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Analyzing the effect of magnetic field on Lubricoolant in machining process

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Abstract
In this paper, literatures about one of the most important problems in mechanical engineering is analyzed. It is obvious that cutting process has a huge impact on accuracy of machining detail and improving the condition of cutting process helps to increase the accuracy of machining detail. Authors analyzed the research works and papers, which is related to effect of magnetic field on liquids. Their purpose of studying those research works is using magnetic field in machining processes, especially, in the condition of lubricating cooling. As a result, they found very essential dates about the effect of magnetic field on liquids.

Keywords: Cutting process, electromagnetic field, fluid, lubricoolant, machining, magnetic field, induction

Introduction
Manufacturing and mechanical engineering is being developed and increased in the Republic of Uzbekistan. There are about hundred machine-building plants, which are working in Uzbekistan. Tashkent metallurgical plant, which are provided with modern technics and technology, is planned to start working during next 2-3 years. Cutting processes has been started to use in machining factories very fast.
Cutting materials has its special point among many technological ways, especially, details, machines and equipment with exact sizes. Nowadays, demand for competitive exactitude is increasing. Universality of mechanical machining "Flexibility" increased its advantage in many production such as standard production, serial production etc. it is possible to reach high accuracy by cutting job. Quality of the machined surface also would be higher. Moreover, cutting is cheaper than other methods: Energy consumption, preparation time of the plant for manufacture are also low. For example, it is cheaper than casting and working with pressure.
This problem is much complicated and serious. The most Famous and talented scientists of the world who worked and are working on the sphere of cutting metals were introduced following basic specialties for developing the subject of cutting:

- Quickening the process of cutting- "intensification"
- Mastering working with new modern materials
- Atomizing and mechanizationing of the process
- Increasing quality and accuracy of working
- Rising scientific degree of explorations

Mechanical working is different with its high effectiveness, "Flexibility", opportunity of machining difficult surfaces and forms, high surface quality, machining new materials (composite materials).
It is important to add high working effectiveness, least energy consumption, technological machinability, reliability and universality.
Controlling the effect of lubricating cooling liquid for intensification on the process of cutting is being important during the last years.
One of the tendencies of developing machine building is application of new technological processes. Especially, by using the achievements of two or more subjects. Nowadays,

Magnets, thermo magnets, thermo electrical conditions are being widely utilized for increasing working effectiveness, decreasing the cost of the product, creating new competitive product.

Work of [14] is in the sphere f metallurgy. Particularly, effect of magnetic field was examined on thermal working of the detail, which is made of high cutting instrumental steel. At first, constant magnetic field affects to detail which is made from P18 steel: temperature is 20 ^{0}C; intensity of magnetic field is more than 7.5*10^5 A/м. It was remained two minutes in each cycle then it was worked thermally. According to author's opinions, reliability of details, which is made from fast cutting steel, can be increased by this invention.

Literature review

Gaponova O.P and Troitskiy A.N [18] has studied the effect of heat treatment on fast-cutting steels hardness under magnetic field. They emphasized that cutting properties of fast-cutting steel can be provided by alloying with high carbides, such as W, Mo, B and Co which doesn't make carbide. If P18, P12 high wolframed fast-cutting steels are changed by more cheaper P6M5 steel, physical mechanical properties of P6M5 are increased by heat treatment using the method of progressive way.

To their point of view, changes of steels and structural changes of steels are because of heat treatment. Heat treatment was carried out in two ways: 1 – temperature of details was increased until it reached treatment temperature under the magnetic field. 2 – Detail was treated under electromagnetic field. Steel P18 has been chosen for experiment and electromagnetic end solenoid oil were settled in container. In the variable magnetic field, Hardness of tempering and hitting viscosity increased and extracting of rest austenite hastened. Process of independent tempering is emerged by the effect of magnetic field. That condition is increased if carbon which is in the structure of steel increases. Structure is more in magnetic field (it is dispersed). In high car boned steels (>0, 6%), because of self-tempering in austenite – marten site adjusting, decreasing of rest austenite and increasing of marten site can be seen. As a result of this, characteristics of solidity and plasticity is increased.

Numerous papers reported that the magnetic field could change the physicochemical properties of water since several decades [1–9]. When water passing through a magnetic field, it become magnetized water. Han *et al.* invented the optical properties of water that between two strong magnets, they found that the infrared absorption property of magnetized water changed [2]. Holysz *et al.* concluded magneting could enhance the conductivity and decrease the surface tension of water [3, 4]. Wang *et al.* has analyzed the effect of a static magnetic field on liquid water using frictional experiments, the results suggested the friction coefficient was smaller in the magnetic field [5]. Cai *et al.* studied the effect of magnetic field on the hydrogen bonds of water, and discussed the mechanism of magnetization based on molecular dynamics simulation, experimental and theoretical models [6–8].

A.G Gvodzev and others [25] studied influence of impulse magnetic field on structure and characteristics of alloying steels and they concluded that it was not traditional method. In the results of carried experiments, impact of magnetic field on structure and physical-mechanical properties of materials: hitting viscosity, wearing by friction, hardness and plasticity has been showed.

E.A Umarov and F.Y Yakubov [19, 20] defined that magnetic field do not always impact on firmness of cutting tool and thermal electrical coefficient of thermal pair similarly. It depends on cutting condition.

S.M Xasanov [26] concluded in his work that technological condition, influence on generation process of oxide layers and existence of magnetic field.

V.E Nikolskiy [27] analytically and experimentally investigated the influence of magnetic and electric fields with tension gradient in the direction of the movement of the contacting gas-liquid phases. The choice of the most effective method of impact on a heat mass exchange process for the purpose of increase in energy efficiency of submersible burning devices are executed. They offer the control method of fluctuations in the contacting phases of gas-liquid with the use of measuring transducer with the cylindrical resonator.

F.L Rashid and his colleague [17] presented an investigation of water evaporation through magnetic field of 0.5 T, which was located at different location of tested water height (water-air interface, water mid height and bottom). An increase in evaporation time led to increase the evaporation rate, the preferred location of magnetic field is at the water-air interface which gave more evaporation rate (6% more than absence magnetic field) compared with other location, there is no effect was seen in the case of putting magnetic field at the bottom of water height

Water treatment by magnetic field or physical water treatment is an attractive but still controversial issue. M Amiri and A.A Dadkhah [16] investigated whether or not a physical water treatment reduces the surface tension of water as reported in some scientific literature. In their work, physical water treatment phenomenon was studied by measuring surface tension of treated and untreated waters. More than 200 tests were done during a six-month period in various conditions to evaluate the validity of the observed phenomenon. The test results showed that surface tension of water is too sensitive to experimental conditions to be considered as a safe and reliable indicator for studying the effects of magnetic field on water. It was found that meaningful changes in surface tension of a liquid sample after a day can be a good indicator for presence of physical or chemical changes in the sample.

It was found that the surface tensions of both tap and pure waters depend on frequency of magnetic treatment. Fig. 1 shows the effect of number of magnetic treatment (frequency) on surface tension of pure water. Magnetic field treatment of tap water also resulted in the similar trend of reduction in surface tension.

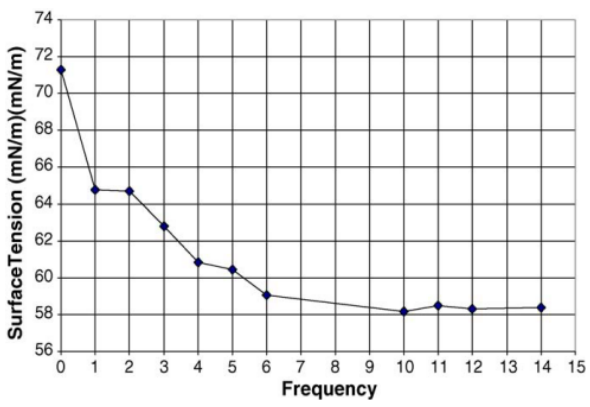

Fig 1: Dependence of affecting frequency of magnetic field on surface tension of pure water

V.N Tritigin *at al.* [13] studied the influence on microflora of water-oiled lubricant cooling liquid of a weak electromagnetic pulse field. The hypothesis of action of an electromagnetic pulse field of extremely low-frequency range on a micro flora is presented.

Throughout the works on a research of cleaning of water oil emulsions influence of the pulse electromagnetic field (PEF) of extremely low-frequency (ELF) range on microflora of the lubricant cooling liquid (LCL) was studied.

In use, the emulsion lubricoolant becomes soiled microorganisms. Lubricoolant is characteristic signs of microbiological defeat hydrogen sulfide selection (the second hazard class) and other accompanying gases possessing an unpleasant smell. Lubricoolant with a steady unpleasant smell even at high technical characteristics, it is unsuitable for application and it has to be replaced. Smell of lubricoolant is one of the controlled indicators, determined by a special technique organoleptic and it is directly connected with concentration in its bacterial flora characterized by its general microbe number. So far for decrease in concentration of microorganisms bio additives are entered into lubricoolant.

Results and discussion

The main effects arising under the influence of magnetic field – polarization of cellular structures, change of membrane potentials, local heating of a cage, breakdown of a cell membrane, etc. that finally leads to braking of growth rate and cell fission and their death.

Installation consists of two parts: power source 2 (generator of pulse currents (GPC)) and inductor 3. In the inductor, the pipe (camera) 4 of magnetically inert material was inserted. On top, through a funnel 1 gave diameter to a pipe previously mixed lubricoolant, about 100 ml. Speed was regulated by a valve 5 and the limiters of a flow 6 which are nozzles with a certain diameter of an opening. Processed lubricoolant gathered in the capacity 7, it was selected in the sterilized ware, and further it was transferred to analyzing - to OMCH and if – the index. Exhaust speed of an emulsion was determined by a standard method – by time of filling of a certain volume. Strength of pulse magnetic field in the solenoid - calculated value. Current intensity and discharge time were calculated according to the oscillogram of an impulse received on the dual Strength trace oscilloscope of pulse magnetic field in the coil of the solenoid was determined by the oscillogram of an oscillograph of C1-117 type by an estimated way.

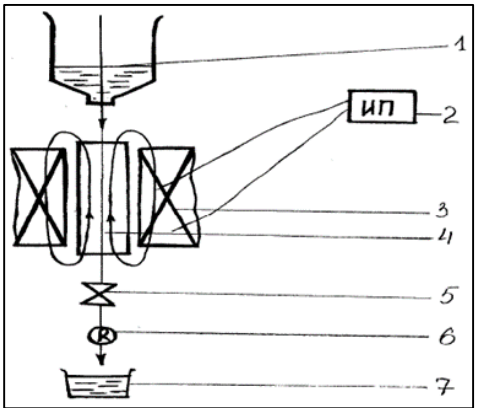

Fig 2: The Schematic circuit of installation for processings lubricoolant in pulse low-frequency magnetic field: 1 - funnel; 2 - power source (generator of pulse currents (GPC); 3 – inductor (solenoid coil); 4 - camera; 5 - valve; 6 - flow limiter; 7 – capacity

Strength of pulse magnetic field in the coil of the solenoid was determined by the oscillogram of an oscillograph of C1-117 type by an estimated way. As a result of the conducted researches it was set (fig. 3)

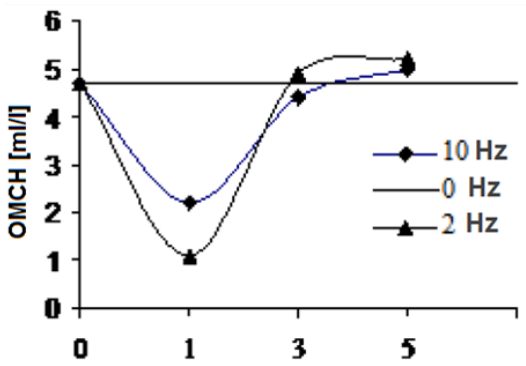

Fig 3: Impulse torsion of magnetic field in the coil of solenoid

I.M Ageev [15] has noted that one of the hypotheses explaining effect of weak magnetic field on biological objects is change of water properties which is their part. Thus, the problem is transferred from area of an electromagnetically biologically to the field of physics of water

Unlike researches of influence of weak magnetic fields on biological objects of work on a research of changing physical properties of water under the influence of magnetic field are rather not numerous. In their works, it was reported about change of light scattering of water and water solutions. It turned out that the value of light scattering is subject to quasiperiodic fluctuations. The range of a scattered light depends by nature-dissolved substance and changes at influence of constants and alternating magnetic fields. These experiments were repeated and authors found light scattering variations with some set of the periods. In the work, measurements of index of refraction, conductivity, acidity, a heat transfer, depth of overcooling, a tangent of dielectric losses of the bid stilled water and ice were taken.

At impact on water of an alternating magnetic field induction 90 nT within 10 minutes and more all parameters changed. Change happens only with frequencies of magnetic field around 0.01, 0.04, 0.06 and 0.08 Hz. The effect depends on orientation of a vector of variation field concerning a vector of a geomagnetic field. If the vector of the operating field is parallel to a geomagnetic field the resonance at a frequency of 0.08 Hz vanishes and if it is not parallel, the resonance of 0.06 Hz vanishes.

S.M Hassan and R.A Rahmon's study [11] is a step towards gaining a better understanding of the effect of magnetism on water properties and on the biology of culture organisms, such as the brine shrimp, A. salina. Their study evaluates the effects of magnetic field exposure on water properties, which in turn affect the hatchability of a salina. Water was passed through three magnetic devices of different intensities, i.e. 0.1, 0.15 and 0.2 Tesla, respectively, once at every 5 hours interval. The dissolved oxygen (mg/L) was found to increase (from 3.84 mg/L to 4.51 mg/L). pH also increased from 7.11 to 7.42 which is favorable for A. Salina. The ammonium (NH4-N mg/L) and ammonia (NH3-N mg/L) levels decreased from 0.43 mg/L to 0.28 mg/L and from 0.36 mg/L to 0.19 mg/L respectively. Salinity (ppt), specific conductance (µS/cm) and total dissolved solids (mg/L) were also found to have increased significantly ($P \leq 0.05$) after magnetization. Overall, the exposure of water to

a magnetic field was found to have increased the hatchability rate of A. Salina significantly ($P \leq 0.05$). A much better increase of 39.61% (41.67 to 69.00) in A. Salina hatchability rate (H %) was attained in water exposed to a magnetic field of 0.15 Tesla for four times. This has positive implications for aquaculture because a higher rate of A. Salina hatchability means that the brine shrimp can be produced more economically and a good sign for application of magnetic water for other aquaculture.

Their study is based on earlier works, which discussed the effects of magnetic field exposure on the properties of water. Magnetic water is produced when water is passed through a magnetic field with the purpose of modifying its structure. The magnetic field can cause a hierarchy of changes ranging from the dynamics of electro solutions to the state of macromolecules of water. Water quality is determined by variables such as transparency, turbidity, watercolor, pH, alkalinity, hardness, and the content of carbon dioxide, unionized ammonia, nitrite, and nitrate. Hence, solutions in water treatment are applied to improve water quality. The changes in physical and chemical properties of magnetized water affect the biological properties of the organisms that consume the magnetic water such as the organism's rate of respiration, which in turn affects its entire metabolic system. Literature have already shown that exposure of water to a magnetic field has positive effects on its properties and that it makes it better, plant and livestock water uptake, and their metabolism.

H Banejad and E Abdosalehi [12] has examined magnetic field intensities of zero Tesla (as a witness), 0.05 Tesla, 0.075 Tesla, and 0.1 Tesla. In addition, they has chosen amounts of water influent 4lit/h and 30lit/h. With doing examination by 3 times and analyze the results with SAS software, have shown that changing magnetic field intensity, amounts of water influent, and also together influence there factors, have significant effects at level of 99 percent on reducing of water hardness. In the other way, for finding their mechanisms, analyzes done by X ray. Calcium carbonate exists in two forms, calcite and aragonite. However, the main form of sediment is calcite. Results showed that amount of aragonite in compare with calcite, by attention to situation, increased 70 percent to 99.99 percent and ratio between calcite/aragonite had a main reducing.

Yukai Wang, Huinan Wei and Zhuangwen Li [10] have analyzed the effect of magnetic field on the partial physical properties of water, tap water and 4 types of magnetized water were measured in the same condition. It was found that the properties of tap water were changed following the magnetic field treatment, shown as the increase of evaporation amount, the decrease of specific heat and boiling point after magnetization, the changes depend on the magnetization effect. In addition, magnetic field strength has a marked influence on the magnetization effect, the optimal magnetizing condition was determined as the MFS of 300 mT. The findings of this study offered a facile approach to improve cooling and power generation efficiency in industrial.

Although many properties of water that influenced by magnetic field have been reported from lots of studies, few works focus on specific heat, evaporation amount and boiling point of magnetized water, and these properties are very important in various applications, including condensed systems, thermal power and other fields. Yukai Wang, Huinan Wei and Zhuangwen Li [10] aimed that their work is to investigate the effect of magnetic field on these properties of water, we studied the specific heat, evaporation amount (heating from room temperature until sample boils), boiling point of magnetized water and tap water. Moreover, influence of magnetic field strength on magnetization effect was discussed.

The specific heat increased very slowly with temperature. However, the specific heat of magnetized water decreased relative to tap water, and the downward trend did not continue with increasing magnetic field strength. For example, the value of MW-3 (300 mT) were 4.0446 J/gK and 4.1203 J/gK at 25 _C and 70 _C, while that of MW-4 (400 mT) were 4.0897 J/gK and 4.1601 J/gK, respectively. Therefore, it suggested that MF could decrease the specific heat of tap water, and the declining trend depend on magnetic field strength. In fact, the lowest specific heat was obtained at magnetic field strength of 300 mT, which indicate the magnetization effect is satisfactory with 300 mT.

Christian Baresel and others [21] have taken the concept of water treatment by functionalized magnetic particles one step forward by integrating the technology into a complete proof of concept, which included the preparation of surface modified beads, their use as highly selective absorbents for heavy metals ions (Zinc, Nickel), and their performance in terms of magnetic separation. The separation characteristics were studied both through experiments and by simulations. The data gathered from these experimental works enabled the elaboration of various scenarios for Life Cycle Analysis (LCA). The LCA showed that the environmental impact of the system is highly dependent on the recovery rate of the magnetic particles. The absolute impact on climate change varied significantly among the scenarios studied and the recovery rates. The results support the hypothesis that chelation specificity, magnetic separation and bead recovery should be optimized to specific targets and applications.

The higher the demands concerning the cleanliness of the component and the surface qualities, the more the change of the magnetic surface characteristics influenced by machining comes into focus. Christen Trap and his colleague [22] examined the influence of magnetic field in machining condition under different aspects to meet the subject matter complexity. Their work focused on the correlation between the process parameters, the batch of the material and the change of the magnetic surface characteristics. The findings concerning the correlation of magnetic characteristics of a workpiece and the machining lead to an optimized approach to the planning of process chains

Md. Anaet and others [23] aimed their work to investigate the effects of heat treatment and magnetic field on the machinability responses during turning process of mild steel. Investigation of machinability has been studied by considering the tool life, surface roughness and chip morphology. The effect on the rise in temperature during the turning operation has been studied. In the experimental investigations, heat-treated mild steel and normal mild steel has been considered as two work materials. Turning operation tests were conducted using lathe machine with automatic feed at room temperature in dry condition. It has been observed that machinability responses with the combined effect of magnetic field and heat treatment gives significant improvement compared to normal machining process in non-heat-treated mild steel. The obtained improvement reflects the feasibility of using this technique as a cost effective turning processes.

Compared to the chemical treatment of industrial circulating cooling water in the field of industrial water treatment, electromagnetic pulse sterilization technology, an advanced technology, is widely used because of its special characteristics — low energy consumption, nonpoisonous and environmentally friendly. In order to get a better cooling water sterilization effect under the premise of not polluting the environment, some experiments about sterilization of heterotrophic bacteria in industrial circulating cooling water by low frequency square wave pulsed magnetic field were carried out by Zhian Lui and his collegue [24]. The comparison experiment on the sterilization effect of low frequency square wave pulsed magnetic field on heterotrophic bacteria in industrial circulating cooling water was carried out by change relative flow direction of solenoid magnetic field and water. The bacterial inhibiting effect was 7.22%~20.35% higher when the direction of flow of water was in parallel with the magnetic field than in anti-parallel. This study analyzed this phenomenon from the perspective of the diamagnetism of the bacteria cells and the electric dipole moment of proteins. Since the bacterium cell membrane contains diamagnetic substances, when a bacterium cell moves in parallel with the magnetic field, it would be slowed down and stay longer in the field than moving in anti-parallel, so the bacterial inhibiting effect would be stronger. Results of this study have important guiding significance for future application of magnetic field sterilization.

Conclusion

According to information above, effect of magnetic field on the process of cutting is noticeable. It is clear that durability of cutting tool can be improved and controlled by using the methods of increasing its stability under magnetic field.

One of the most important thing is that it can be possible to control effectiveness of heat treatment of tool material. It is obvious that work effectiveness can be improved by increasing wear resistance of cutting tool by using lubricoolant.

According to literature analysis, magnetic field impact on the properties of lubricating condition sufficiently.

On the other hand, impact of lubricating liquid on cutting condition depends on its properties. It is shown above that magnetic field strongly affect the physical-chemical properties of lubricoolant.

It is clear from literature analysis above that effect of lubricating cooling condition of which physical-chemical properties are changed by magnetic field.

It is also obvious that effect of magnetic field on liquids depends on their magnetizing condition. As conclusion, changing properties above and controlling their impact on cutting process has a huge scientific and practical importance.

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