Fundamental Study on Magnetic Field Assisted Lapping with Rubber Magnet

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ABSTRACT

In the manufacturing of "die", the degrees which is depended on the hand works of a skilled worker occupy a still an fairly wide area in the final finishing process.

In this paper a new method of lapping as a way of automatically finishing the "die" is proposed, which utilizes a permanent rubber magnet to apply to the final finishing process of the "die" and is one of magnetic field assisted lapping.

This method does not require any expensive and complicated apparatus compared with other magnetic field assisted lapping.

In this paper two types of rubber magnet stronger and weaker magnetic forces were used, and hardened steel S55C as a specimen, and the mixture of #400 and #800 of WA abrasives and city water as a lapping fluid respectively were employed. Fundamental analyses of the lapping operations were made.

It became evident that the lapping is also possible in this method as well as in conventional lapping.

1. INTRODUCTION

In the manufacturing processes in today that an automatic method has been advanced, still, the hand works have been main current which regard the experiences and the feelings of the skilled worker depended on the precise eyesight and tactual sense of a man as important in the final finishing of "die". In recent year, however, "Magnetic Field Assisted Lapping" has been used. These are; 1) utilizing the magnetic floating abrasives by using the mixture of abrasives and magnetic fluid[1), 2) giving the magnetic field to the magnetic fluid closed up tight and then polish with abrasives[2) and 3) making the abrasive wheel (metal bonded wheel) itself magnet[3). So, these methods are complicated and expensive in the experimental apparatus. While, this method proposed newly here does not require any expensive and complicated apparatus because of that this method employs only "permanent rubber magnet" as a lap. This method intends to apply to the automatic polishing of "die" in time. In general, because of that the most of die materials are magnetic material, there are no necessities to use any expensive and complicated apparatus mentioned above if this method is employed.

Furthermore, because of that rubber plate magnet is employed as a lap in this method, it becomes possible to polish over the wide area fairly and followings to the contour to be finished will also be faithful with uniform pressure between lap and finishing surface. Accordingly, it can be considered that this method has a advantage compared with the other methods mentioned above.

So, in this report, the fundamental studies on the lapping mechanism, the geometry of the lapping face of rubber plate magnet and the selections of optimum polishing conditions etc were carried out.

2. TEST CONDITIONS

A) Experimental apparatus

The schematic view of experimental apparatus is shown in Fig. 1. Reciprocating rod ⑤ attached to crank ③ is reciprocated by driving motor ① through variable–speed drive. ②.

Lapping is carried out by the mixture of abrasive (WA) and city water existing at interface of rubber plate magnet ⑥ and work with constant pressure. This rubber magnet is suspended by reciprocating rod with rigid holder.

B) Permanent rubber magnet

The specifications of permanent rubber magnet are shown in Table 1. Two types No. 1 and No. 2 were used. Fig. 2 is a lapping face of the plate rubber magnet as a lap. Lattice grooves are provided to be better the holding of lapping fluid as shown in the figure.

C) Lapping conditions

Lapping conditions are shown in Table 2. Lapping speed is about 16 m/min in average.

D) Specimens

Machine structural carbon steels S55C were employed as specimens, which were tempered at 660℃ after 820℃ water quenched and have then vicker's hardness of $H_v = 275 \sim 280$. They have the sizes of 90(length) × 90(width) × 19(height)mm, and have a hollow of 45mm dia. and 5mm depth at the

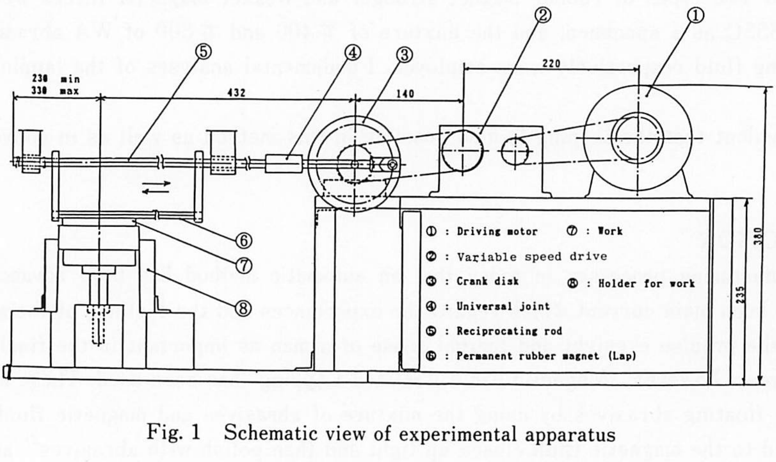

Fig. 1 Schematic view of experimental apparatus

Table 1 Specifications of rubber magnet

	Type	Thickness	Adsorbing force	note
NO. 1	M-1008	0.8 mm	3.0×10^3Pa	Anisotropic type (Barium-Ferrite)
NO. 2	E-620	2.0 mm	9.4×10^3Pa	Isotropic type (Strontium-Ferrite)

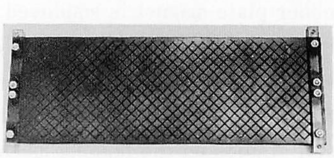

Fig. 2 Lapping face of rubber magnet

Table 2 Test condition

Work	Machine structual carbon steel S55C
Abrasives	White alandum #400, #800
Lapping fluid	A Mixture of 50wt% of WA and city water
Injection volume	10gf/min

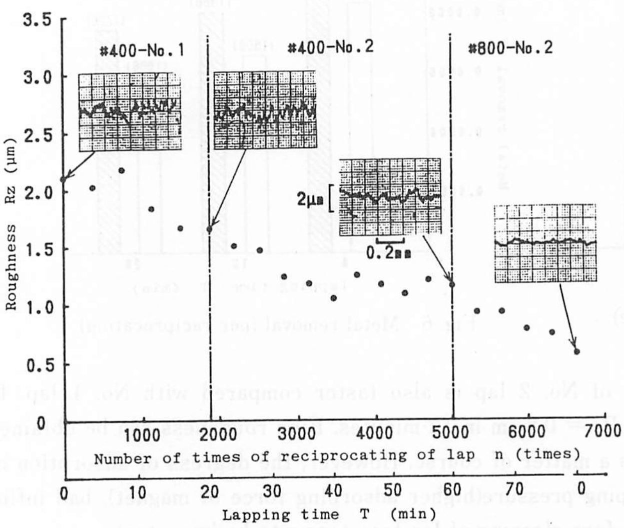

Fig. 3 Variations of roughness of face lapped

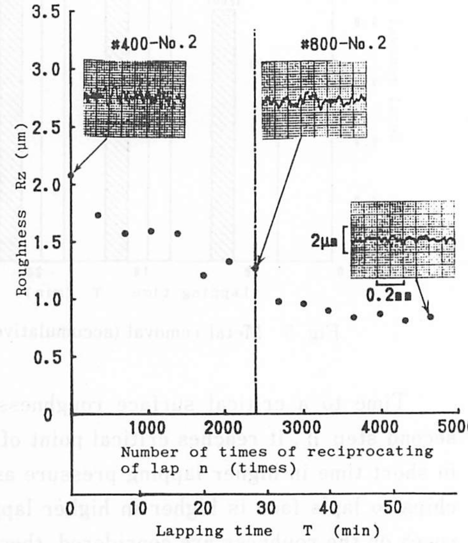

Fig. 4 Variations of roughness of face lapped

center of the face to be lapped as a store spot of lapping fluid. They have been ground to $R_z = 2.1\ \mu m$ with surface grinding previously.

3. EXPERIMENTAL RESULTS AND DISCUSSIONS

The variations of the surface roughness(R_z : ten point irregularities) across to the direction of lapping are shown in Fig. 3 and Fig. 4, they have been averaged at eight points.

Fig. 3 shows the variations of R_z on the same specimen lapped at three steps Ⅰ, Ⅱ and Ⅲ.

In first step Ⅰ lapping was carried out at 20 minutes with #400 WA abrassive by No. 1 lap, surface roughness was improved from $R_z = 2.1\mu m$ to $1.66\mu m$.

Then in second step Ⅱ, at 40 minutes with same abrasive with No. 2 lap stonger magnetic force than No. 1, surface roughness was improved to $R_z = 1.16\mu m$, the surface roughness are however not improved at about 20 minutes after beginning of second step Ⅱ, a critical point of $R_z = 1.05\mu m$ is appeared, if the lapping were repeated the surface roughness is not improved after that.

In third step Ⅲ, smaller size abrasive #800 of WA and No. 2 lap of same magnetic force used in step Ⅱ were used, surface roughness was improved to $R_z = 0.57\mu m$ in 20 minutes lapping.

Fig. 4 shows on the condition of lapping divided into two steps Ⅰ and Ⅱ, No. 2 lap of stronger magnetic force was used from the beginning of first step Ⅰ differ from Fig. 3, as a matter of course, the increase of adsorbing force of magnet increases the ratio of improvement of surface roughness in cooperation with the increase of the rate of metal removal.

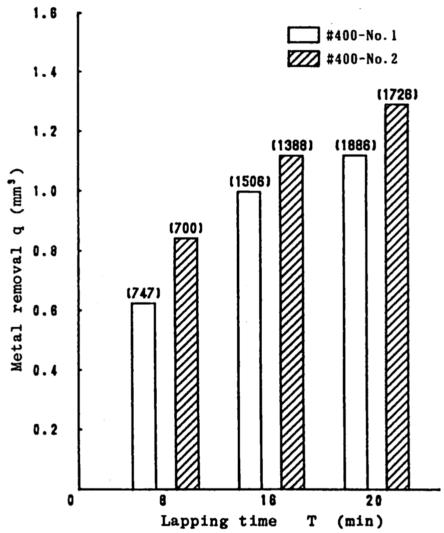

Fig. 5 Metal removal (accumulative)

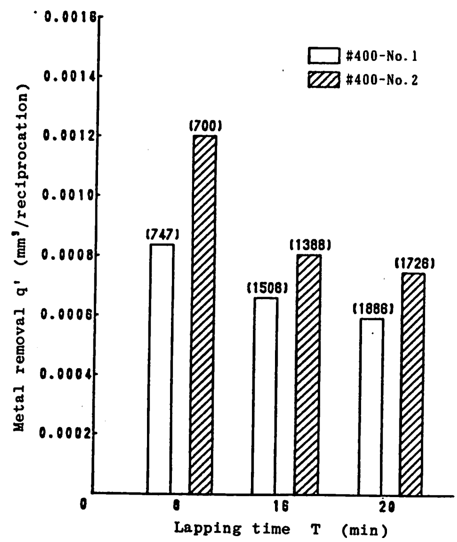

Fig. 6 Metal removal (per reciprocation)

Time to a critical surface roughness of No. 2 lap is also faster compared with No. 1 lap. In second step Ⅱ, it reaches critical point of $R_z = 0.8\mu m$ in 12 minutes. Fine roughness can be obtained in short time in higher lapping pressure as a matter of course. However, the degress of adsorption of chips to lap's face is higher in higher lapping pressure(higher adsorbing force of magnet), bad influences on the rouhness are considered, therefore cleaning of lap face seems to be important.

The relations between metal removal and lapping time are shown in Fig. 5 and Fig. 6, the figures in parentheses show the number of times of lapping. The differences of the figures in the same lapping time between No. 1 and No. 2 lap are cause of that the load of the experimental apparatus is increased because of stronger magnetic force of No. 2 lap, therefore the figures in No. 2 lap are small.

The computations of metal removal were computed from the surface irreglarities in each lapping steps and they are the average of seven points.

Fig. 5 shows the variations of accumulated metal removal q to the lapping time prescribed. q increases with the increase of lapping time but the rate of increase decreases with the increase of the lapping time in both No. 1 and No. 2 lap. And it is shown that the stronger magnetic force No. 2 lap shows the more metal removal in spite of smaller number of times of lapping in same lapping time.

Fig. 6 shows the variations of metal removal q'per one reciprocation of lap to the lapping time prescribed. q' decreases with the increase of lapping time in both No. 1 and No. 2. The rates of decrease of metal removal in No. 2 lap are bigger than in No. 1 lap, this seems to be the same phenomena that in conventional lapping higher lapping pressure decreases the cutting performance because of the fracture of abrasive. Therefore it should be intended in using the stronger magnetic force lap that the injection of lapping fluid should be short interval.

4. CONCLUSIONS

Magnetic field assisted lapping utilized permanent rubber magnet was proposed newly, hardened steel S55C were lapped with #400 and #800 WA abrasives. Following results were obtained.

1) Lapping is possible by using permanent rubber magnet as well as in conventional lapping.

2) The magnet of stronger magnetic force can be obtained more metal removal.
3) The magnet of stronger magnetic force can be obtained finer surface fast.

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