VERIFICATION OF THE IMPACT OF FINISHING TECHNOLOGY ON THE SURFACE ROUGHNESS

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The article is focused to compare and evaluate different finishing technologies, such as milling and ISF technology, which are isotropic super fine machining. There were compared two gears manufactured by the same technologies, processes and made of the same material, in the company ZTS Sabinov, however, different finishing technologies were used on each wheel. Both gears are machined by milling and grinding on one of the wheels was used finishing technology ISF. Measurement and evaluation proved that the ISF technology has a strong influence on the final surface roughness.

KEYWORDS

roughness, surface, gear, measurement, technology, parameters

1 INTRODUCTION

Roughness is seen as part of geometric deviations with a relatively small distance of inequalities. Material defects caused by accidental damage or material defects (pores, cracks), are to the surface roughness not included.

The surface quality of parts is one of the conditions for their proper function, and significantly influences the component life. Roughness represents the amount of inequality from the ideal shape and arises as a result of:

- Used instruments and related parameters (micro geometric shape and size of the irregularities)

- applied surface treatment (physical and mechanical condition).

In the engineering industry material tends to be intensively stressed during the manufacturing process. During machining, parts of removed material thermally and tension stressed. Machining takes place in primary, secondary and tertiary deformations. Due process in the tertiary area, on a work piece, just beneath the surface, hardness, tension and possibly structure can be changed. State of the work piece after the final finishing of components affects the properties of the final product. In dynamically stressed components such changes have a key influence on the properties of their reliability and durability.

Figure 1. Measuring gear

2 MATERIALS AND METHODS

Measured components are gears type Satellite No. 2000-16-0009.

Material: STN 14 220, low-alloyed stainless steel for case hardening, weldability and good formability, good thermoforming. Normal annealing - 860 ° C, soft annealing -700 ° C, hardening - 840 ° C to 870 ° C, first quenching - 880 ° C water/oil, the second quenching 780 ° C - water / oil, tempering - 160 ° C / 1h.

Usage of materials: highly stressed parts of machinery and road vehicles (gears, drive shafts and camshafts, pins, plate and sprockets, shaft joints), cylinders for motor drive chain, gear.

- teeth case hardening up to 0.6 ÷ 0.9 mm

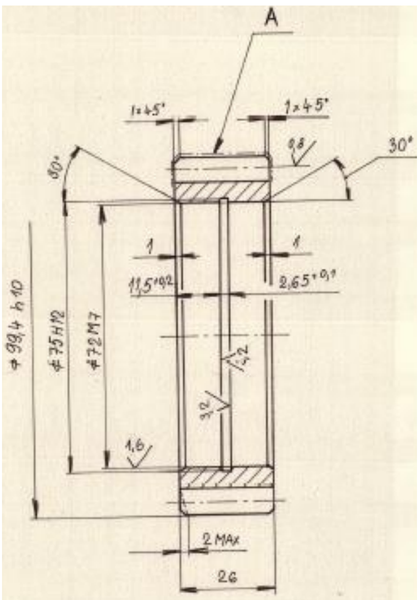
- Hardened to 58 ÷ 62 HRC

- Number of teeth: 30

- Module 3

- Gearing ground; roughness Ra = 0.8

Figure 2. Drawing of the gear



Measurement procedure:

At the beginning of the measurement it is necessary to insert a measuring device into touch Optac LC10. The device is put into operation On/Off button.

Followed by calibration of the instrument using a reference. After calibration test followed by measuring the teeth. Was measured every fifth tooth. The measured values were evaluated using software Optac.

Parameters roughness- meter:

1. The sensor touch: 33 mm
2. Zoom 1: 10,000
3. Measuring rate: 0.500 mm
4. Measurement of distance 277.000 mm

2.1 Milling Technology:

Milling is a cutting operation in which, sheet of material is collected in the form of small individual particles of the work piece. Milling machine revolves around its axis, and by its teeth gradually cuts into the work piece, which is simultaneously pushed against the movement of the machine. Each tooth of the machine gradually cuts tiny chips from the workpiece, not continuously, so the cutting process is interrupted. The essence of milling is machining of the work piece into the required shape, size, and obtain the desired surface roughness.

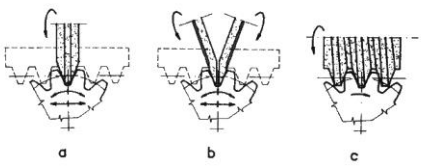
Grinding of front gears:

By grinding the teeth of the gears are being finished after the heat treatment. External and internal gearing of front gears are ground in two ways:

• dividing
• self-generating method

2.2 Grinding technology

Grinding rolling was used when grinding the samples, which is more accurate. Ground gear performs a rolling movement along the imaginary toothed rack. Part of the imaginary gear rack can be formed by a trapezoidal profile grinding wheel or two disc grinding wheels. The most powerful way is grinding by the disc of the shape of evolent screw, whose principle is the same as self-generating milling process.



a) one grinding disc with trapezoidal profile
b) two grinding discs
c) evolent screw shaped grinding disc

Figure 3. Self-generating method

2.3 ISF technology

Acronym ISF means "izotrophy SUPERFINISH", that is isotropic super fine machining. ISF method creates a super smooth surface with a final value of roughness up to Ra 0.02 µm, R = 0.14 µm, which serve to decrease noise of hobbing and running noise of the construction elements, to reduce friction and thus the cost of energy consumed, to extend the service interval and durability. It is a finishing process that is environmentally friendly. ISF technology is used in the aerospace and automotive industries to complete various parts for engines, for components of sports equipment, for turbines for power generation. It improves the surface properties precisely lathed and milled parts and also is used in the medical industry for surface treatment of implants and surgical instruments. FIG. 31 shows component before finishing by ISF technology, and after treatment by ISF technology.

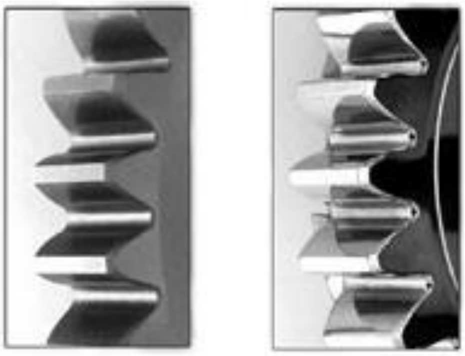


Figure 4. Component before and after machining by the technology ISF

Among benefits of the surfaces machined by the ISF technology belong reduction of friction and wear, increases the operating life and improves the resistance to corrosion. It also increases performance, enhances conventional machining operations such as grinding and lapping. Extensive benefits of ISF:

- It improves wear resistance, reduces the cost of lubrication, improves corrosion resistance, reduces vibration and noise, decreases the torque, extendins the operating life of components, reduces the time of failure, minimizes overheating and friction, less fuel, less wear, lower operating temperatures , increases power output and efficiency, improves durability, lowers the cost of spare parts, quieter operation.

It is a chemical-mechanical process that gradually removes increased roughness and makes the surfacesmooth. The result is finishing with a small change in the dimensions of parts. Increasing the life time of the parts is the result of better machined area that divides the load over a larger area and reduces the formation of surface friction. ISF is a process of two stages that ends by polishing.

The following figure shows the differences between the two technologies:

Figure 5: The sequence of machining by the ISF technology

2.4 Place and conditions for carrying out of experiment

Measurement was held in metrology laboratories of Prima Bilavcik, Ltd. in Uhersky Brod. Measuring the surface quality was carried out on a contact roughness-meter Optacon LC10. It is a portable measuring instrument, which enables fast and accurate measurement of surface roughness.

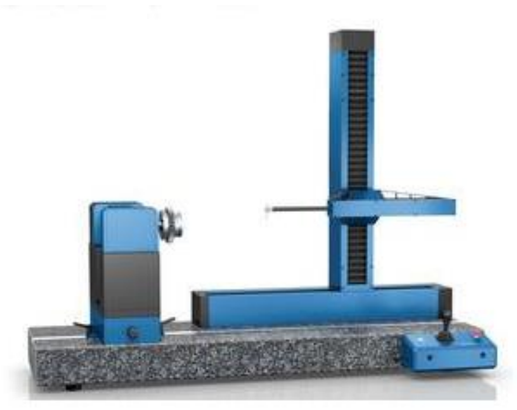


Figure 6. Roughnesstester Optacom LC10

2.5 *Roughness tester Optacom LC10 provides:*

Nearly wear-free parts.
All measurement systems are incremental, optical and contactless.
Very low consumption of stylus tips thanks to optacom soft-touch.
Stylus tip breakage is allmost impossible.
All machines measure as you manufacture without stylus arm-pivot.
Our guides have a maintenance interval of 50 km.
Measuring range up to 425x425 mm are standard.
Simple machine operation via built-in joystick.

The movement range and the measuring range are identical for all our machines

Table 1. Technical data of roughness tester Mitutoyo SJ-400th

Technical parameters	
Measuring speed	0,1 – 2mm/sec (optimized automatically)
Maximum measuring force	10 – 15 mN
Straightness	+/- (1,5 + L/100 µm)
Accuracy	+/- (1,5 + L/100 µm)
Measuring system	optical, incremental and contactless in a all axis (X, Z, T)
Resolution in X and Z axis	0,02 µm,
Resolution at the stylus tip	0,03 µm
Measuring range (X axis, Z axis)	225mm
Radius of the stylus tip	from 0,002 to 1 mm
Angle measurement	78° upwards; 87° downwards
Dimension (WxDxH)	950 x 380 x 725mm
Weight	150kg

Evaluation of roughness parameters were controlled by the touch-like way and profile method with instruments and software brand Optac. Measured target, also called the primary profile, in addition including components and other components (waviness and shape). These components should be eliminated by filtering. After filtration the roughness profile is obtained. The computer, which is an external device and which contour ografu provides and reliable and easy operation of the entire measurement process.

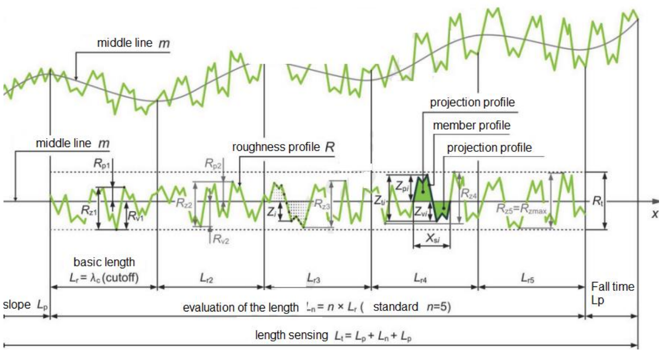


Figure 7. Roughness profile

For this method of measurement, overall lenght Lt is not evaluated. At the beginning and at the end of the recording there are undesirable interferences caused by the start and stop of the sensor. Removing those parts of the profile, Ln – the evaluated length is obtained, which is divided into several basic lengths Lr. The center line *m* divides the actual profile so, that in the range of basic lenght, the characteristics of the longitudinal and transverse direction are evaluated. The most commonly evaluated parameters of roughness are arithmetic deviation of the surface Ra, the arithmetic average of the greatest profile heights Rz and the maximum value of the greatest hights of the profile Rzmax. These roughness parameters were provided to us by the device Optac LC10.

2.6 Software for viewing measurement gears

For observation of samples Optacom software was used. Program is used to communicate with Roughness-meter Optacom. It allows to individualy store measurements and protocols. Includes one software interface for all modules, a comprehensive list of features with a graphical designation, automatic calibration of the sensing touch, red-green graphic for percentage expression and automated transfer to Q-DAS.

Figure 8. Software Optacom

3 THE MEASURED VALUES

In the present experimental part of this study, the analysis of the quality of the surface of gears is carried out in order to compare the roughness parameters according to the different finishing technology. Gears were machined by different finishing techniques. One was milling and the another one has been machined by the ISF finishing technology. When evaluating the surface, the roughness parameters were monitored, sucha s Ra (mean arithmetic deviation considered of the evaluated profile), Rz (maximum height of the profile roughness), Rzmax (maximum value of the greatest heights of the profile) and Wt (height of the waviness).

Gearing grinding machining:

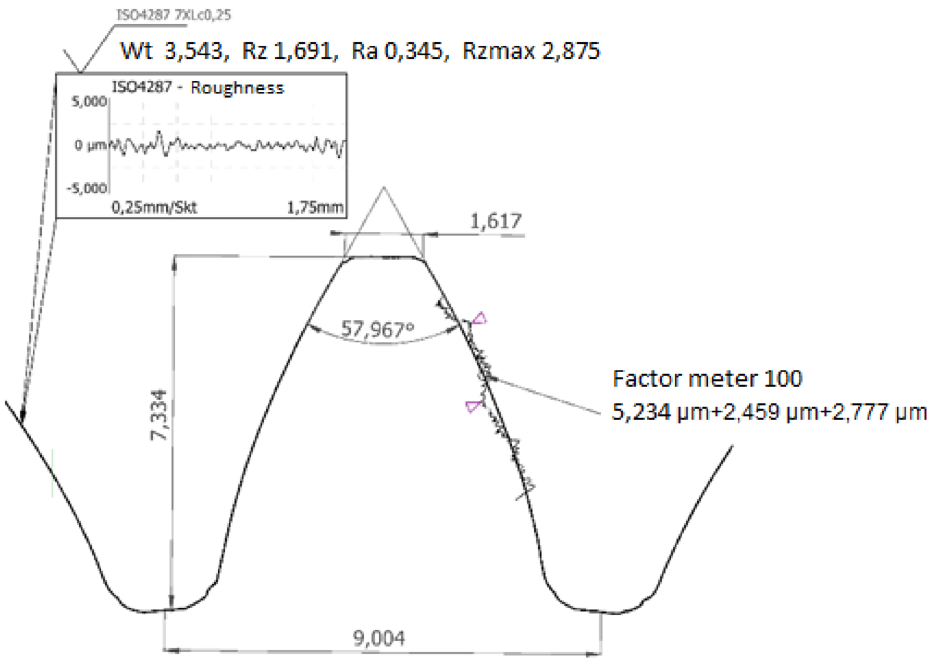


Figure 9. Chart grinding technology

Machined gearing technology ISF:

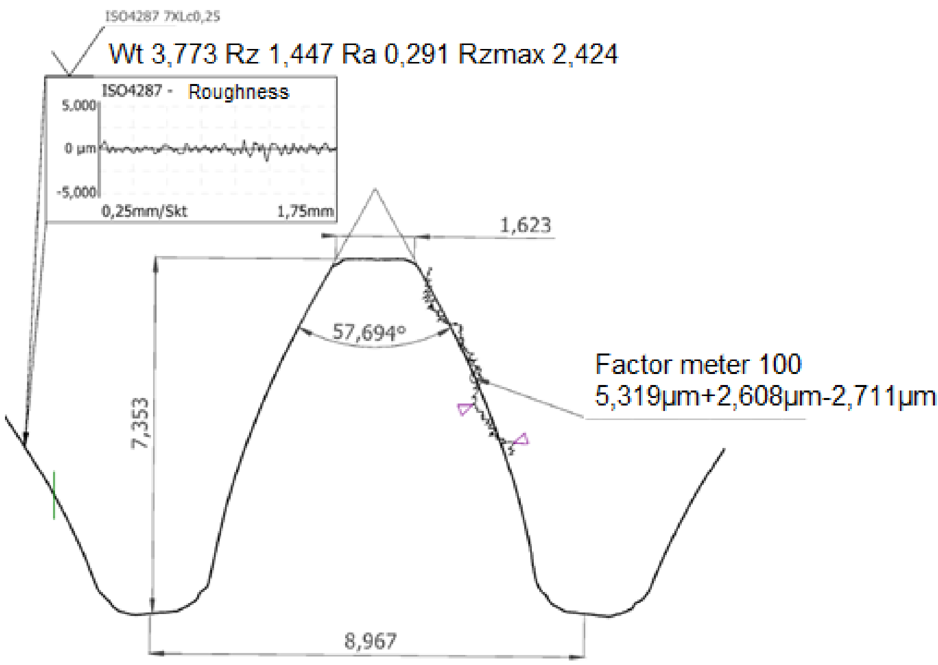


Figure 10. Chart ISF technology

For the evaluation of surface roughness gear we used the ISO 4287.

4 MEASUREMENT RESULTS

Figures 9 and 10 show the measuring of gear wheels. For individual surface machining technology, we can see the differences. When conventional milling technique is used, values are higher in comparison to the ISF technology. The milling technology includes higher fluctuations in roughness

values Ra, R, Rzmax. The ISF technology provides more stable values and are at lower level except for the value of waviness (Wt), which could be caused by the noise. Milling technology includes large fluctuations, which results that it can not reach the surface quality of ISF technology, even though the surface quality is sufficient, it qualifies for the conditions set by the machinery industry.

ISF technology has the perspective and importance, especially nowadays as the requirements and demands on machine and machine components rising, which means constantly reducing maintenance processes of the machine during operation. Implementing ISF technology into machines and components production for machines has economic advantages. Still, however, it depends on the requirements for the component or machine. Anyway, for machine parts and functional units of larger and more expensive machines, I would recommend this technology because it can significantly reduce overall friction of the functional areas which could partly solve the problem of minimizing the effects of temperature on the production process and the functionality and life-time of the machine and its components.

5 CONCLUSION

The gears are most commonly used in transmissions in which there is friction and consequently the wear. In terms of tribology it is necessary to ensure adequate lubrication characteristics. Oil reduces friction, prolongs life, reduces noise, reduces wear and improves performance. Gear to be machined surface grinding reported as results from this experiment increased wear and need more frequent monitoring and oil changes. Compared to the gear wheel of the working ISF technology, which has a lower surface roughness, thus less wear and less degradation of the oil surface of the engaging portion need not be replaced as often. Also, the benefits of technology ISF reflected in the overall life of the components and operation of the machine, which has a lower emission longer service life, lower maintenance costs and repairs.

The goal of the experimental part was to evaluate the surface quality of the same two selected gears. The teeth were made in the same company with the same procedures. The difference was in finishing technology after machining. The samples were measured and evaluated roughness-meter contact Optacom LC10. 4 parameters of roughness were evaluated: Ra, Rz, Rzmax, and Wt. For the values of Ra, Rz, Rzmax the values were lower for ISF technology. For milling technology the value Wt was lower. Achievements examining the surface of the samples show that the ISF technology is suitable for engineering benefits. Using finishing technology, ISF, however, significantly increased the cost of producing parts which ultimately increases the cost of the final product.

The biggest problem ISF finishing technology is its availability and higher price. Also, the problem is the introduction of this technology into its production process due to lack of interest of companies such costly technologies. ISF Technoogy is particularly important in the future for improving environmental properties of engineering.

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Available on the internet:

<http://www.merici-pristroje.cz/optacom-0/>

Fig. 1, 6, 8 : <http://www.merici-pristroje.cz/optacom-0/>

Fig. 4, 5: <http://www.cryosciencetechnologies.com/rem-isf>

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