Proposal of high performance eco-friendly (water soluble) coolant utilizing strong alkali ion water

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Abstract

Recent years, use of strong alkali ion water produced by electrolyzing high purity water (RO water) with addition of a small amount of electrolyte (potassium carbonate) is becoming widely used as a substitutable cleaning liquid in place of organic solvent which is said to exert a bad influence on the environment. The authors have been conducting a research to apply this strong alkali ion water (pH12 or so) to a working fluid for material removal processing. This is to cope with various problems relating to the existing water-soluble working fluid such as coolant putridity and the associated deterioration of factory environments and increased disposal costs of working fluids as well as to improve machining efficiency and tool life. In this study, the authors would like to describe how the working fluid consisting of water-soluble lubricant diluted with the strong alkali ion water contributes to the improvement of factory environments and verify experimentally that the said fluid could improve the tool life by 1.2 to several times. In addition, a factor contributing the improvement of material removal characteristics has been found to be the fact that the friction resistance of the said fluid containing the strong alkali ion water is as low as 2/3~1/2 of that of the fluid diluted with the city water.

1. Introduction

Recent years, electrolyzed ion water (acid ion water and alkali ion water) produced by electrolyzing high purity water (reverse osmosis (RO) water) with addition of a small amount of electrolyte is being paid attention from environmental point of view [1]. The acid ion water with its strong bacteria-killing action is used in the medical and agricultural fields. And the alkali ion water is becoming widely used as a

substitutable cleaning liquid in place of organic solvent which is said to exert a bad influence on the environment. The authors have made attempts to apply the strong alkali ion water of around pH 12 to the working fluid for material removal. Until now, various kinds of water soluble working fluid with excellent properties have been developed, but there still exist various problems relating to the putridity of the working fluid which deteriorates the factory environment and disposal of the fluid. Especially, the putridity problem is said to give an influence on the fixation rate of the factory workers. Since strong alkali ion water has a high pH such as 12, it not only can prevent ferrous metal materials from getting rusted, but also can inhibit the fluid putridity due to the propagation of bacteria. As other advantageous effects of the working fluid using strong alkali ion water, improved tool life and removal efficiency and controlled solidification of the grinding dusts are pointed out [2].

In this research, diluted strong alkali ion water was applied to the cutting and the grinding process and the processing characteristics were examined, and clarification of the effect development mechanism was attempted at the same time.

2. Manufacturing method of the strong alkali ion water and its features

For generating the strong alkali ion water, a device having a structure as shown in **Fig.1** was used. This device uses a cation exchange membrane and employs a system that the electrolyte solution (potassium carbonate solution) circulates only around the anode side and the RO (reverse osmosis) water will pass through the cathode side. Though potassium ion remains in the strong alkali ion water (pH≥12) generated, its amount is substantially small as 0.18%.

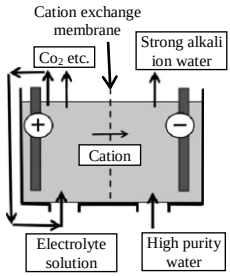


Fig.1: Structure of strong alkali ion water generation device

3. Researches into the drilling characteristics

Drilling experiments were carried out in a processing vessel placed on the vertical machining centre as shown in **Fig.2** using a working fluid diluted with the strong alkali ion water, RO water and the factory water. As a working fluid, emulsion liquid was used diluted to 5%. The strong alkali ion water with pH 12.2 became pH 10.5 after dilution.

3.1 Effect on the tool life

The drilling test was carried out on SUS304 workpiece with TiN coated high-speed steel drill (ϕ6.8). Here, emulsion lubricant was used as a working fluid diluted with RO water and the alkali ion water at the concentration of 5%. Failure of the drill occurred after drilling 104 holes when the fluid diluted with RO water was used, while number of the holes drilled before the drill got failure was 1367 when the fluid diluted with the alkali ion water was used. This means that the tool life increased by a factor of 13 times.

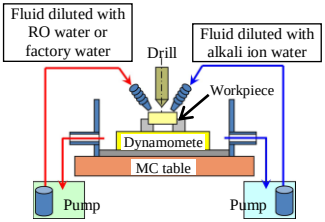


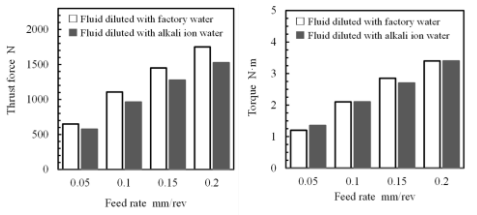
Fig.2: Schematic of drilling experiment utilizing strong alkali ion water

3.2 Effect on the thrust force and the torque

Measurement results of the thrust force and the torque varying the feed rate in the range of *s*=0.05~0.2mm/rev are shown in **Fig.3**. A series of the experiment were conducted with one single drill, but no wear was seen on the chisel.

In drilling SUS440C (*V*=7m/min) with TiN coated HSS drill, the thrust force and the torque were lower by 5~20% when the fluid diluted with the strong alkali ion water was supplied compared with the case where the fluid diluted with the factory water was supplied.

Although the result with the tungsten carbide drill is not shown, the thrust force and the torque were reduced by 5~10% when the fluid diluted with the strong alkali ion water was used compared with the case where the factory water diluted fluid was supplied even under high cutting speed *V*=26m/min for SUS440C.



(a) Thrust force (b) Torque

Fig.3: Effect of strong alkali ion water on thrust force and torque
(TiN coated HSS drill, SUS440C, *V*=7m/min, *d*=6mm)

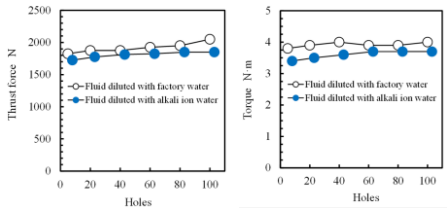
3.3 Transitional change of cutting force in the continuous drilling

Transitional changes of the thrust force and the torque when 100 holes were drilled on the SUS440C with a TiN coated HSS drill are shown in **Fig.4**. Drilling conditions were *V*=7m/min and *s*=0.2mm/rev. Both the thrust force and the torque were found

5~10% lower when the strong alkali water diluted fluid was used than the case where the factory water diluted fluid was used.

3.4 Reasons for the lowered cutting force

The following points could be the reasons for the lowered cutting force when alkali ion water-dilutedsolution was used. (1)The surface-activating agent contained in the cutting fluid as a lubricant component gets slightly flocculated by alkali ions, which might enhance a strength of the oil film. (2)The alkali ion component is replaced with the amin contained to strengthen the rust-preventing property of the cutting fluid, which might increase the oiliness of the fatty acid. Clarification of these factors will be discussed in the next report.



(a) Thrust force (b) Torque

Fig.4: Effect of strong alkali ion water on the change of thrust force and torque
(TiN coated HSS drill, SUS440C, V=7m/min, s=0.2mm/rev, d=6mm)

4. Conclusion

It was demonstrated that the use of strong alkali ion water as a diluting solution of a cutting oil effected a longer tool life than the case where city water or the like were used. In addition, it was also made clear that a part of the reason for the improved tool life was the lowered normal force resulted when alkali ion water was used as a diluting liquid.

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