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NEW APPROACH FOR THE CRANKSHAFTS GRINDING AND DETERMINATION OF THE 3D SURFACE ROUGHNESS MODEL FOR THE CRANKSHAFTS BEARINGS

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Abstract: The novel technological equipment for diesel engines crankshaft bearing surfaces (journals) grinding has been elaborated. This technology is generally applicable to the medium size shipboard diesel engines with crankshaft journal diameter from 100 up to 350 mm. This innovation allows repairs of the crankshaft to be carried out directly in the engine housing, without removing it from the engine, and, in addition, making unnecessary to dismount the whole engine. Furthermore, when the above mentioned technology was certified for grinding of the crankshaft journals, the geometrical form and surface roughness of bearings fully complied with the established technical requirements. Thus novel technology provided the efficient solution for crankshaft bearing machining problems which allow significantly decrease maintenance time of ship engines and to save considerable financial resources.

Accordingly the new three-dimensional surface roughness model, and its microtopographical surface roughness parameters, which are suitable for diesel engine crankshafts bearing surfaces were developed as well. It has been determinate, that the optimal microtopographical model of the particular surface is composed by the following parameters: roughness height parameter R_{aT} and two spacing parameters S_{m1} and S_{m2} . The measurement basis for these roughness parameters is a mean plane of overall roughness.

Key words: crankshaft grinding, 3D, surface roughness

1. INTRODUCTION

This article is closely related with one of EU significant manufacturing industry branch – ship building and ship repair. When the ship's diesel engine repairs are done normally the crankshaft journal (bearing) surfaces must be renewed according very precise geometrical and surface roughness requirements. Currently technologies available for ship repair enterprises are sufficient to ensure these requirements; however, they are very expensive and time consuming. Therefore it was decided to conduct a comprehensive research of the shipboard diesel engines crankshaft journals surfaces machining. This allowed us to improve technological processes by designing the novel grinding equipment as well as to determinate the respective surface roughness parameters.

Furthermore, it is important to note that crankshaft bearing surfaces must be seen as 3D object with definition of *microtopographical* surface roughness parameters which reflect to real surface. By analysing the scientific researches in this field we found that there are no comprehensive researches available in this particular field, especially as regards the shipboard engines crankshaft journals surface *microtopography*. Taking into consideration the above mention arguments in the research work the new technological approach has been used, which significantly simplifies technological work and allows crankshaft journal grinding performing inside the housing without removing it from engine. This technology saves significant financial resources as well as time of engine repair itself.

Therefore this research has real production assignment with practical implication. Solving problems related with surface accuracy it is possible to considerably improve the crankshaft machining process as well as performance of maintenance operations and consequently overall quality of repair works.

Used scientific methodology: research of the diesel engines crankshaft journals surface roughness was based on theory of contingency fields, which gave opportunity to create the credible (maximally close to the real conditions) model of surface roughness and *microtopographical* surface roughness parameters related to this model.

2. NEW CRANKSHAFTS GRINDING DEVICE

The grinding device is elaborated for crank pin journals grinding to the next “repair” dimensions or into any other dimension when geometrical and surface roughness parameters should be renewed. Furthermore, when the grinding operations are carried out the grinding device is based directly on crankshaft journal, with previous dismantling of the connection road and bearing liners (see Figure 1). It is important to note that grinding device also can be used for machining of the crankshaft main journals – in this case crankshaft should be centred in the stationary turning machine.

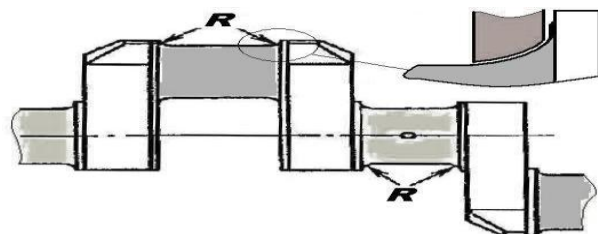


Fig. 1. Grinding device placement on the crankshaft bearings

In principle by changing of the base rings and liners of the grinding device (depending of journal dimensions) it is possible to use this grinding device for machining of any type of diesel engines crankshafts. However additional difficulties occur when is necessary to process very small (journal $\varnothing < 100$ mm) and very large (journal $\varnothing > 350$ mm) crankshafts.

The renewable crankshaft journal surface is abrasively processed by the flat surface of grinding stone. Such kind of abrasive stone placement is very unusual for grinding operations, however, only in this manner it is possible to carry out crankshaft journals grinding in very limited space (inside the engine housing). Therefore, relatively small diameter and specific position are compensated by the high rotation speed of the grinding stone.

Feeding motion of grinding device is ensured manually by operator, who steady moves the device in parallel to machining surface and in the same time performing cyclic round-shape motions. The grinding depth is fixed by the special adjustment plates and screws. In exceptional cases, when at the end of machining is necessary to achieve the very smooth surface it is possible to use the special polishing discs and polishing wax.

Furthermore, the grinding device fully ensures high accuracy of the geometrical and surface roughness parameters in accordance with the technical requirements for this type of repair operations. The elaborated device is experimentally tested in production and fully proved its efficiency.

The grinding device is electro-mechanical hand instrument, whose principal construction is relatively simple and safe. Its main parts are following: drive mechanism, reduction gear, base plate, regulation and basing system, grinding stone, fixing mechanism and iron ring of grinding stone, load control gauge, as well as complimentary equipment.

The grinding stone placed in the iron ring by assistance of the bronze bushing is fixed on the drive shaft of mechanical reduction gear. Sufficient and tight connection between grinding stone and drive shaft is achieved by usage of special fixation nut. The drive mechanism is connected with the basic plate of grinding device on which in its turn is fixed regulation and basing system. Thus the orientation of the grinding stone towards the crankshaft journal surface is ensured.

Elaborated grinding device is innovative, there are no known analogical in the ship repair, therefore it is important to understand and follow to the specific requirements which are foreseen for the work with this device as well as scrupulously perform the technical maintenance of equipment. Furthermore, the exact nature and properties should be investigated as well. For this very reason the 3D crankshaft bearings surface modes shall be elaborated (Blunt & Jiang, 2003).

3. SURFACE ROUGHNESS MODEL

The mathematical model of the surface roughness has to be complete enough to describe the real surface and in the same time simple enough for practical use in industry. In order to successfully work out the crankshaft journals surface roughness model, classification of rough surfaces and research of irregular roughness model has been done (Torims, 2005).

It was defined that every type of mechanical machining and surface creation process has their own, unique surface roughness topography. However, all mechanically processed surfaces principally can be divided into two groups: *isotropic* and *anisotropic* surfaces. The isotropic surface is surface whose roughness parameters in the all directions are the same but for anisotropic surface the roughness parameters are different depending on measuring direction.

Isotropic roughness structure is typical for details which surface is machined by following methods: EDM, sand or pellet blasting, vibro – abrasive, polishing and lapping. But anisotropic surface structure is characteristic for surfaces machined by various abrasive methods, e.g. grinding, superfinish, rolling and broaching, etc.

Despite the above mentioned classification surfaces with the identical structure can have absolutely different character of surface inequalities. Therefore, in the research the detailed surface irregularities classification were done. Generally by surface roughness mathematical functions these surfaces can be divided into three groups, namely, with regular character, irregular character and mixed type.

The regular type of irregularities characterises by periodical bodies of inequalities which are very similar and in the first approximation can be described by the periodical mathematical function (Rudzitis et al., 2001).

But the irregular type of inequalities characterises with irregular height and form of roughness. Furthermore, mixed type of profile is forming when regular and irregular character factors are combined, in fact this type is allocated between both above described kinds of irregularities.

According above described classification, the shipboard diesel engines crankshaft journals machining with the mechanical grinding method, can be looked as anisotropic surface with irregular character of surface roughness. This kind

of surface can be described by normal distribution or Gaussian law. The probability density in separate surface cross-sections can be described by the Equation 1 (Rudzitis, 1975):

$$f(h) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{h^2}{2\sigma^2}} \quad (1)$$

where: h – surface heights deviation from the mean line;
 σ – standard deviation of surface roughness profile.

Furthermore σ is mathematically related with the roughness height parameter R_a , and this can be extracted in the following manner:

$$R_a \approx \sqrt{\frac{2}{\pi}} \sigma \quad (2)$$

But for the 3D approach the microtopographical surface height parameter should be introduced:

$$R_{aT} = \frac{1}{A} \iint_{\Omega} |h(x, y)| dx dy \quad (3)$$

where: A – area of the covered surface, mm²;

$h(x, y)$ – surface roughness (points) deviation from the mean plane, in planes x and y .

Although, R_{aT} describes surface roughness height in three dimensions it is not sufficient for the full description of the surface, because the surface irregularities density is not covered yet (Gohar & Rahnejat, 2008). Figure 2 shows how different heights concentration can be for the same R_a .



Fig. 2. Schematic illustration of two different surfaces

Therefore, in order to achieve the complete surface roughness model for the crankshafts bearings spatial parameters should be used too, namely S_m :

$$S_m \approx \frac{2}{n(0)} \quad (4)$$

The 3D spacing parameters S_{m1} and S_{m2} can be calculated:

$$S_{m1,2} = \frac{2}{n(0)_{1,2}} \quad (5)$$

where: $n(0)_{1,2}$ – number of „zeros” within one length unit, when the profile crosses the mean plane in the two perpendicular directions to each other.

4. REFERENCES

- Blunt, L. & Jiang, X. (2003). *Advanced techniques for assessment surface topography*. Elsevier, UK
- Torims, T. (2005). *Researches on machining of diesel engine crankshaft journals surfaces*. (2005) Doctoral Thesis. Riga Technical University. Latvia. Riga
- Рудзит, Я. А. (1975). *Микрогеометрия и контактное взаимодействие поверхностей*. Рига, „Зинатне”
- Rudzitis, J.; Shiron, E.; Skurba, M. & Torims, T. (2001). *Classification of rough surfaces*. Scientific proceedings of Riga Technical University. Part 6. Vol. 2. Riga
- Gohar, R. & Rahnejat, H. (2008). *Fundamentals of Tribology*. Imperial College Press, UK