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Manufacturing of Twist-Free Surfaces by MAM Technologies

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Abstract

Currently grinding is commonly used as the finishing operation to manufacture seal mating surfaces and bearing surfaces, especially in the automotive industry. It would lead to more resource-efficient production if the cost- and energy-intensive grinding process could be replaced by machining with magnetic polishing or magnetic roller burnishing. The machined surfaces by turning or grinding usually have twist structure on the surfaces, which can convey lubricants such as conveyor screw. To avoid this phenomenon have to use special kind of techniques or machine, for example, rotation turning, tangential turning, ultrasonic protection or special toll geometries. All of these solutions have a high cost and difficult usability. In this paper the authors describes a system and summarizes the results of the experimental research carried out by the authors mainly in the field of Magnetic Abrasive Polishing (MAP) and Magnetic Roller Burnishing (MRB). These technologies simple and also cheap while result the twist-free surfaces. During the tests C45 normalized steel was used as workpiece material which was machined by simple and Wiper geometrical turning inserts in a CNC turning lathe. After turning, the MAP and MRB technologies was used to reduce the twist structure. The evaluation was completed by advanced measuring and IT equipment.

Keywords: magnetism; twist-free; polishing; rolling

1. INTRODUCTION

The turning always creates a twisted surface, namely regardless of the machined material or whether that is hardened or not respectively. This surface has regular structures corresponding to a thread shaped structure (twisted) which, by the advance of the tool along the rotating workpiece are producing a screw pitch.

The reason for this phenomenon is that the feed motion of the tool will cause twist structures on counter faces for radial shaft seal rings can cause leakage. For example, the surface which is produced by turning with the typical kinematic roughness and spiral pattern creates a conveyor effect in the gap between the seal ring and the shaft. Depending on the direction of rotation leakage or dry running at the seal ring can occur which results in permanent leaking.

Plunge grinding is a tried and tested manufacturing technique for creating twist-free surfaces. However, it has been established in the meantime that in spite of twist, rolled surfaces do not create a conveyor effect. In fact a typical rolled surface does not show roughness peaks but wide plateaus which are interrupted by flat remaining valleys. This structure results in a high bearing line fraction. Substitution of grinding by hard turning and rolling can reduce costs for components of this type and shorten cycle times. [1, 2]

2. STRUCTURE OF TWIST SURFACE

Twist structures are characterized by microscopic structures which are comparable with a thread structure on a shaft surface. The Fig 1 shows the surface of a turned shaft schematically. The parameters are described in the Mercedes-Benz standard MBN 31007-7 in 2009 [3, 4].

DP – period length (mm),
Dγ – twist angle (° ’ ”),
Dt – twist depth (μm),
DG – number of threads ( ),
DF – theoretical supply cross section (μm^2)

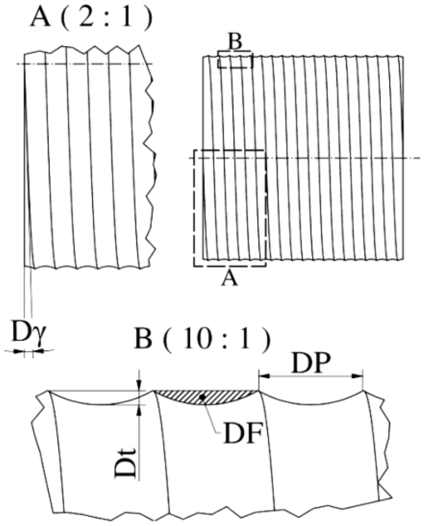


Fig. 1. Parameters of twist surface [5]

The parameters are dependent on process parameters (feed, nose radius etc.). During the rotation of a turned shaft, the liquid entrains in the circumferential direction and is deflected axially because of the twist structures [4].

The industry is currently looking for alternative manufacturing processes, for example hard turning, milling, burnishing or laser polishing. Besides these processes there are two similar technologies, the Magnetic Abrasive Polishing (MAP) and the Magnetic Assisted Roller Burnishing (MARB) which are also able to produce twist-free surface.

3. MAM TECHNOLOGIES [6]

Denomination Magnetism Aided Machining (MAM) comprises a number of relatively new industrial machining processes (mainly finishing and surface improving) developed presently, too.

The magnetic force makes these processes simpler and more productive. Machining force is generated by an adjustable electromagnetic field between two magnetic poles within the working area ensuring the necessary pressure and speed difference between the tools (abrasive grains, pellets or rollers) and the workpiece. [6]

3.1. Magnetic Abrasive Polishing (MAP) [7]

The polishing for decrease of surface roughness and increase of resistance against wear, corrosion and produce twist-free surface. Magnetic Abrasive Polishing is one such unconventional finishing process developed recently to produce efficiently and economically good quality finish. In this process, usually use ferromagnetic particles are sintered with fine abrasive particles (Al_2O_3, SiC, CBN or diamond. The MAP equipment for cylindrical surfaces was adapted to a universal engine lathe (Fig. 2.).

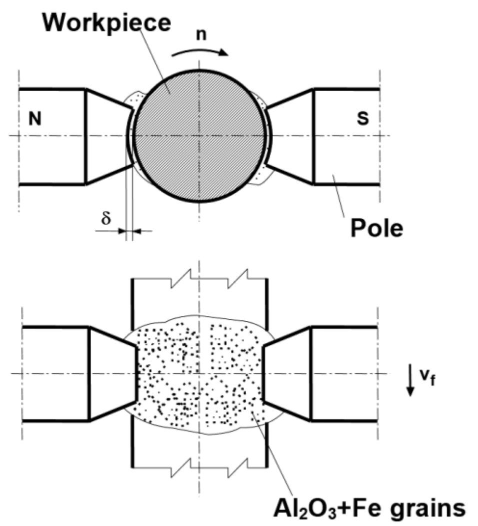


Fig. 1. MAP technology [7]

3.2. Magnetic Assisted Roller Burnishing (MARB) [7]

The main goal of roller burnishing is to achieve high-quality smooth surfaces or surfaces with pre-defined surface finish. One or more balls plastify and deform the surface layer of workpiece.

Almost all processes for the manufacturing of high-quality surfaces can be replaced by roller burnishing (e.g. fine turning, grinding, superfinishing, lapgrinding). This proven process entails considerable technological and economic advantages for surfaces in the roughness area R_z <10 μm.

For roller burnishing was applying mechanical force to press the rolling ball onto the surfaces. To avoid the harmful deformation by mechanic pressing the necessary pressure and relative speed between the tools and the workpiece are ensured by the magnetic force.

The magnetic roller burnishing equipment for cylindrical surfaces was adapted to a universal engine lathe (Fig. 3.)

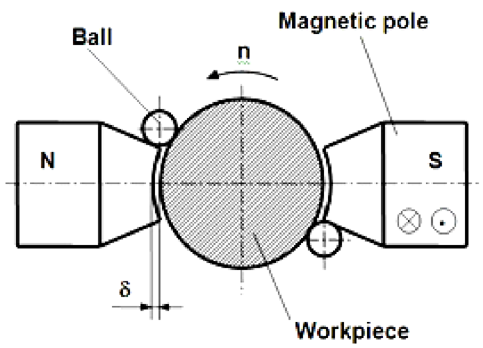


Fig. 2. MARB technology [7]

4. EXPERIMENTAL SETAP

In the performed investigations the shaft surfaces were manufactured purposefully by turning using different cutting tool. Then the surface was machined MAM technologies (MARB and MAP). Furthermore was made a grinded part as a reference to be able to compare the surfaces made by different technologies. During processing the workpieces C45-type steel with a diameter of 26 mm and a length of 100 mm were selected as processing elements. Cutting tool was inserts with wiper geometry (WNMG080404W-MF2, TP2501) and conventional inserts (WNMG080404-MF2, TP2501).

The MAM equipment is able to work as polishing and rolling function where the electromagnetic poles were fixed onto the slide of the lathe. In the tests the voltage (U = 40 V), current (I = 10 A) (direct current, adjustable) and the generating magnetic induction (B = 0,96 T) were the same under rolling and polishing too. The generated magnetic induction was reduced (B = 0,75 T) with polishing grain because of the applied Al_2O_3 shielding properties. The magnetic jaws (poles) surrounded the workpiece with a δ = 3 mm gap (clearance).

The turning, rolling and polishing technological parameters see the Table 1.

Table 1. Technical parameters of machining operations

Turning	
f (mm/min)	0,133
v_c *(m/min)*	117
a_p *(mm)*	1
Rolling	
f (mm/rev)	0,1
v_r *(m/min)*	22
Polishing	
t (min)	1,5
v_p *(m/min)*	62

5. EVALUTAION

After the manufacturing there are six different surfaces (grinded, turned by simple and Wiper insert). As first step were measured the surfaces roughens by MITUTOYO Formtracer SV-C3000 roughness tester. The measured results see in Table 2.

Table 2. Roughness values after machining

Technology	Ra (μm)	Rz (μm)
Grinded	0,54	3,43
Turned (simple)	1,2	6,09
Rolled	0,40	2,40
Polished	0,96	4,93
Turned (Wiper)	0,45	3,05
Rolled	0,27	1,92
Polished	0,38	2,79

Than was measured the twist surface by thread method. This method is a simple and fast method because it is consist of a thread and weight. The thread made from steel, plastic or wool (e.g.: fishing line or sewing thread). In this research were used steel thread where the steel diameter of 0,04mm. The weight depends on the applied thread material and diameter so in this case is 50g [8].

5.1. Measuring procedure

During the measurement has to rotate the workpiece in horizontal position and superimpose the thread with the weight (Fig 4.)

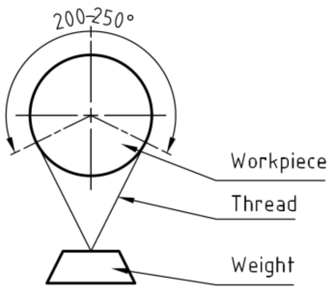
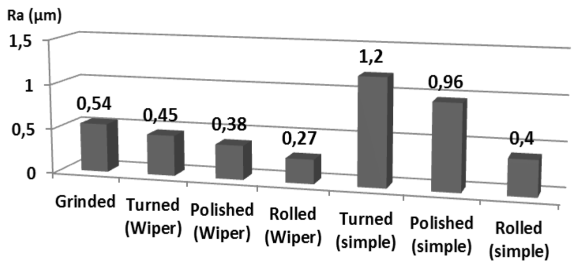


Fig. 4. Thread method [9]

The measuring takes one minute and during this time the workpiece peripheral speed 20 m/min. Then have to measure the displacement of thread (a_1) and must be performed the rotation the other direction and also have to measured it (a_2). The average of two values (1) is the characteristic number of twist surface (a_m). [9] The results are presented in Fig 5.

$$a_m = \frac{a_1 + a_2}{2} \text{ (mm)} \tag{1}$$



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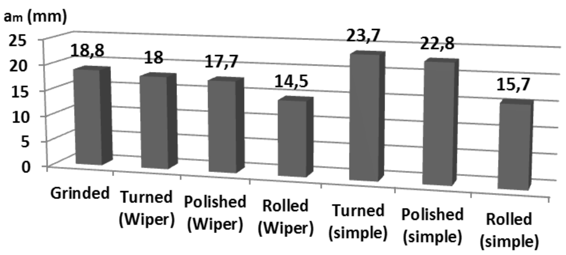

b)

Fig. 5. Measurement results of Ra roughness a) and characteristic number b) of twist surface

6. CONCLUSIONS

The research shows that MAM technologies are new manufacturing opportunity for surfaces to obtain desired functions such as surfaces with tribological function.

According to the expectations the Wiper insert produced a less than twisted surfaces compared to the simple one and as you see in the Fig 5. the grinded surface were worse than the rolled.

So that, instead of grinding can be machined with MAMRB which is faster, economical, easier and some case does not require workpiece transfer. Also there are negatives, like accuracy (size and position) which depends on the previous manufacturing. However, the MAP technology is not able to produce the expected surface.

7. ACKNOWLEDGEMENTS

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