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Determination of the optimal working gap of Magnetic Assisted Roller Burnishing tool

Zsolt Ferenc Kovács[1], Zsolt János Viharos[2], János Kodácsy[3]

[1, 3] Pallas Athene University, GAMF Faculty, Dep. of Vehicle Technology, Kecskemét H-6000 Hungary, kovacs.zsolt@gamf.kefo.hu
[2] Institute for Computer Science and Control of the Hungarian Academy of Sciences, Budapest H-1111 Hungary
[1] Department of Manufacturing Science and Technology, Budapest University of Technology and Economics, Budapest H-1111 Hungary

Abstract **– In this paper, the authors present the results of experimental work regarding permanent Magnetic Assisted Roller Burnishing (MARB) tool. This type of special tool using the magnetic field to produce the necessary force for roller burnishing. This tool especially applicable to rolling flat and 3D surfaces. For the correct operation of tool, need to set up an optimal distance between the tool and workpiece. In order to define it the authors measured the z-axis direction force, which occurring between the tool and workpiece by the magnetic force pulls the rolling balls on a cone which located the end of tool. The evaluation was completed by advanced measuring and IT equipment.**

I. INTRODUCTION

The Magnetism Aided Machining (MAM) technologies relatively new industrial machining processes. The MAM technologies mainly suitable for finishing and surface improving. The MARB toll developed to reduce the surfaces roughness, increase the surface hardness and deburring edge of flat (in some cases even 3D surfaces) metal parts. The magnetic force makes this process simpler and more productive. The machining force is generated by the magnetic field between the workpiece and tool, important to set up the right tool-worship distance to ensuring the necessary rolling pressure.

II. MAGNETIC ASSISTED ROLLER BURNISHING

The MARB tools contain four magnetizable bearing balls and by the magnetic force, these balls pulls on a cone which located the end of tool and this creates the necessary rolling force (Fig. 1.).

The first generation MARB tool works with an electro magnet (see on Fig. 2.). This construction has advantages, for example the adjustable magnetic force which makes less important the gap distance. But this adjustable function cause problem in the usability, because it is require cables and so inconceivable on a modern CNC machine.

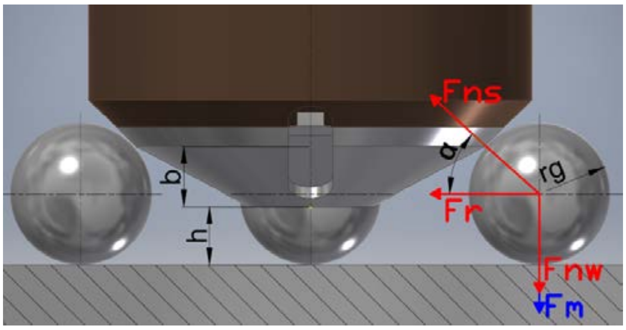

Fig. 1. The generated force during roller burnishing

The new type of MARB tool works with permanent magnet instead of the electro magnet (see Fig. 3.). Thanks to the permanent magnet design the tool can be place in the tool magazine. But as it was mention, the tool gap has great significance and so has an optimum value.

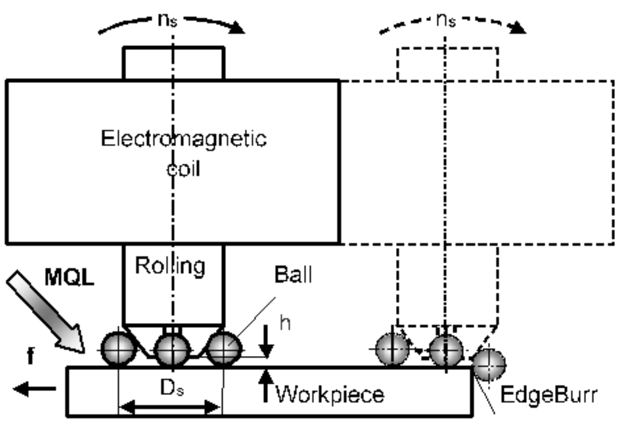

Fig. 2. Concept of the electro MARB tool

III. DETERMINATION OF WORKING GAP BY CALCULATION

The optimum *h* distance can determine by calculation and experiment. For the calculation the necessary parameters known (r_g=8 mm and b=7 mm) and can write the equation (1) and (2) by the Fig. 1. vectors:

$$h = r_g \cdot (\sin\alpha + 1) - b \tag{1}$$

$$F_{nw} = F_r \cdot \tan\alpha \tag{2}$$

From this:

$$F_{nw} = F_r \cdot \tan \cdot \left(\arcsin\left(\left(\frac{h+b}{r_g} \right) - 1 \right) \right) \tag{3}$$

In the equation (3) the F_r is a constant, because not change the permeability of ball and the gradient of magnetic field during rolling. By the equations can make a graph function of the *h* and F_{nw}/F_r (Fig. 3.).

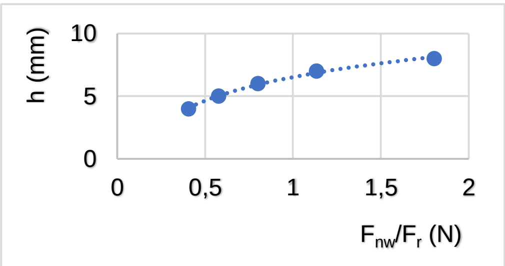

Fig. 3. The relationship between h and F_{nw}/F_r

The calculations are initiated with *h*=4 mm gap and tested up to *h*=9 mm. Under the *h*=4 mm the balls can fly away, because the balls reach the tool edge which made from bronze and there can not be affect the magnetic field strength. Reach the *h*=9 mm gap the *α* angel will be 90° and in this case the balls are close to each other which reduces the effectiveness of rolling. So under *h*=10 mm the rolling ineffectual.

The diagram of Fig. 3. shows that the optimum gap distance are between *h*=7 and 8 mm. Taking into consideration the possible unevenness of workpiece, preferable select the smaller gap value (*h*=7 mm).

IV. DETERMINATION OF WORKING GAP BY EXPERIMENT

The results of the calculations may be different from the reality and therefore it is carried out the determination of gap by experiment. During the experiment was used a CNC milling machine and a KISTLER 9125A24A2 force and torque measuring instrument was used for the measurements.

As a first step to avoid the accidents, the tool was tested in a standing position (without the main rotating movement) and after known the optimum gap, was measured the rolling force while the tool is rotating.

A. Standing tool

Using the results of the calculations for the experiment the starting position was the maximum *h*=10 mm gap and tested up to *h*=2 mm. The measurement arrangement shown in the Fig. 4.

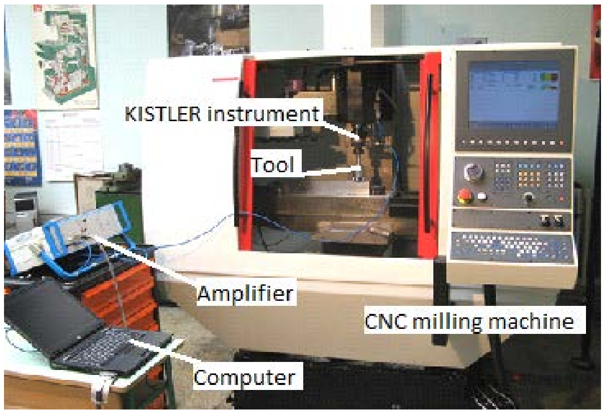

Fig. 4. Experimental setup of the force measuring

The measurement start in *h*=10 mm, without balls. Then placed the balls and the tool began to move away from the surface with 2 mm steps. The result of measurement is shown in Fig. 5.

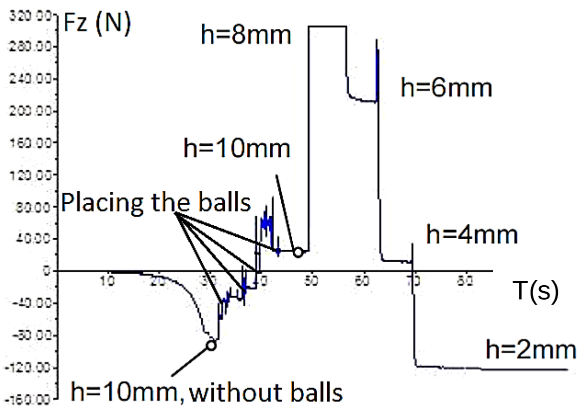

Fig. 5. Changing magnetic force depending on the tool distance

As shown in Fig. 5. without the balls the tool attracting the workpiece, this is the reason of the negative F_z force. After that placed the balls into the work space, the tool began to pushing the workpiece by the balls. As can be seen in Fig. 5. the maximum force with *h*=8mm and under *h*=4 mm gap the force will be again negative. This means the tool again started to attract the workpiece by the balls and the end of the tool.

According to the expectations and calculation, the maximal burnishing force was measured at h=8 mm.

B. Rotating tool

The main problem with the rotation is that the centrifugal force is increasing which can critically reduce the burnishing force and also the balls can fly away. In order to avoid this the rolling was measured during increasing rev. The rev was increased from 100 rev/min to 1200 rev/min.

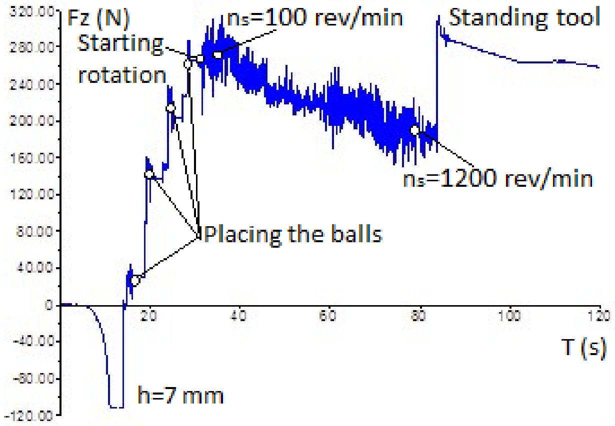

Fig. 6.Changing magnetic force depending on the rev

As shows the Fig. 6. effect of the increasing rev the rolling force decrease from 280 N to 200 N. This is represents that the force decrease by 30%. This decline does not a big value and in the practice never use 1200 rev/min because the high rev negatively affect the quality of surface. So the tool can be safely used until 1200 rev/min.

V. FURTHER DO LIST

The further scheduled for the examination of the effect of rev for the rolled surface. In addition had to examine what is the effect the gap distance (the section between *h*=7 mm and *h*= 9 mm) for the surface roughness

REFERENCES

[1] J. Kodácsy, J. Líska: Magnetic Assisted Roller Burnishing and Deburring of Flat Metal Surfaces. Advanced Materials Research Vol. TransTech 472-475 Publication Ltd, Zürich, 2012, pp.: 908-911.

[2] Zs. Kovács: Development of magnetic roller burnishing (thesis). BME, Budapest, 2015, pp.: 2-15.

[3] E. S. Gadelmawlaa, M. M. Kourab, T. M. A. Maksoucf, I. M. Elewaa, H. H. Solimand: Roughness parameters, Journal of Materials Processing Technology Vol. 123, 2002, pp.: 133-145

[4] W. Grzesik, K. Zak: Modification of surface finish produced by hard turning using superfinishing and burnishing operations, Journal of Materials Processing Technologies, Vol. 212, 2012, pp.: 315-322

[5] J. Kodácsy, J. Danyi, A. Szabó, Gy. Fülöp: Magnetic Aided Roller Burnishing Metal Parts. 7th International Conference on Deburring and Surface Finishing, UC Berkeley (USA), 2004, pp.: 375-378

[6] LR. K. Gillespie: Deburring and Edge Finishing Handbook, ASME Press, New York, 1989.

[7] A. Szabó, J. Kodácsy, J. Danyi (2006): The State of the Art and Recent Results of Magnetism-Aided Surface Improving and Edge Finishing Processes. 10th International Research/Expert Conference, TMT 2006. LLoret de Mar/Barcelona (E), 2006. pp.: 85-88.