	1,63	0,237
E*F	1	1373,61	20,55%	1373,61	1373,61	9,58	0,015
Error	8	1146,83	17,16%	1146,83	143,35		
Lack-of-Fit	6	1123,12	16,81%	1123,12	187,19	15,79	0,061
Pure Error	2	23,71	0,35%	23,71	11,86		
Total	15	6682,70	100,00%				

ticed, that the percentage contributions of factors *A, B, D, E* and *F* to cutting force was 27.76, 20.12, 12.28, 0.02, and 1.98%, respectively. Factors *B, E* and *F* are hierarchically included in the model since their interactions have significant impact. In the light of these data, the most important MQCL control factors according to their contributions affecting the cutting force were *A, B* and *D*. The error rate was 17.16%, which meets the standard of the principle which states that "error level should be less than 20% for reliable statistical analysis [7]. The final regression equation for the resultant cutting force for the investigated MQCL control factors under aforementioned cutting parameters (113 m/min, 0,195 mm/rev. and 1 mm) is presented by equation (1).

The coefficient of determination of the obtained regression equation was calculated as R-sq=82.84% which demonstrates that the regression fits the data properly.

Moreover, lack of fit test in not significant (p-value is more than 0,05) which is desirable, as it indicates that any predictor left out of model is considered not significant and the established model predicts the experimental data well. Regression equations for the cutting force components were formed in a similar way according to the BIC criteria and are presented by equation (2), (3), and (4), respectively.

The coefficient of determination of the obtained regression equations for *Fx*, *Fy*, and *Fz* were calculated as 87.78%, 90.51%, and 81,99%, respectively.

3.2 Surface roughness parameters

As previously mentioned, the surface roughness parameters were measured according to DIN 1990 (DIN EN ISO 4287: 1998) standard, by a frequently used profilometer. A total of five measurements were performed for each processed segment at different locations, and the arithmetic mean was adopted as a reference value for data processing. Graphical interpretation of the measured roughness parameters given in equations (1-4)

$$F_{res}=695,78-0,736\times A+0,0122\times B+16,99\times D-0,23\times E-3,47\times F-0,0074\times BD+10,56\times EF \quad (1)$$

$$F_{x}=268,7+2,197\times A+0,00874\times B+4,67\times D+7,42\times F-0,043\times A^{2}-0,004\times BF \quad (2)$$

$$F_{y}=225,35-0,542\times A-0,002\times B+0,718\times C-0,39\times D+2,94\times E-3,92\times F-0,0035\times C^{2}+0,0083\times BD \quad (3)$$

$$F_{z}=549+1,953\times A+0,01\times B+6,02\times D+2,94\times F-0,041\times A^{2}-0,008\times BF \quad (4)$$

Table 4. MQCL control factors and their levels for roughness parameters

A	B	C	D	E	F	Ra (µm)	Ry (µm)	Rz (µm)	Rq (µm)
30	1800	120	Menzel (95)	Rake face (R)	Two	1,6800	11,3950	11,3950	2,0850
30	300	30	Castrol (39)	Flank face (F)	One	1,0650	7,8625	7,8625	1,3250
50	1050	30	Menzel (95)	Rake face (R)	One	1,1600	8,6800	8,6800	1,4600
10	1050	120	Castrol (39)	Flank face (F)	Two	1,5150	10,8025	10,8025	1,8950
50	300	75	Castrol (39)	Rake face (R)	Two	1,1300	7,5650	7,5650	1,3700
10	1800	75	Menzel (95)	Flank face (F)	One	1,3400	14,6875	14,6875	1,7600
50	1800	30	Menzel (95)	Flank face (F)	Two	1,3200	8,7425	8,7425	1,6000
10	300	120	Castrol (39)	Rake face (R)	One	1,1300	7,5650	7,5650	1,3700
50	1800	120	Castrol (39)	Rake face (R)	One	1,3150	8,3425	8,3425	1,6000
10	300	30	Menzel (95)	Flank face (F)	Two	1,3225	8,5200	8,5200	1,6275
50	300	120	Menzel (95)	Flank face (F)	Two	1,1675	8,8635	8,8635	1,4125
10	1800	30	Castrol (39)	Rake face (R)	One	1,3975	9,6650	9,6650	1,7000
30	1050	75	Castrol (39)	Flank face (F)	One	1,2150	8,2300	8,2300	1,5100
30	1050	75	Menzel (95)	Rake face (R)	Two	1,0800	7,3150	7,3150	1,3175
30	1050	75	Castrol (39)	Flank face (F)	One	1,1900	7,5800	7,5800	1,4600
30	1050	75	Menzel (95)	Rake face (R)	Two	1,0200	6,9900	6,9900	1,2400

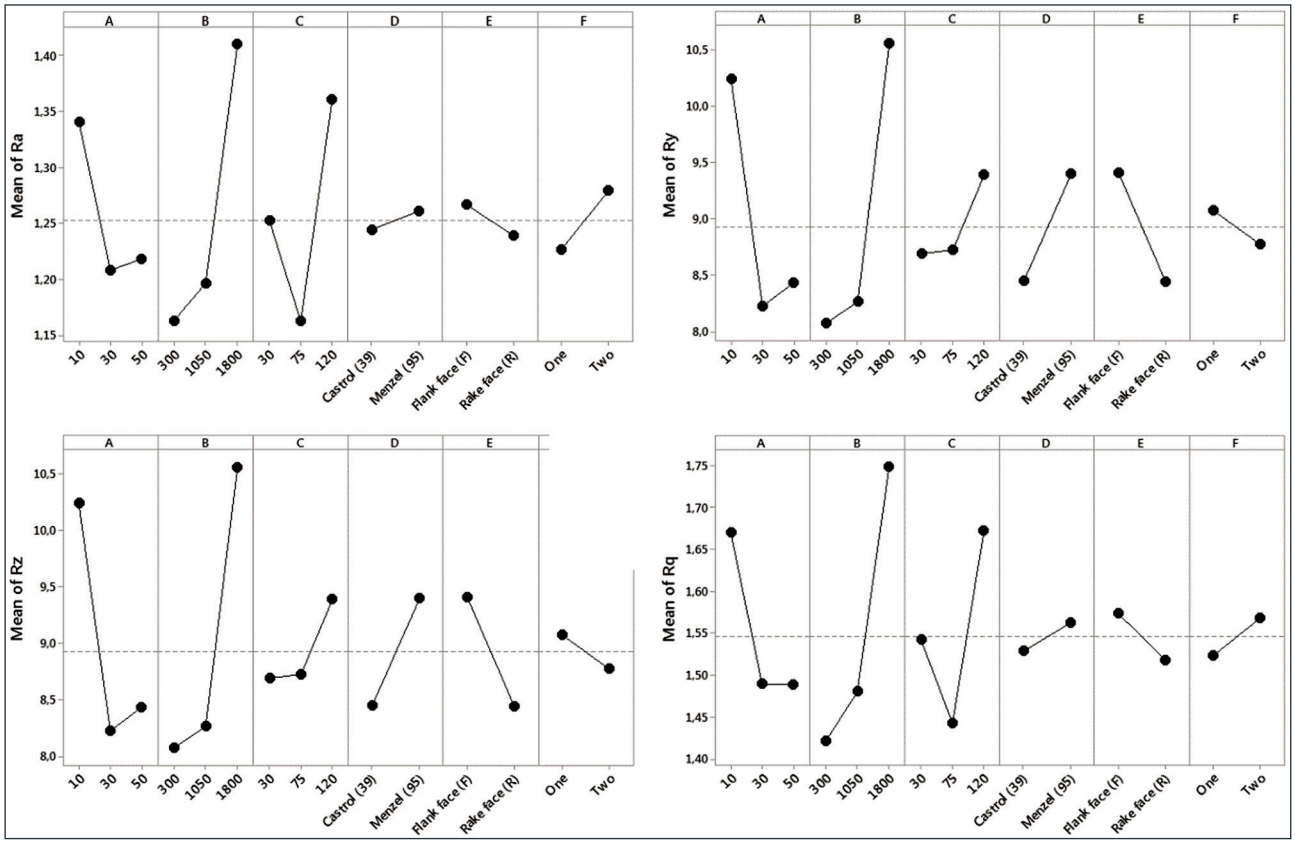

Figure 5. Main effect plot for measured surface roughness parameters

Table 4. can be presented in means of main plot for all investigated MQCL control factors according to Figure 5. From the results shown in Figure 5., it can be seen that the amount of oil and water have the greatest influence, while the character of spray distance cannot be unambiguously determined due to the variable nature when varying from lower to upper level. The nature of the influence of the analyzed surface roughness parameters is almost the same, and accordingly the influence of the domi-

nant parameters is described only on the example of the arithmetic mean deviation of the profile, Ra. Namely, by increasing the amount of oil to the medium level is reflected in a sharp drop in the mean arithmetic deviation of the profile. Upon reaching a certain level of lubrication, and under the condition of an additional increase in the amount of oil, the variation of the arithmetic mean deviation of the profile is approximately constant, but with a tendency to increase slightly. This nature of change indicates that for MQCL systems there is a marginal lubrication effect or saturation threshold of the lubricant used. In order to explain the effect of oil film saturation on contact surfaces, it is necessary to observe it as a hydrodynamic process aided by the pressure of the carrier air. At the moment when the lubricant fills all the micro-irregularities between the contact surfaces that are in relative motion, a hydrodynamic layer of continuous character is formed. Thus, regardless of the additional increase in lubricant consumption, this effect remains unchanged, which describes the existence of an objective limit in terms of lubrication. A similar trend and nature of change is noticeable in the case of the amount of water from the minimum to the middle value, but with a significant increase in the arithmetic mean deviation of the profile under the conditions of the maximum amount. The assumption is, therefore, that the lubrication effect is more dominant than the cooling effect.

Observing the total amount of the supplied working medium in the cutting zone, it turned out that the effect of the MQCL system does not depend only on the total amount of supplied but also on the composition of the dispersed (atomized) working medium. With an effectively applied amount of atomized mist in terms of better quality of the treated surface, medium to higher percentage of oil in the formed mist has a more favorable effect on the measurement results.

Although there is a slight or insignificant increase at the maximum ratio, it seems that for the oil-in-water ratio at the middle level, a compromise has been established between the cooling and lubrication effects in order to achieve the best processing quality.

On the other hand, as a result of the creation of a stable lubricating layer, the contact friction between the surfaces is reduced, which affects the cooling effect. In support of this phenomenon is the pressure of the carrier air, which through the conduction drains the part of the resulting temperature from the cutting zone.

The variation in the roughness values of the treated surface for the conditions of the MQCL processing system through the nozzle stand-off distance is attributed to the cooling and lubrication effects of these systems. At lower values of the nozzle stand-off distance, the speed of the carrier air (constant pressure) is higher than the speed of the formed droplets, while by gradually increasing the distance, this difference decreases until a certain moment when they become the same. With further increase, the velocity of the carrier air becomes lower than the velocity of the formed droplets. The formed oil-on-water droplets are at small distances of nozzles of larger stand-off distance and move at lower speeds. On the other hand, due to the existence of the boundary layer effect (vortex beam) due to the rotation of the workpiece, the probability that the formed droplets of such properties will penetrate into the cutting zone are relatively small. Increasing the stand-off distance to a certain level increases the speed of movement of the droplets and at the same time reduces their dimensions, which increases the possibility of penetration of the boundary layer and bringing it to the cutting zone. An additional effect that enhances their penetrating power is the so-called "secondary atomization" which further reduces their dimensions, homogenizes the aerosol and the ability to adequately bring into the cutting zone. In this context, there seems to be a limit value in terms of nozzle stand-off distance that significantly affects the efficiency of these cooling/lubrication systems. By placing the nozzles at a distance greater than the ideal reduces the efficiency of the system due to the lower speed of the carrier air and the additional reduction in the dimensions of the droplets. The droplets formed in this way do not have enough kinetic energy to penetrate the boundary layer, and in addition, there is a scattering of jets in the working space, and thus an incomplete effect of wetting and lubricating the contact surfaces.

Vegetable based oil with a lower kinematic viscosity index (Castrol with 39 mm^2/s), although far less influential compared to oil and water flow rates for the roughness indicators of the treated

surface, forms a more stable oil film on the contact surfaces in the cutting zone.

According to the experimental conditions of the test within the research, the ideal distance for almost all indicators of the roughness of the treated surface is at a medium level. Thus, a compromise is satisfied between the amount of working medium and the stand-off distance of the nozzles through the speed of the carrier air and the formed oil-on-water droplets in order to have a better cooling effect and lubrication of the contact surfaces. For the experimentally measured results, the significance was checked by statistical processing of data through the BIC criteria of variables for the significance level of 5%. The results of the ANOVA for the mean arithmetic deviation of the profile Ra, and the mean height of the irregularities Rz, are presented in Table 5. and Table 6. It is noticeable that for both presented quantities, the percentage contributions of the oil and water flow rates have the most dominant effect. By using a Pareto chart, aforementioned values can be graphically presented as shown in Figure 6. Similar to the case of cutting forces, the regression equations for the indicators of the surface quality as a function of the varied factors of the MQCL system are represented by equations and its coefficient of determinations in (5), (6), and (7).

Table 5. ANOVA results for the mean arithmetic deviation of the profile, Ra

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Model	5	0,330271	71,21%	0,330271	0,066054	4,95	0,015
Linear	4	0,251699	54,27%	0,251699	0,062925	4,71	0,021
A	1	0,037516	8,09%	0,048385	0,048385	3,62	0,086
B	1	0,153141	33,02%	0,172218	0,172218	12,90	0,005
C	1	0,029431	6,35%	0,019723	0,019723	1,48	0,252
F	1	0,031612	6,82%	0,031612	0,031612	2,37	0,155
Square	1	0,078572	16,94%	0,078572	0,078572	5,89	0,036
C*C	1	0,078572	16,94%	0,078572	0,078572	5,89	0,036
Error	10	0,133507	28,79%	0,133507	0,013351		
Lack-of-Fit	8	0,131394	28,33%	0,131394	0,016424	15,55	0,062
Pure Error	2	0,002113	0,46%	0,002113	0,001056		
Total	15	0,463778	100,00%				

Table 6. ANOVA results for the mean height of the irregularities, Rz

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Model	11	57,0000	99,24%	57,0000	5,1818	47,45	0,001
Linear	6	35,2824	61,43%	35,2824	5,8804	53,85	0,001
A	1	8,1839	14,25%	6,8645	6,8645	62,86	0,001
B	1	15,5164	27,01%	11,8189	11,8189	108,22	0,000
C	1	1,2240	2,13%	3,9213	3,9213	35,91	0,004
D	1	3,9014	6,79%	4,6388	4,6388	42,48	0,003
E	1	5,4131	9,42%	5,4797	5,4797	50,18	0,002
F	1	1,0437	1,82%	1,0437	1,0437	9,56	0,037
2-Way Interactions	5	21,7176	37,81%	21,7176	4,3435	39,77	0,002
A*B	1	7,2409	12,61%	2,6196	2,6196	23,99	0,008
B*D	1	2,1474	3,74%	0,1453	0,1453	1,33	0,313
C*D	1	1,5396	2,68%	5,1590	5,1590	47,24	0,002
D*E	1	1,6674	2,90%	4,5570	4,5570	41,73	0,003
D*F	1	9,1222	15,88%	9,1222	9,1222	83,53	0,001
Error	4	0,4368	0,76%	0,4368	0,1092		
Lack-of-Fit	2	0,1728	0,30%	0,1728	0,0864	0,65	0,604
Pure Error	2	0,2641	0,46%	0,2641	0,1320		
Total	15	57,4368	100,00%				

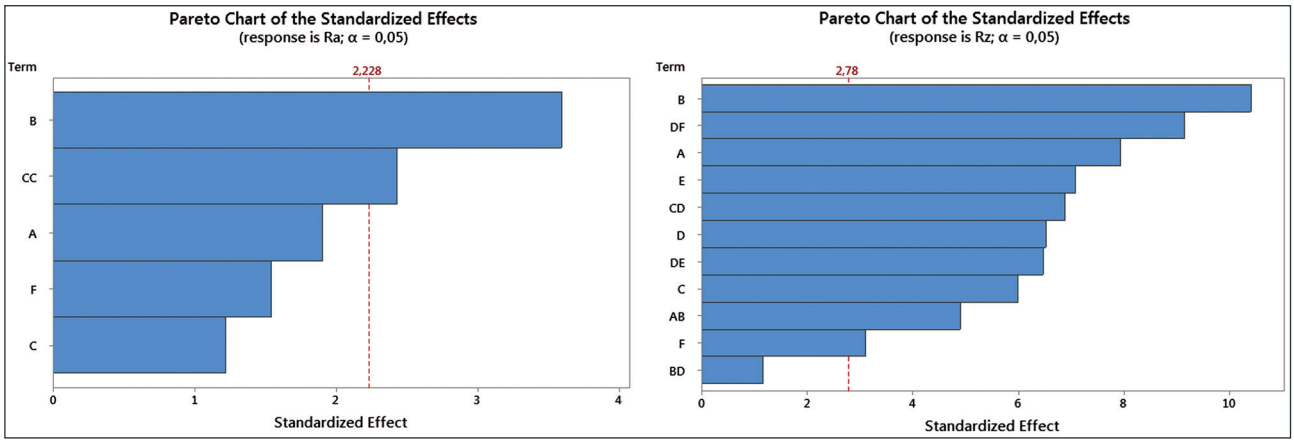

Figure 6. Pareto chart for Ra (left) and Rz (right)

4. Optimization of MQCL process factors

To determine the optimal MQCL process factor values, or more precisely, in order to minimize all cutting force components and all investigated surface roughness indicators according to the given regression equations, a process optimization based on desirability function was performed. Figure 7. is the optimization plot showing the optimal process factors of the investigated MQCL system with a high value of the desirability function, indicating that the optimal settings of parameters are almost ideal with a high value of composite desirability of 0,952. It is clear from Figure 6. that the predicted value of minimum cutting forces F_x=*263,42N*; F_y=*220,60N*; F_z=*541,68N*; and surface roughness parameters *Ra=1,12µm; Rz=5,287µm* and *Rq=1,291µm.*

Based on the presented analysis of the optimal processing conditions, it can be seen that the ideal value of the oil flow rate is 50ml/h, water flow rate of 300ml/h, the stand-off nozzle distance is 30mm by using a vegetable based cutting oil with a viscosity index of 39mm^2/s.

Such an atomized oil mist has to be applied to the rake face of the cutting tool through a single nozzle in order to meet minimum measured values.

5. Conclusions

In the aforementioned study we investigated the effect of control factors of the oil-on-water droplet MQCL system using the definitive-screening design. The study involved a six-factor design with three continuous and three categorical factors. The results can be drawn as follows:

- Through the variation of MQCL system factors with constant values of machining parameters, the influence of dominant parameters on the process conditions in the form of indicators of the surface roughness parameters and cutting forces was investigated. In the case of cutting forces, according to ANOVA, it was proved that the amount of oil and water, then the type of lubricant used are the most influential variables on the conditions of the process.
- Vegetable-based cutting oil with a lower index of kinematic viscosity (*Castrol Hysprey*) proved to be a more adequate choice in terms of cutting forces. The advantage of oil with lower index of kinematic viscosity from the aspect of lubrication is reflected in better fluidity properties, which can be related to the assisted effect of pulsating aerosol jet on which principle the analyzed MQCL system works.
- Other parameters of the MQCL system are of minor influence and are statistically insignificant on the results of the process. The exception is the interactive effect of the aerosol impact point and the number of off nozzles used, which is a statistically significant size.
- Statistical analysis of the experimentally obtained results of the surface roughness parameters *(Ra, Ry, Rz, Rq)* proves that the oil and water flow rates, and the nozzle stand-off distance have the most dominant effects. The nature of the influence of the stated parameters is identical for all indicators with minimal variations.

$$R_z=12,731-0,1717\times A-0,002128\times B+0,01494\times C+2,849\times D-0,6088\times E-0,323\times F+0,000123\times AB-0,000203\times BD+0,04990\times CD-0,5802\times DE-2,219\times DF \quad (R\text{-sq}=99,24\%) \quad (5)$$

$$R_a=1,409-0,00352\times A+0,000177\times B-0,00972\times C+0,00462\times F+0,000071\times C^2 \quad (R\text{-sq}=71,21\%) \quad (6)$$

$$R_q=1,72-0,00456\times A+0,000244\times B-0,01272\times C-0,1672\times E+0,0489\times F+0,000094\times C^2 \quad (R\text{-sq}=79,71\%) \quad (7)$$

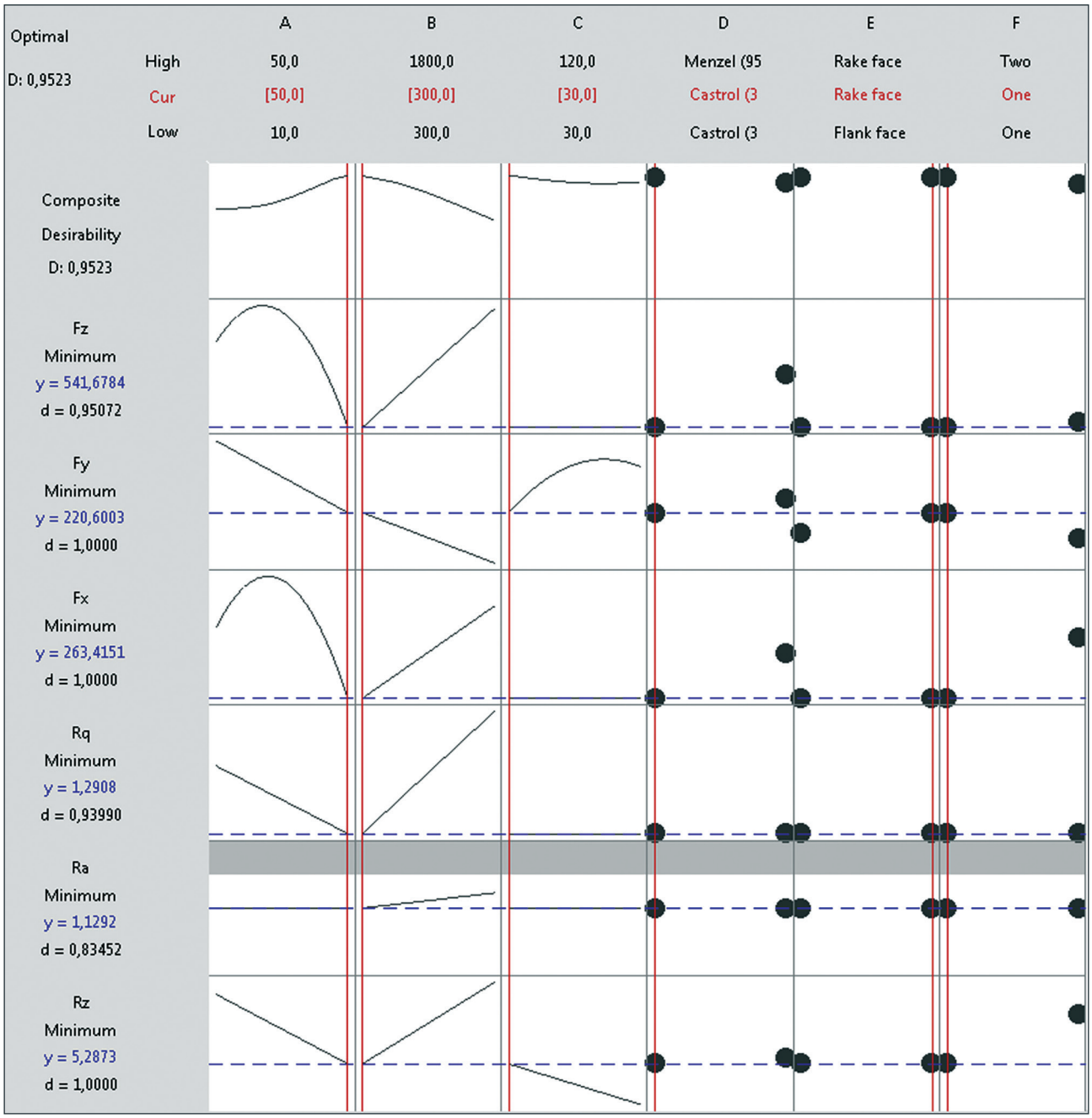

Figure 7. Optimization plot

When it comes to the amount of oil as the most dominant parameter on the test results of the turning test, it has been proven that there is a certain level of the required amount at which the so-called saturation effect occurs. This effect is explained through the process of hydrodynamically formed oil film which, by filling the micro-irregularities between the contact pairs, ensures the necessary and sufficient lubrication effects.

Observing the total amount of the cooling/lubrication medium into the cutting zone, it turned out that the effect of the MQCL system does not

depend only on the total quantity but also on the composition of the dispersed aerosol. The effective amount of aerosol formed in terms of better quality of the treated surface is that with a medium to maximum percentage of oil in the total mixture.

Maximum oil flow rates with lower kinematic viscosity and minimum water flow rates represent the optimal process parameters of the MQCL system at medium cutting parameters.

Optimization has proven that a shorter nozzle distance due to a series of satisfied compromises (carrier air velocity, velocity and dimensions of formed droplets, targeted jet delivery to the cutting zone, jet propagation angle, etc.) provides the best penetration conditions in the cutting zone and thus the best cooling and lubrication effects.

It is highly recommended that further research on MQCL turning processes of stainless steels should be conducted in combination with machining parameters (cutting speed, feed, and cutting depth) in order to consider the complete condition and impact of MQCL systems and point out their advantages as an alternative to conventional coolant and lubrication strategies.

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Water culture in the traditional architecture of Bosnia and Herzegovina

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Abstract

Through this writing the influence of water to the architecture and urban fabrics, particularly the form, design and function developed during the Ottoman period in Bosnia and Herzegovina will be analyzed in order to depict its significance in creating specific water culture. Furthermore, the social, spiritual and other intangible aspects of water culture are emphasized since they are inseparable in formation of its complete impression. Analysis of tangible and intangible aspects of water culture, lead to the conclusion that it was significant phenomenon, which influenced tradition as well as architecture in Bosnia and Herzegovina during the Ottoman rule and still is has important meaning by being a part of the Bosnian culture and tradition.

Keywords: Water culture, architecture, Bosnia and Herzegovina

1. Introduction: Water in correlation with urban development, and architectural design

Water is one of the natural elements which have the essential role in life maintaining, growth, progress and prosperity in general. It has the power to sustain, life **[1].**

With technological evolution and development, and higher standards, the need and demand for water exploitation increased in parallel. Therefore, in our century there is a notable occurrence and expansion of institutional regulations, laws, projects and organization dealing with regulation of water use.

Ancient civilizations first arose in the fertile valleys of the world's great rivers. Rivers patterns influenced human population dwelling places, commerce, and conquests since prehistory times, embedded in language, culture, and history.

Consequently, water has spiritual significance and meaning, high symbolism in many cultures and religions all over the world. It can be concluded, that in some way water shapes culture and vice versa.

Through different historical periods, water joined with architecture expressed different messages. It was often used as a symbol that indicates the wealth of the certain nobleman, power of the state, strength of particular corporation etc.

Water united with architecture creates wide assortment of different structures made for its use in various purposes, accompanied with different technical and decorative solutions.

In short purpose of water sorted by importance/ use can be summarized as:

1. Drinking / Cleaning
2. Agriculture
3. Industrial / Economy / Hydropower
4. Transport
5. Sport / Recreation (physical and emotional) / Health / Tourism
6. Aesthetic (decorative), Culture

2. Water culture: the term definition

In this writing one of the key words is the phenomenon named "water culture" or "water cult" which could be used in different contexts.

According to that, it is necessary to explain in which framework the phrase will be used in this writing.

"Culture is considered as a system of shared values, beliefs, behavior and symbols that the members of society groups use to interact with their social surrounding. The way in which cultures manifest themselves is made tangible through three different categories: 1. Beliefs and values; 2. Traditions, ritual, practices; 3. Symbols, artifacts". **[2].**

The water culture presents the people's relationship with water and its consumption by various ethnic groups in particular time or place (in

different cultural contexts). Simplified, it is the culture of living along with water.

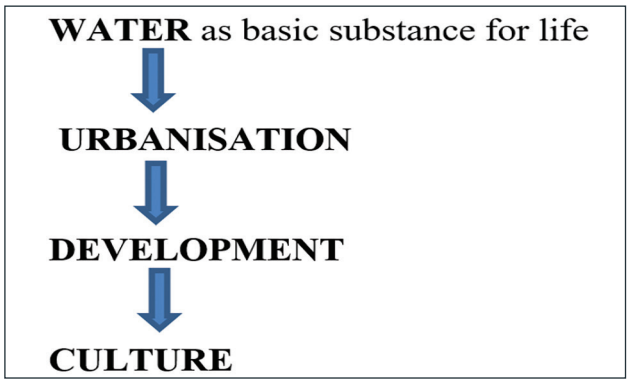

Figure 1. Simplified scheme of Water's connection with progress of civilization, development and culture as the final effect.

Furthermore, cultural and traditional occasions in the past were mostly performed in places where water was destined for recreational or spiritual purpose.

Good examples of architectural are traditional baths which were, at the time, also one of the most frequent places for socialization and sometimes preparation for religious performances (habitually at Christianity, Islam, Judaism etc.)

In Europe, especially in the Middle Ages and under the influence of the church, ban on the public bathrooms had powerful influence for a long time. In most of Europe, except the Balkans, Russia and Finland, people started regularly wash themselves just between one and two hundred years ago **[3].**

The tradition of bathing as socially, emotionally and physically satisfying experience still exists in many cultures, with time improved with modernized techniques.

3. Water and water cult in Bosnia and Herzegovina, during Ottoman era

One of the most important resources and greatest values of Bosnia and Herzegovina is clean water.[1] Bosnia and Herzegovina is a mountainous area (mostly karst terrain), with many river valleys. River valleys are areas where first dwellings begun (by water) and later in those areas first Bosnian settlements were formed.

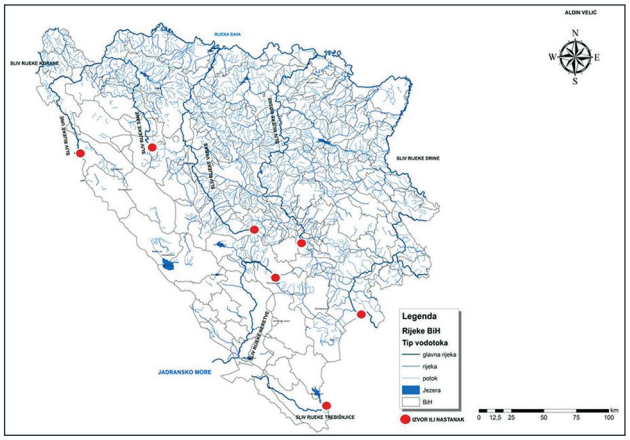

Figure 2. Map of the Bosnian rivers [4].

First identified architectural structures by water, or for its usage were from Roman period, when "water culture" started its rudiments in this area. Today they can be found in traces and only as archaeological remains.

Medical features of thermal waters were well-known during Roman and Ottoman Empire also (Banja Ilidža, Gradačac, Banja Kiseljak, Kiseljak mineral water, Banja Laktaši, Fojnica, Sanski Most, Bihać, Bjeljina, mineral water of Olovo, Slana (salty) banja Tuzla, Višegrad, Banja Luka's geothermal waters etc.) **[5].**

Country is abundant with mineral springs and they were used in that purpose even in first century. Even in that period there were baths in wealthy houses or villas[2]. That tradition in Bosnia and Herzegovina has been extended by influence of the Ottoman Empire **[7].**

During the Ottoman period (1463-1878) very different lifestyle and amenities, mostly related with the arrival of a new religion (Islam) were introduced to this country.

1 In Bosnia and Herzegovina there is 262 (smaller and bigger) rivers, and very small part of Adriatic Sea coast in Neum, about 25 km, and meaningful number of natural lakes and accumulations. In Bosnia and Herzegovina, isprosperous with thermo-mineral springs, underground rivers and waters enriched with minerals [6]

2 „Thermae have been found at many of the „rustic villa" that have been explored in Bosnia and Herzegovina. They fall into two groups, depending on their position:
1. The first group consists of baths that were separate from the dwelling areas and farms,
2. The second group consists of bath suites that were incor-porated into the building to form a single entity" [10].

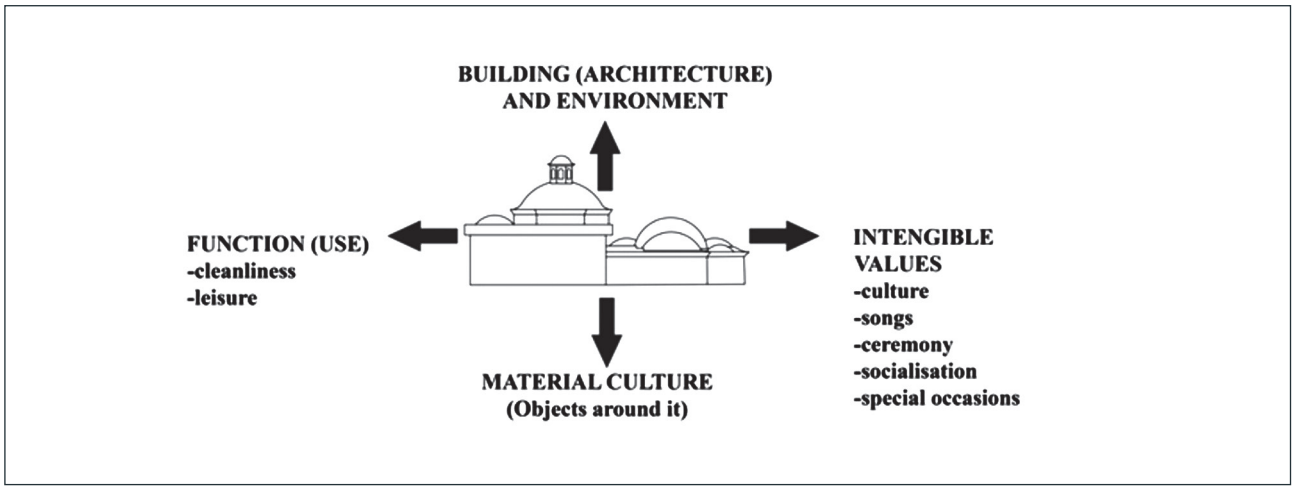

Figure 3. Tangible and intangible aspects of water cult scheme [8].

Daily bathing as habit and cleanliness generally has become very important part of daily routines.

Bathing, by purpose, can be divided in 4 groups:
1. For personal hygiene/cleanliness,
2. Ritual/religious,
3. Therapeutic/ health and
4. Recreation / leisure.

4. Material and spiritual segments of water cult

Material culture includes society involvement and it is in shape of material goods. Yet, spiritual is associated with art, religion, feelings, philosophy. Physically, material is visible while spirituality is present in our mind and feelings. These two categories are usually referred as tangible and intangible values or legacy **[8].**

Importance of inherited material culture and spiritual values is present in human understanding of identity **[9].**

Cultural transmission is elaborated through understanding of the properties of artifacts, the traces of the past.

Water cult expansion and need for the wide assortment accessories influenced the development of new crafts in urban areas. Chlothes and cosmetic products for bathing were mostly imported, while wooden, copper and other metal objects were also made in Bosnia by domestic craftmans **[7]**. That way, they supported development of certain crafts and activities and vibrancy of the urban cores.

Figure 4. Findings from archeological excavation in Firduz Bey hammam clay pipes, copper bowl for water (tas) [11].

Figure 5. Photographs from the National Museum in Sarajevo: exponents of water culture heritage, hammam equipment: left-rug and bowl and right-hammam clogs

Figure 6. Photography from the National Museum in Sarajevo: Copper bowl „Ibrik“ (Mentioned in many folk songs), typical for daily use for water in that period.

4.1. Material expression of water culture

It has to be noted that architectural and infrastructural constructions are not only important on behalf of their pure function or as tools for water usage, but also should be emphasized as material (tangible) expression of water culture.

4.1.1 Traditional settlements of Bosnia and Herzegovina built in Ottoman period

When Ottomans came to Balkan area, a new type of urban fabric and settlements spread all over the Bosnia and Herzegovina. It was applied in areas ruled by the Ottoman Empire. Their maintenance was managed within charitable foundations „Waqf”**[12].**

Water presence in public and private buildings indicates importance of water in formation of an Ottoman urban settlement from multiple points of view **[8].** This model of settlements establishments, by the similar principle was applied in Bosnia and Herzegovina later, but in much smaller scale.

For Ottomans it was great pleasure to see the running water and hear its sound. They gave a great respect to the water, as in life, as in architecture. They built the pubic fountains, drinking fountains, water channels and water structures everywhere where it was possible, even in private houses **[13].** Drinking fountains are examples of meeting point, meaningful from the aspect of socialization in Bosnia and Herzegovina. **(Figure 11)** demonstrates the use of water in residential architecture jointed with landscape to form special climate and pleasant place to live in (especially in dry and hot Herzegovina summer days). Similarly, the high-level relation of traditional residential architecture, nature and water can be seen in complex of Velagićevina in Blagaj, set on the bank of river Buna **[14].**

Fresh water from nearby river Bregava through open channels flowed in private gardens. It is representative example of very high and ecologically accepted standards, even for contemporary time.

Figure 7. Residential compound Begovina in Stolac [15] with water channels through gardens (marked with blue arrows).

Figure 8. Stolac is example that resembles to Ottoman settlements (by its concept) placed next to water/river, where water is excellently used in various purposes and is contributing to the concept of this town in Herzegovina [15].

Figure 9. Place for religious ablution or abdest in the garden of the entrance and place for abdest on the vestibule of the house, visible on the house facade [17].

4.1.2 Water culture inside of private areas (homes) in Bosnia and Herzegovina

Almost every house in urban areas in Bosnia and Herzegovina had place for bathing **[7].** Among Bosnian Muslims there was not only five times-a day ablution ritual. They applied a *gusul* bath (religious ritual of washing the whole body) obligatory washed their hands before and after meal and mouth after meal. It was also obligatory to perform the bathing of dead person before funeral etc. All of those rituals were a part of daily habits and bathing culture. In the cause of maintaining the personal hygiene their houses had also private baths called *banjica or hamamdžik.* To provide the warm water they were usualy placed beside a furnace **(Figure 10).**

Although the people technically could take abdest in the *banjica,* they usually performed the *religious ablution*- washing before pray in the special basins of in house where the wasted water did not flow with together fecal water **[16].**

There were even examples of small hammams of private houses, (Hasanbeg Rizvanbegovic house in Stolac and many different cases of private baths in Bosnian houses in that period **[7].**

Underneath (Figure 10) is example of Svrzo's house, one of best preserved examples of Ottoman comfortable lifestyle in the city (in wealthier houses).

Figure 10. Example of house bath, wardrobe with furnace and toilet from Svrzo's house, which is contemporary Museum of the Sarajevo [17].

4.1.3 Public water structures of Ottoman period in Bosnia

In Bosnia and Herzegovina subsists wide range of water structures: bridges, wells, mills, fountains and faucets, water supply systems, swimming pools, thermal spa, leading to the contemporary types as the hydro –power central…, and their development was affected from many different cul-

tures which had been influential on land of Bosnia and Herzegovina in different periods of time. There has been Illyric, Roman, Slavic, Ottoman and Austro-Hungarian influence in this area. All of them gave specific signet, some of them more than others, and made Bosnia and Herzegovina multicultural and 'colorful' as it is also today.

Architectural elements or even complete urban assembles from Ottoman period, made deep influences in formation of urban fabric, and still are engaged as a "living part" of many contemporary urban settlements:

Water structures of Ottoman Bosnian urban settlements:

Hamamlar (hammams), ***hamami***
Şadırvanlar (fountains), šadrvani
Çeşmeler (drinking fountains), **česme**
Sebiller (special public faucet constructions), ***sebilji***
Musluklar (faucets), česme
Sarnıçlar (cisterns), ***cisterne***
Köprüler (bridges), ***mostovi***
Su değirmenleri (water mills), ***mlini*** **[18].**

In Bosnia and Herzegovina ***public baths (Hammam)*** use primarily started when Romans came to this areas, then continued in form of Ottoman hammams, after that appeared Austro-Hungarian public baths with more modern facilities, and now, in contemporary time, continued in form of swimming pools with modern equipment, modern spa and sauna systems (mostly as a part of hotel/touristic offers).

If we observe example of Ottoman bath or hammam, which was „imported" to Bosnia with other supplementary elements, we will reveal the type of architectural structure that comprise all purposes (cleanliness, religious rituals, health improvement, leisure and socialization).

Wells- are maybe first and, at the time, important water structures because of their purpose (to provide drinking water). In Bosnia and Herzegovina, according to their purposes and the way of collecting water, different types of wells could be found.

In karst Herzegovina water was very valuable and it was hard to get. Collecting rainwater method- (čatrnje) sometimes even by help of animal's strength.

Even after the city water supply systems was well-developed, many water wells are still remained in private houses in Sarajevo. Some of them still survive as a memory and meaning of something that brings good into household **[7].**

Fountains (Shadrvan, Sebil and Faucets) are one of the most representative and frequent examples, or favorite architectural element used in purpose of symbolism (symbol of life, symbol of

Figure 11. Drinking fountain in Sarajevo, from the old postcards of the city. (Historical Archive of Sarajevo)- left, Sadrvan in front of the Begova mosque –right. (primary built 1530 and renovated many times).

power) through different historical periods. During Ottoman period many types of fountains and faucets shaped in different architectural designs were built accentuating the importance of the water cult, especially because of the fact that providing the clean water for people was one of the most respectable shapes of benevolence at that time.

Figure 12. Wooden and clay pipes from old Ottoman water supply system. [7]

Mills have been the early type of water structures which used water for production. Old Mills on river Pliva in Jajce are the exemplar ensemble consisted of 20 old mills adjusted with natural environment. They present simple folk structures beauty **[15]**. They were renewed in 1985. Today they belong to the cultural heritage of Bosnia and Herzegovina and are also adapted for visiting in the tourist purposes.

Figure 13. Mills in Jajce [19].

Bridges from Ottoman era built over the Bosnian rivers remained in present time as one of the most valuable architectural monuments. Beyond testifying certain period of Bosnian history, they are also recognized as symbols of cities. They were usually built in classical Ottoman style shaped into elegant but solid arched shapes (**Figure 14).**

Crafts by the water: Hitting and rolling of fabric, used for clothing sewing for home use in the form of rugs were prepared in the river. Stolac on river Bregava was recognizable after these old crafts. They still use them for washing rugs.

4.2 Water cult: Spiritual values

"Spiritual is considered as universal experience of the human" **[23].**

It is commonly, when mentioning spiritual, that people frequently associate it with religion. In reality, it is much more extensive and multimeaningful term. Spiritual is very often integrative with the cultural from numerous points of views [3] **[24].**

4.2.1 Art

Water as segment of daily life, segment of architectural works, different amenities, or objects for its use, were mentioned many times in songs and poems.

Water culture, as phenomenon and as media of connection between people, remained a part of spirit in Bosnian cities until contemporary time. It was often mentioned in old „*sevdah*" songs *(sevdalinka),* and it is mentioned in modern (leaned on traditional roots) popular songs of new generations.

Even western artists saw the inspiration in strenght of water symbolisim in Oriental culture. Shadrvan often appears as the place for social meetings and important part of public life and interaction. Yet, hammam was usually the place where social interaction was accentuated, inspiration in paintings and arts generally. Fountains were well known as places where people had chance for meetings (neighbor talks, daily news, young couples meeting place etc.).

3 Culture is still also used in the sense of a general process of spiritual, intellectual, esthetical and technological development or, in other words, a process of increasing civilization [25].

Figure 14. Old Bridge Area of the Old city of Mostar, river Neretva [20], Herzegovina (left); The Mehmed Paša Sokolović Bridge, river Drina, Bosnia (right). [21]

Figure 15. "Mlinice" and "stupe" in Stolac (developed in Ottoman era) for washing rugs and clothes [22].

Figure 16. Painting of hammam interior atmosphere [3].

4.2.2 Linguistic influences

When speaking about intangible heritage of one nation, definitely, we have to take into the consideration, as well its language. The linguistic heritage is the prominent indicator of various influences from other regions to Bosnia and Herzegovina.

As a part of the intangible heritage, from the time of the Ottoman rule many words remained in the Bosnian language as the legacy from Ottoman Turkish. Most loanwords were adopted from its origin, with adjustments to the bosnian language. During the almost five centuries, Ottomans strongly influenced the local people in many levels.

„Variant of Serbo-Croatian was favoured by political centres of power in Yugoslavia**[26].**

In all Old Yugoslavia languages, which were affected by Ottoman linguistical influence exist the expression *„turcizmi"*[4] which is used for words that retained in use (with small justifications to the slav languages).

4 In the dictionary „Hrvatski enciklopedijski rječnik" (Croatian Encyclopedia Dictionary) the word turcizam is explained as polysemous"[27].
(All of them remained in contemporary use, as the legacy from Ottoman rule, especially ones from tradition of hammam bathing. Some of them were completely new expressions in Balkan area. As the tradition itself, those words were the new terms that were not in use before Ottomans.)

5. Conclusion

Bosnia and Herzegovina is place of many cultural mixtures and influences on small territory. Today the water cult shaped by various impacts through the past is inwrought in Bosnian heritage and presents one of the cultural legacies. During Ottoman period the special water cult has been developed, and it has been expressed in tangible and intangible features. Consequently, in the new net of settlements built in Ottoman period various types of structures and objects for water use has been developed and they are still testifying water cult of Bosnia and Herzegovina.

After the analysis of all aspects of water cult it is observable that the phenomenon of water cult had significantly participated in architectural creation and traditional behaviors in Bosnia and Herzegovina during Ottoman era.

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Mechatronic dog feeder systems

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Abstract

Today, the dog feeder is a modern device. However, the requirements and needs of dog owners are expanding every day, so that the innovation of such devices is unimaginable without the installation of a large number of electronic components. By installing sensors, actuators and RTC modules (Clock Real Time), a mechatronic approach to the commissioning of existing devices is achieved.

Mechatronic integration of components should allow adjustment of time interval, quantity and preparation of dispensed food. All these requirements should be combined with the development of an automatic feeder which, in addition to the mechatronic feeding module, also integrates a water service module.

The setting of parameters and the programmable mode of operation of the automatic feeder provide the possibility of a proper dog nutrition, based on a veterinarian recommendation.

Key words: Automatic feeder, programmable mode, ultrasonic sensor, RTC module.

1. Introduction

All dog owners know the effect of adequate and timely nutrition of their pet . However, due to the busyness of the owner, and other life activities, it often happens that the dog's diet is prolonged or completely omitted. Also, due to ignorance, owners are often not sure how much and what vitamin structure they should feed their dog. All this doesn't reflect the lack of care of the owners, on the contrary, they are very often attached to their pet and want to provide them with maximum care.

In addition to adequate nutrition, water must always be available to the dog [1]. Due to physical activity, dogs often get very hot, and because of that they need to drink water constantly so that they can get colder. For that reason, the automatic feeder should also provide permanent water supply.

1.1 Dog nutrition

One of the way to avoid very common obesity by dogs are increased physical activity but it should be clear that proper nutrition is essential for a healthy life of a dog. However, owners are often not instructed in their pet's dietary specifications.

The age and healthy condition of the pet often requires different diets, which owners should adhere to. What owners often overlook is the fact that the diet differs from the breed, age and even from the physical activity of the animal.

In order for the dog to have a balanced diet, the veterinarian's recommendation is to feed him every day at the same time with a controlled amount and type of food. If the diet is unbalanced, or in larger quantities, various disorders occur in the body which leads to the disease development [1].

For this reason, there are a large number of cases in the world where a certain type of dog suffers from obesity or malnutrition. This happens in 35% of cases, which leads to their early death.

Dog disease very often doesn't reflect the negligence of the owner, but occurs as a result of insufficient information on proper nutrition. Owners must also be instructed whether the dog's health condition may require special diets.

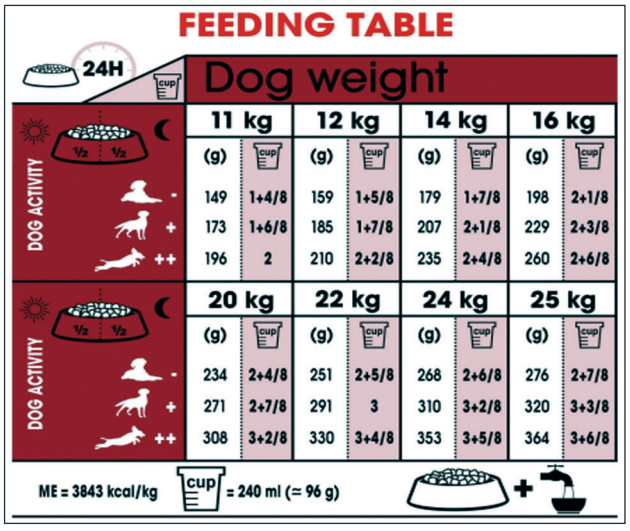

Figure 1. Table of proper dog nutrition[2]

Determining an adequate diet is achieved with a mandatory medical examination and a recommendation from a veterinarian. Among others, the recommendation of veterinarians is that dehydrated food is a safest option for feeding of the dog [2]. There are tables on the dehydrated food packaging that show the required amount of food, regarding the breed, the age and the weight of the dog, so that the possibility of incorrect feeding of dogs by the owner is reduced to a minimum (Figure 1.)

2. Automatic feeder model

The automatic feeder should, at a certain moment, react like the owner himself, communicate with the dog and dose the required amount and composition of food from the tank.

In order to meet the growing demands and needs of the owner, the feeders should have the integration of electro-mechanical components that unite the modern system. The feeder model should consist of a food dispenser module and a water dispenser.

To ensure the healthy life of a pet, it is of great importance that the food is dispensed in a precisely determined composition and quantity and at a determined time. This is a special diet that is very often part of the veterinarian's advisory recommendation.

Figure 2. Physical model of the feeder

3. Mechatronic integrations of the components

Integrating the components, the automatic feeder ensures a right and adequate way of feeding the dog. The correct way of functioning of the feeder is defined through the mechatronic modules of the food and water dispenser, who perform all the needed tasks. The modules integrate moving mechanical parts with sensors and actuators.

Figure 3. Interior of the automatic feeder

3.1 Food dispenser

The food dispenser is a complex module of the mechatronic system of the feeder. It is made of three compartments, in which are three different food placed.

Components A, B and C are transported to the part of the feeder where they are joined together, via the three output canals using gravitational dosage, and then are placed in the feeding bowl.

For individual feeding regimes, the food dispenser module dispenses the needed amount and compound of food, using different food compartments. The vitamin mode of the food dispenser is based on dispensing one, two or three components in the right ratio. The dispensing is achieved by activating servo motors H1, H2 and H3, who conduct the dispensing in different ratios. (Figure 4).

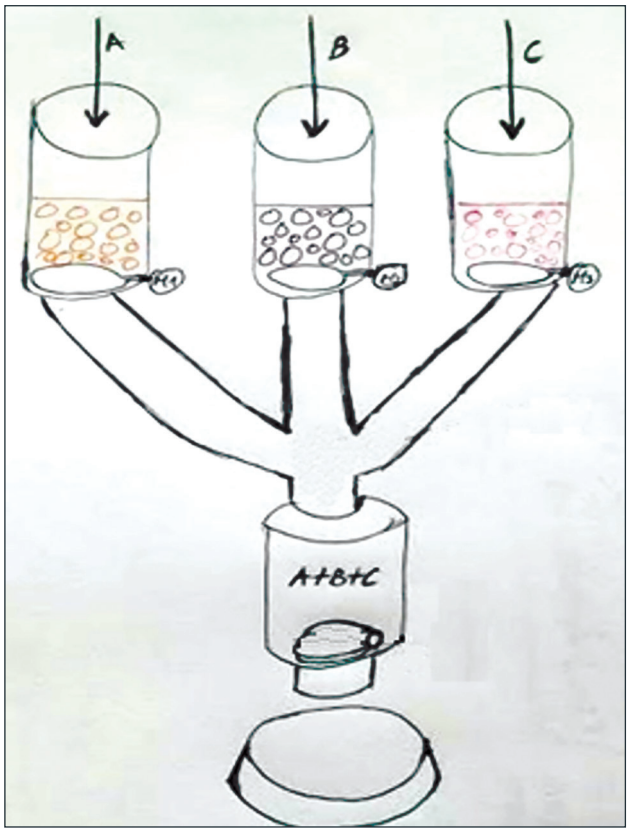

Figure 4. Food dispenser sketch

3.2 Water dispenser

The water dispenser is also an important mechatronic-integrational part of the feeder. It is located in the housing of the feeder and, combined with the ultrasonic sensor and actuator, regulates the level of the water in the container (Figure 3). When the sensor reads the distance in front of it, it sends a signal to the Arduino and notifies it that the water bowl is empty. That signal is further sent to the servo motor, which starts running and opens the valve, which lets water out of the container. The water bowl starts being filled with water until the desired level is reached (which is specified in the Arduino code). When the food bowl is empty or the water is not reaching the desired level, the motor is activated and opens the valve so that the water level can rise to the desired amount. When the water bowl is filled with the desired amount of water, the motor shuts down.

3.3 Program mode of the feeder

The program mode of the feeder is set and adjusted to the needs of an older dog, whose health conditions, breed and age demand limited feeding for example a feeding regime where is the dog is fed two times per day with three different structures, which are recommended by the veterinarian.

The feeder is programmed so that the food is being dispensed two times throughout the day, in the exactly specified time. Three micro servo motors are built into the dispenser module, whose main task is to dispense the food component from the individual containers. The amount of the dispensed component is regulated with the number of revolutions of the motor.

When the food dispensing is done and the motor has stopped working, a buzzer is being activated via the speaker (as an actuator) and it consists of tones defined in the program. The sound signal of the feeder serves as a mean of communication with the pet as well as a notice for the dog that the food was dispensed.

RTC (Real Time Clock) is a computer clock who is being used to execute specific feeder activities in the precisely defined time. The RTC is a multifunctional module time and date tracking and presents the most important part of the feeder (Figure 5). It also has an adjusted battery, which supports the module during operation if there is no electric current available.

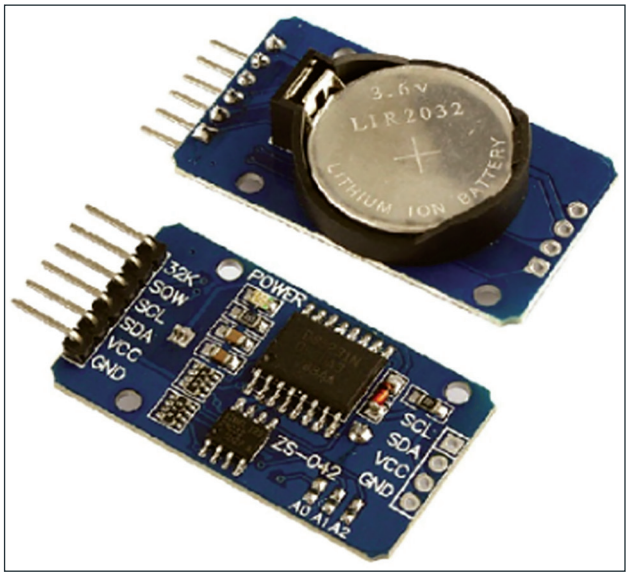

Figure 5. RTC module

With the RTC module, the signal is sent to the motors in the time defined in the Arduino program. When the servo motors receive the signal, they start running and dispense the food out of the container. The duration of the motor's running

time is defined by the number of repetitions of the commands for motor rotations, which are specified in the Arduino program.

The breadboard is a constructional base which is being used for connection of the components with the Arduino (Figure 6). Arduino Uno is a microcontroller board that integrates the control structure of the feeder, which is being used for communication between actuators and sensors and thus achieving the functionality of the feeder [5, 6]. Among other actuators, a servo motor MG996R is being used, whose purpose is for opening the valve of the water container. The ultrasonic sensor HC-SR04 is being used to measure the water level.

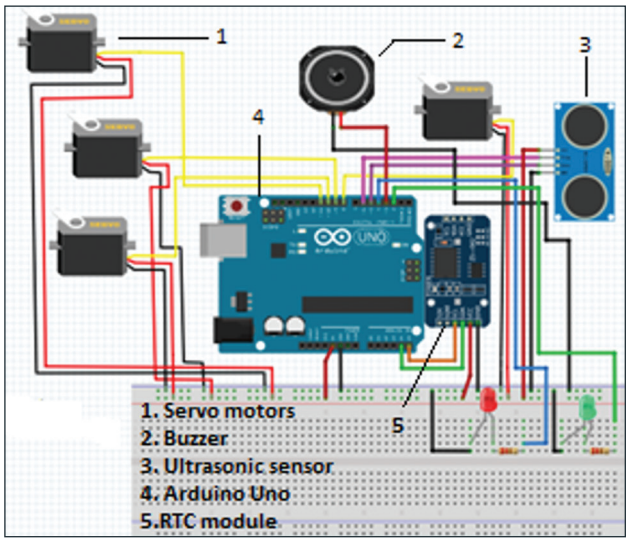

Figure 6. Diagram of the mechatronic integrations of the components

Conclusion

The built mechatronic model of the automatic feeder, with the help of actuators and sensors, makes an automatic feeding regime possible, by dispensing the prescribed amount of food in the exactly specified time. By doing so, it ensures a proper feeding regime and the numerous tasks of the owner are reduced to a minimum.

Depending on the breed, age and health condition of the dog, the automatic feeder gives the opportunity of a programmable feeding regime, which are recommended by the veterinarian or the advisory person.

The biggest contribution of the improved feeder lies in the possibility of adjusting the time interval for the feeding, as well as the amount and compound of the food dosage. This programmable mode achieves timely dispensing of the needed amount of food and so ensures a healthy feeding regime for the dog. Even though the modules are based on the specification of a certain breed of dog, they can be adjusted depending on the needs, age but also for another dog breed.

The automatic feeder can be used for different feeding regimes for all dog breeds. This mechatronic approach to integration of electronic components should prompt a development of automatic feeders for every type of pet.

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