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Full Length Research Paper

Ecological pure ionized gaseous medium in the technology of machining

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Investigations have been carried out to using unconventional cutting fluids to prevent both health and environmental hazard caused by liquid cutting fluids. The use of liquid cutting fluids (emulsion, minerals oil, etc) during cutting process may be effective at reducing component cutting forces, improve the machined surface quality, and the tool life, but it pollutes the environment and poses health hazard to machine operators because of their sulphur and phosphorus content. Another important point is that of the liquid cutting fluids recycling problem that is, they require expensive and special equipment for their recycling. Thus it makes them to be economically ineffective. Therefore ionized gaseous medium (IGM) was used to eliminate or reduce the negative effects of liquid cutting fluids (CF) during turning operations. The results of the research study indicated that IGM is not only ecologically "pure", but is more effective than liquid cutting fluids in terms of tool life improvement, the machined surface quality and tool property. The obtained results show that IGM increased the coated hard alloy inserts life by 1.5 times compared to liquid CF and 2.5 times compared to dry cutting process. The machined surface quality was increased by 15 and 11% using IGM in comparison with dry and liquid CF turning, respectively. The environmental pollution was reduced 2 times by IGM in comparison with liquid (CF).

Key words: Ionized gaseous medium, liquid cutting fluid, tool wear, coating, dry turning, compressed air turning, corona discharged current.

INTRODUCTION

The current high demand by customers (consumers) for an improved product quality and also the environmental protection has led to the development of new technology of producing (manufacturing) products to meet these demands. This latest development has led to the inability of wide usage of the traditional cheap cutting fluids (CF), because of their sulphur and phosphorus content which cause an irrevocable damage both to the environment and the machine operators' health.

Another important point is that the usual liquid cutting fluids are economically ineffective, because they require special and expensive equipment for their recycling. Therefore the application of dry electrostatic cooling (DEC) technology to the cutting zone is a big area of interest to modern researchers (Vereschcava and Prilukova, 1999; Vereschcava et al., 1998; Agafonov et al., 1996; McCluire et al., 2005; Kirillov et al., 1997).The results of their studies indicate that this method of cooling/lubricating the cutting area is very effective in terms of cutting tool efficiency, machined surfaces quality and environmental safety.

The use of IGM reduced the environmental pollution by 1.5-2 times when compared to liquid or soluble oil cutting fluid or water based emulsion. Besides the parts (element), machine with IGM does not require further washing or cleaning.

The concept of dry electrostatic cooling technology is the ability of its regulated feeding of pressurized air which is treated with a unipolar corona discharged current (I_K) to the cutting area (Yakubu and Eveev, 1999). Ionized Gaseous Medium (IGM) is an example of DEC technology.

The cooling concept of IGM is the feeding of ionized and ozonized air to the cutting zone which is ecologically safe and environmentally friendly. Thus, in the modern time, the use of IGM is very vital.

The purpose of the research study was to substitute the usual cutting liquid fluids with IGM without compromising the cutting tool efficiency (life) and machined surface

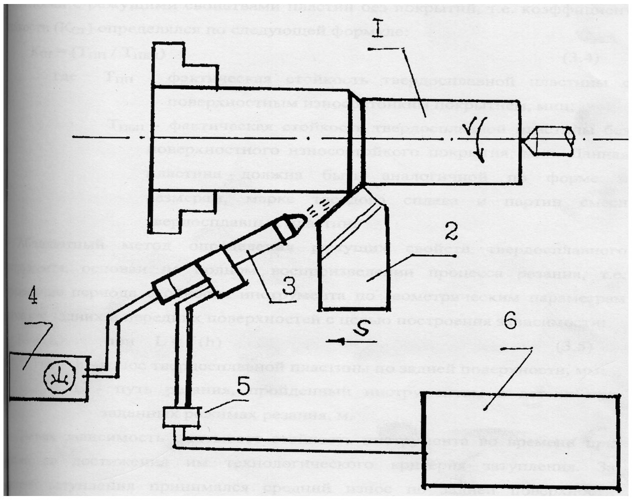


Figure 1. Schematic sketch of experimental set up for turning process with IGM. (1, Work piece; 2, Cutting Too; 3, Vakarsh Nozzle; 4, Varkash's Power Source; 5, Cable from Compressor; 6, Compressor; S, Feed direction).

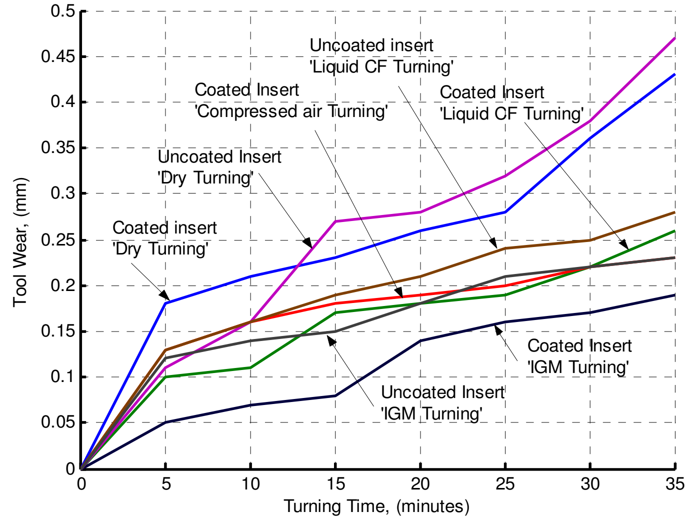


Figure 2. The effect of cutting fluids on Tool Inserts' wear, mm. (Cutting Conditions: V = 150 m/min, F = 0.1mm/rev, t = 0.5 mm).

quality.

MATERIALS AND METHODS

The materials used as the cutting tool were Titanium Nitride coated hard alloy tips obtained from grade T5K10.

The experimental researches were carried out on the following models of universal lathe machines 16K20, 16K20PF1 and railway wheel pair turning machine model UDA-112 made by Polish firm "Rafamet"

The experiments were carried out under the following conditions:

1. Turning without the application of cutting fluids that is, "dry" turning.
2. Turning with the application of liquid cutting fluids (i.e. soluble oil "ERA").
3. Turning with ionized gaseous medium (IGM).

The schematic sketch of turning with the application of IGM is shown in Figure 1.

The work-piece samples were obtained from a low carbon steel grade C45. The turning process was conducted with following regime: Speed (V) = 150 m/min, Feed (F) 0.10-0.15mm, Depth of cutting (t) = 1.0 mm.

Tests were conducted to find out the influence of cutting fluids especially IGM on the wear-resistance (tool life) of the cutting tool, quality of the machined surface and the parameters of machining like speed, depth of cut and feed and as well as on component cutting forces in turning. A Germany tool maker microscope with electronic reading device was used to determine the hard alloy tips Flank Wear. For this particular research the Flank Wear was used as criterion to define the tool life.

This is because Flank wear is more intensive than the crater wear and it has greater effect on the tool life, its efficiency as well as the quality of the machined surface. In other words most tools failure is caused by Flank Wear. The cutting force increases directly proportionally to the increase in the Flank wear (Sharma, 2006).
The measurement of the tool wear was executed within a progressive time interval until the defined limit of wearing was reached.

The measuring of the micro surface imperfection (surface roughness) of the machined surface was done using a double microscope model MIS-11 which was mounted on the lathe machine.

The component cutting forces were registered through the universal dynamometer model 600 which was directly mounted on the lathe machine with the help of a special hydraulic apparatus with pressure indicator.

RESULT AND DISCUSSION

The effect of cutting fluids (IGM) on the cutting tool wearing

In accordance to the accepted physical model of coated hard alloy tool wearing, the character and the strength of clinginess of coating to the hard alloy surface matrix to a large extent define the intensity of coating breaking off at contact area between the tool and work piece (Kuzin, 1986).

On the other hand the application of cutting fluids will reduce the rate of wearing and improve the tool life and its efficiency as well as the surface quality. However this depends on the type of cutting fluids used and the method of its feeding.

The result of the hard alloy material T5K10 wearing presented in Figure 2 indicated that coating reduces tool wear that is, increases the tool life. But the application of cutting fluids will further reduce the tool wear. However the level of this reduction depends on type of cooling/lubricant medium used.
It was observed that tool wear of the uncoated inserts during turning with application of liquid (soluble oil) fluids and IGM was even lower than those coated inserts under dry turning condition.

The result showed that IGM reduces coated cutting tool wear to about 3.0 times compared to uncoated cutting

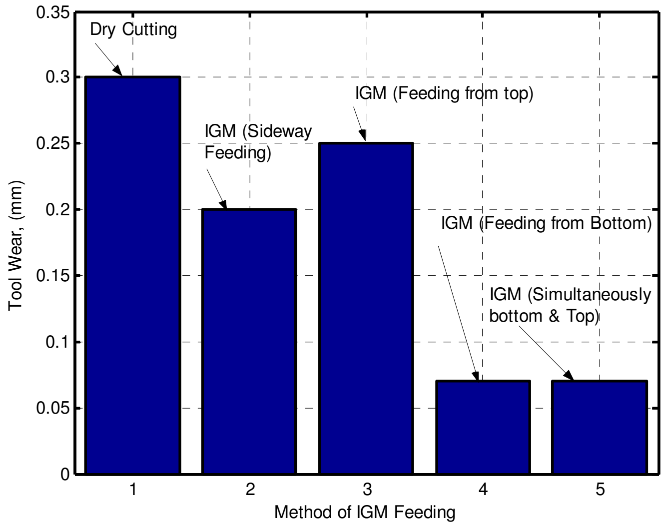


Figure 3. The influence of IGM Feeding Method on the Tool Life. (Cutting Conditions: V = 150 m/min, F = 0.1mm/rev, t = 1mm, T = 10 min).

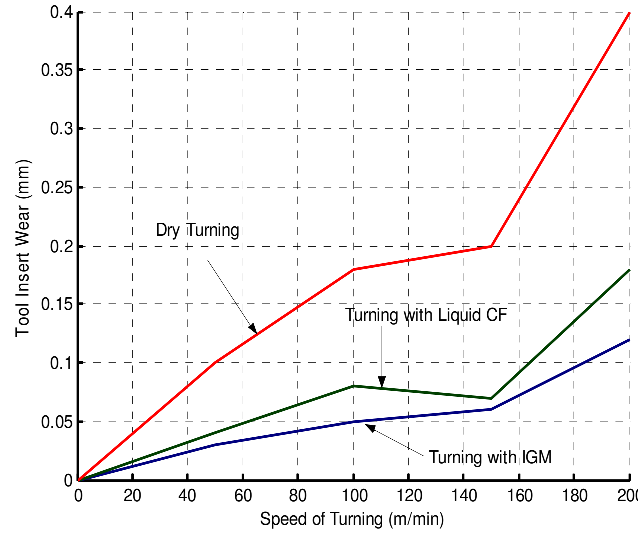


Figure 5. The effect of cutting speed (V) on the tool wear. (turning regime: f= 0.1 mm/rev, t= 0.5 mm, T= 5 min).

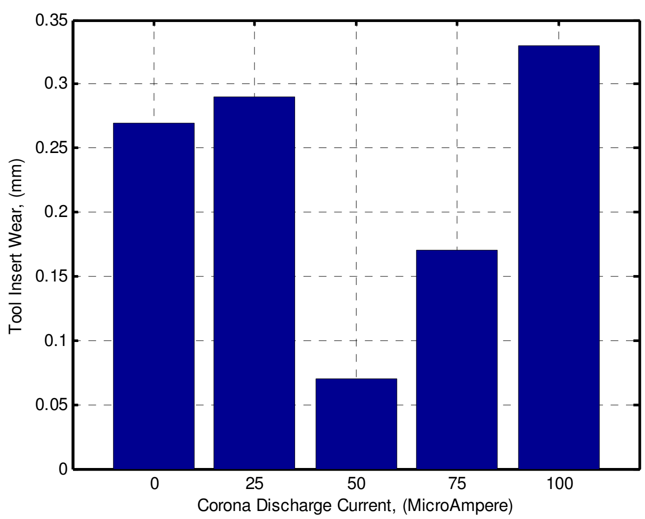


Figure 4. The effect of corona discharged current (I_k) on tool wear (T=15 min).

tools in dry turning and 2.5 times compared to coated inserts under dry turning, 1.5 times and 50% for coated inserts under turning with liquid fluids and compressed air respectively.

For uncoated inserts T5K10, IGM reduced the tool wear to about 2 times, 1.22 times as compared to dry and liquid fluid turning, respectively. Figure 3 shows the influence of IGM feeding method on the tool wear.

It was observed that IGM compared to dry turning, improves the tool life to about 10% when fed to cutting area from top of the tool, 31% for its cross (traverse) feeding, 300% when fed from bottom and when simultaneously fed from bottom and top of the tool. The effectiveness of IGM is due to its better lubricating and cooling power as compared to other cutting fluids.

However IGM's cooling and lubricating power to some extent depend on the value of the corona discharge current. It was noted from the result of the experiment performed (Figure 4) that IGM's highest (maximum) lubricating and cooling ability was reached when the corona discharged current I_K= 50 µA. The lowest value of tool wear was also obtained at this value i.e. I_k= 50 µA

The effect of cutting parameters (feed, depth of cut and speed) on coated hard alloy tools life

Speed

The result of cutting speed's (V) influence on the tool wear is presented graphically in Figure 5. It can be deduced from the result that as the cutting speed increases, the rate of wearing increases also. However, the rate of wearing was reduced drastically by application of IGM.

For instance the tool wear was reduced from 0.40 to 0.10 mm when V= 200 m/min compared to dry turning and from 0.18 to 0.11 mm in comparison with liquid cutting fluid.

Feed

Experiment was conducted to find out the effect of feed using different cutting fluids.

The result indicated that tool wear increase directly proportional to the increase in feed Figure 6. But with application of cutting fluid there was a decrease in the tool wear. Besides, IGM four (4) times reduced the tool wear compared to dry cutting, especially when the feed

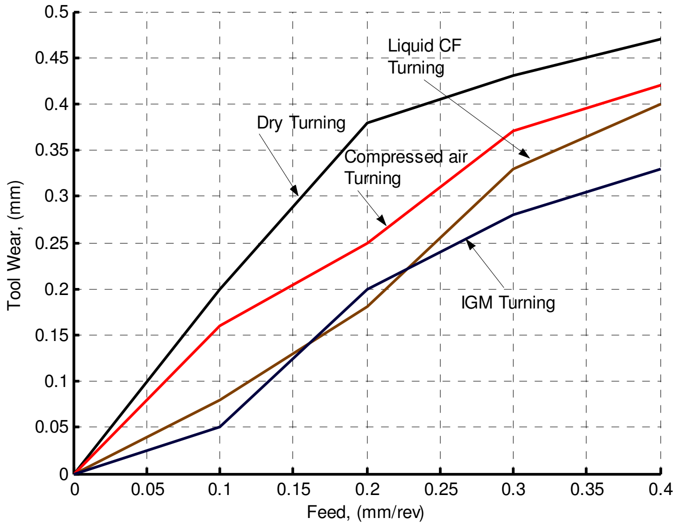


Figure 6. The influence of feed (f) on the tool wear. (Turning regime. V= 15 m/min, t= 0.5 mm, T= 5 min).

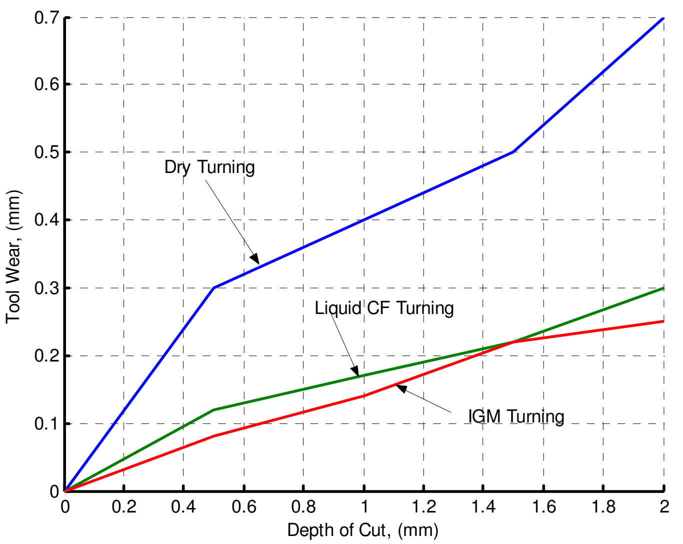
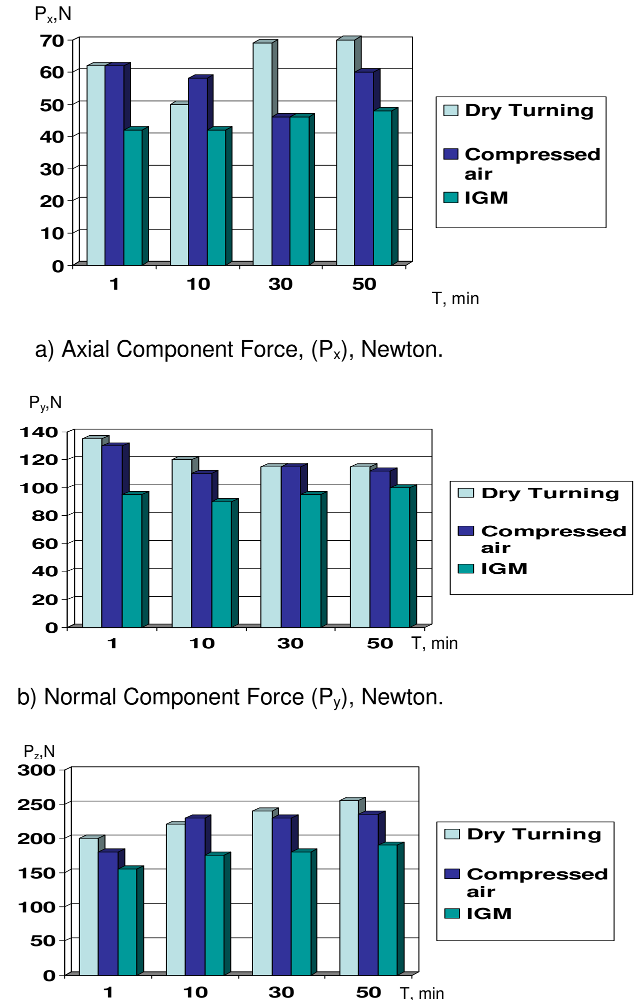


Figure 7. The influence of the depth of cut on the tool wear. (Turning regime V= 150 m/min feed (F) = 0.15 m/min, T= 5 min).



a) Axial Component Force, (P_x), Newton.

b) Normal Component Force (P_y), Newton.

c) Tangential Component Force (P_z), Newton.

Figure 8. The influence of IGM on the component forces during turning. (Turning conditions: V = 150 m/min, f = 0.1 mm/rev, t = 1 mm).

was equal to 0.1 mm, one and half (1.5) times reduction to compared to turning with liquid cutting fluid, and 3 (F) on the cutting tool wear times compared to compressed air respectively. When value of feed (f) was above 0.25 mm, IGM reduced the tool wear by 1.6 times, 1.3 times, 1.4 times in comparison with dry turning, compressed air turning and turning with liquid cutting fluid, respectively.

Depth of cut

The result of the experiments showed that a rise in the depth of cut (t) will give a direct proportional rise to cutting tool wear. Just like the previous mentioned parameters (speed and feed), the intensity of the tool wear depends on the type of cutting fluid used.

Here IGM once again exhibited its advantage over other types of cutting fluids. It was established that on the average the application of IGM during turning reduced the tool wear (that is, increase tool life) to almost 3 times lower than the dry turning (i.e. from 0.7 to 0.25 mm) and to 20% lower compared to liquid fluid (Figure 7).

The influence of IGM on the component cutting forces during turning

The cutting force during turning (machining) is one of the basic parameters that determine the efficiency of the cutting process. It also defines the productivity of machining, choice of equipment, accuracy of the machining (Yakubu, 2001) (Figure 8).

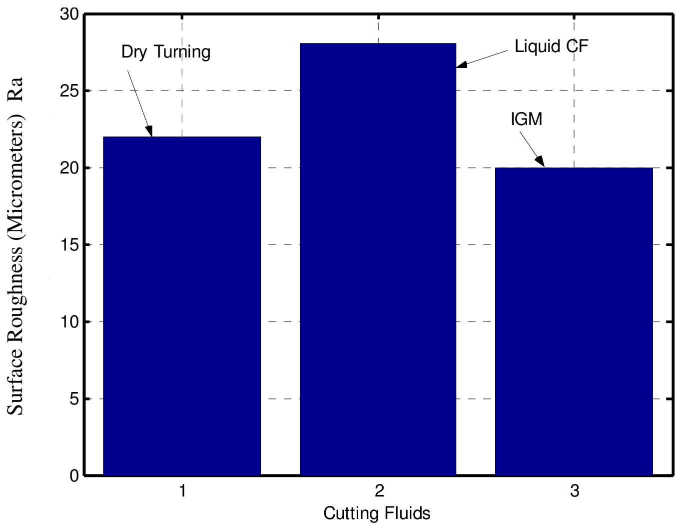


Figure 9. The effect of IGM on the surface roughness (R_a) [Surface Quality].

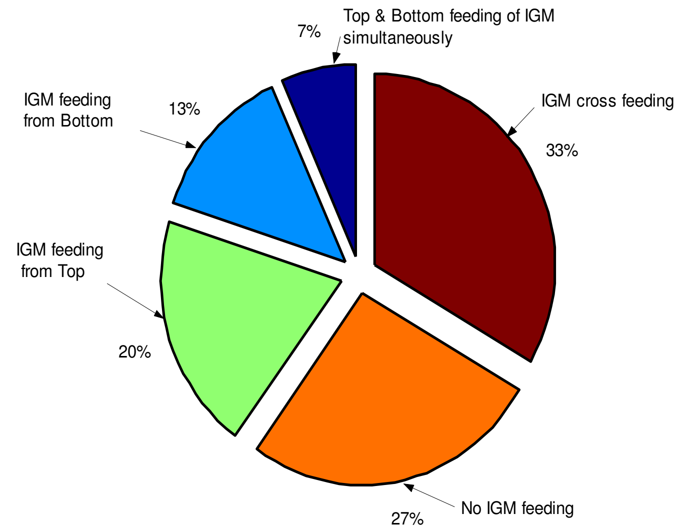


Figure 11. The surface roughness according to IGM method of feeding in %.

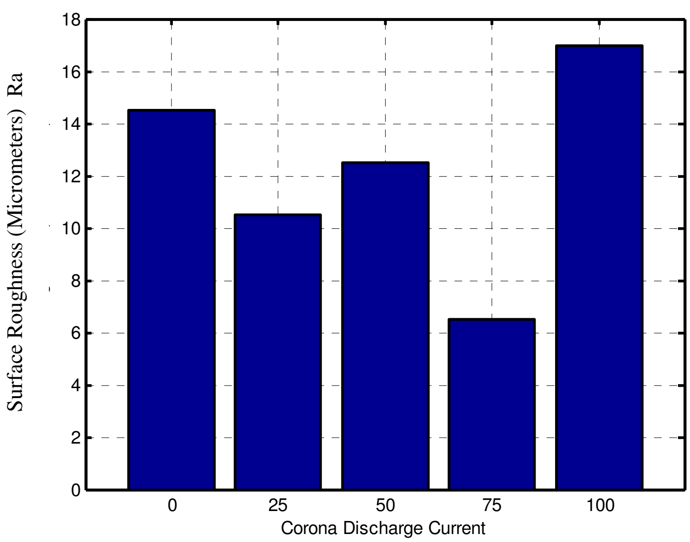


Figure 10. The effect of corona discharged current on the surface quality (R_a).

The result of the component cutting forces during turning is presented graphically in Figure 8. It was established that IGM reduces the component cutting forces to 40 and 30% in comparison with dry and compressed air turning respectively. This was because the use of IGM provides effective cooling and reduction of deformation at the cutting zone.

Besides, the ratio between the component forces $P_x < P_y < P_z$ was maintained throughout the experiment (the whole turning process).

The result of the experimental study revealed that when IGM was applied during the turning process, the coefficient of turning was reduced (lower) and practically did not change through the cutting period (time). This enabled the reduction in the cutting force to about 2 times lower, compared to dry turning.

The effect of IGM on the machined surface quality

The results of the surface roughness of the machined surface under various methods of turning (that is, dry turning, turning with IGM and liquid fluids) were presented in Figure 9.

The result indicated that the lowest surface roughness (that is, best surface quality) was obtained during turning with the application of IGM and the worst surface quality was got when liquid cutting fluid was used.

It was also established that both the IGM method of feeding to the cutting area and the value of the corona discharged current affect the machined surface quality. These are presented graphically in Figures 10 and 11).

It was noted that lowest surface roughness was obtained when corona discharged current (I_K) was equal to 75 µA (Figure 10) and when IGM was fed to the cutting area from both the bottom and top of the work piece simultaneously (Figure 11).

Conclusion

IGM is most effective when it is being fed to the cutting zone simultaneously from top and bottom or when fed from bottom at a distance of 40 mm.

It was established that the best machined surface quality was obtained when the corona discharged current was 75 µA. This means that there was better lubricating and cooling by IGM at this value.

IGM influences the parameters of cutting (speed, depth of cut and feed) by reducing the negative effects of these parameters.

The use of IGM reduced the environmental pollution by 1.5 - 2 times when compared to liquid or soluble oil cutting fluid or water based emulsion. Besides the parts (element), machined with IGM does not require further washing or cleaning.

Recommendation

During turning, IGM should be fed to the cutting zone from bottom and top simultaneously for optimum performance.

The value of corona discharged current (I_K) should be equal to 75 or 50 μA

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REFERENCES

Agafonov VN, Belov MA, Shalabin VS (1996). The research study of cutting parameters on the physical and technological indices of grinding process. Ulyanov state Technological University.

Kirillov AK, Vereschaka AS, Akhmatyanov ID (1997). High effective cutting with the application of Ecological

Kuzin VV (1986). The increase of multi layers and compositional hard alloy tools' serviceability and reliability and their further treatment, PhD Thesis, Moscow, p. 238.

McCluire Thomas F, Ferguson TD, Burcle JO (2005), Pollution Prevention Guide to using Metal Removal Fluids in Machine Operations, Institute of Advanced Manufacturing Sciences, Cincinnati, Ohio, USA. pure ionized mediums. International conference proceedings, No. 51, 1997 Kharkov state university. pp 46 - 54.

Sharma PC (2006). Production Engineering 10th Edition, S. Chand & Company Publisher, New Delhi, India. p. 925

Vereschcava AS, Prilukova YN. (1999). Design of Ecological pure cutting fluids; Machine production Bulletin 7: 32-35.

Vereschcva AS, Kirillov AK, Nozdrina SO (1998). Design of Ecological safe "dry" cutting. Conference proceeding of Kharkov state Technical University. pp 28-29.

Yakubu SO (2001). The enhancement of coated hard alloy tools effectiveness by optimizing its surface treatment method prior to coating.

Yakubu SO, Eveev DG (1999). The efficiency increase of hard alloy grinding process using ionized gaseous medium. Conference proceedings, "Science week-99" Moscow, MIIT, P.V-32.