ROLE OF SELECTION OF MEASURING METHODS IN DIAGNOSING OF STRUCTURE ACTUAL SURFACE IN THE RUBBERY TORSIONAL VIBRATION DAMPERS

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Summary

The paper presents problem of selecting the measuring method of geometric structure of the surface formed by laser beam in damper. Measurements in 2D system, in the context of value and giving satisfactory results need to be verified in 3D. This is due to the fact, that the surface after the laser machining is specific. Although, you can choose the machining options that allow to obtain a certain roughness of the surface, but there is no information about its spatial structure. Such information includes a description of the structure made in 3D system.

Keywords: damper, laser machining, surface texture, 2D and 3D measurement

ROLA DOBORU METODY POMIAROWEJ W DIAGNOZOWANIU STRUKTURY POWIERZCHNI CZYNNYCH GUMOWYCH TŁUMIKÓW DRGAŃ SKRĘTNYCH

Streszczenie

W pracy przedstawiono problem doboru metody pomiaru struktury geometrycznej powierzchni tworzonej wiązką lasera na powierzchniach czynnych tłumikach. Pomiary w układzie 2D, dające w kontekście wartości satysfakcjonujące rezultaty wymagają weryfikacji w układzie 3D. Jest to spowodowane tym, że powierzchnia po obróbce laserowej jest specyficzna. Można wprawdzie wybrać te warianty obróbki, które umożliwiają uzyskanie określonej chropowatości powierzchni, ale brak jest informacji o jej strukturze przestrzennej. Takie informacje zawiera opis struktury wykonany w układzie 3D.

Słowa kluczowe: tłumik, obróbka laserowa, struktura geometryczna powierzchni, pomiar 2D i 3D

1. REQUIREMENTS FOR SOME SURFACE OF TORSIONAL VIBRATION DAMPERS

Working multi-cylinder engine is the source of vibration, which may be hazardous for the fatigue strength of the whole drive system. The biggest threats to the working system are torsional vibrations, which generally do not cause vibroacoustic phenomena. In order to reduce the threat coming from the torsional vibration in addition to the direct solutions, such as change of rotational speed, frequency vibrations of the shaft, the course of excitation forces, used indirect methods - torsional vibration dampers [1].

Torsional vibration damper normally is positioned at the free end of the engine's crankshaft (Fig. 1).

Currently, in multicylinder combustion engines, installed in passenger cars are used rubbery dampers (Fig. 2).

This type of the damper dampens resonant torsional vibrations of the engine crankshaft principally based on dynamic principle by making a suitable inertial force which periodically balances the driving forces variable.

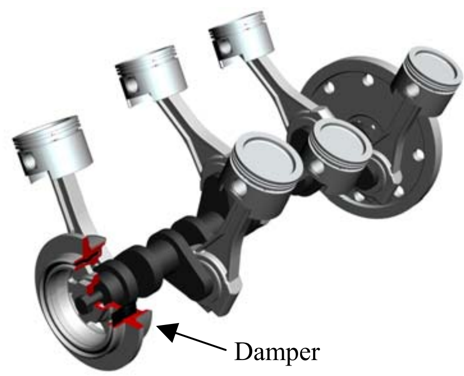
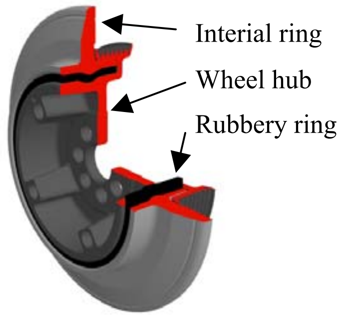


Fig. 1. Crank-piston engine system with a damper

The rubbery damper, what is worth remembering, there is also internal damping rubber, which directly affects on the amount of energy dissipated by the damper. Damping is inseparably connected with the deformation rate, which depends on the relative velocity between the hub and inertia ring damper.



a)

b)

Fig. 2. Torsional vibration damper: a - model of damper, b - a real damper

The rubber insertion (rubbery ring) may have varied shape (actually whichever), but it is important to provide an uniform shear stress distribution across the cross-section rubber, which considerably increases the lifetime of damper [2].

This requirement is difficult to fulfill, especially in the dampers, where is using a rubber vulcanization process in order to combinable portions of damper. In this type of damper, in case of exceeding the permissible shear stress often causes damper's damage (Fig. 3). Taking this into account in order to increase the reliability and durability of damper, technology of damper's installation has changed. The process of rubbery ring vulcanization was replaced by the injection process.

It is worth mentioning that the correct positioning of the rubbery ring of damper (Fig. 4), affects not only to the correct position of hub and inertia ring during rubber injection process, but also to condition of active surface damper (such as roughness), which affects to the quality of the installation and subsequent operation of damper [3, 4].

Fig. 3. View of rubber insert damaged due to overload during operation.

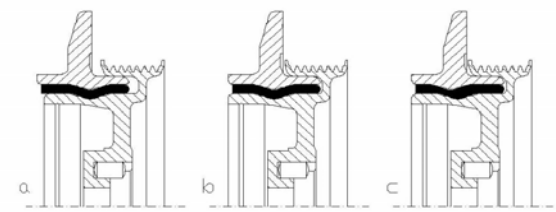


Fig. 4. Examples of different positioning of rubber insert with respect to the hub and the inertia ring in rubbery damper torsional: a, c - incorrect; b – correct

Light of the above, at the design stage of manufacturing technology may be selected machining method of that provides achieve adequate geometric structure of the surface (e.g. Ra, Rz, preparation method and orientation) [5, 6]. Incorrect selection of these parameters affects on the effectiveness of damper. There are cases when exceeding a certain amplitude of shaft torsional vibration, the inertial ring begins to slide on the outer surface of rubber pad and the damper becomes an additional rotating element of an engine.

2. SHAPING OF STRUCTURE IN CUTTING PROCESS

Currently, many ways of shaping the geometrical surface structure (GSS) are known. The vast majority of the surfaces are formed by supplying energy to them: these surfaces are not cut, not subjected to a thermochemical machining. These include surface which is formed by casting, sintering or molding, and such surfaces reflect the wavy finish of matrix surface machining with which they come into contact.

However, they represent a small percentage of the area of machine parts. The vast majority are which surfaces are formed by supplying energy to them: mechanical machining (tool tip), chemical (etching), thermal (plasma, laser beam) or a hybrid, for example after electro discharge-abrasive machining processes. Geometrical structure of the surface depends on the shape of the tool and kinematic movement of the work piece relative to the tool.

Tool geometry may be determined by the geometry of the blade (formed after turning tool machining, milling tool, drill) or geometry shaping surface (spheres in the shot-peening), indeterminate (characteristic of physical processes) and random (in abrasive process) [7]. The combination of tools and kinematics of its motion gives rise to different GSS (Fig. 5).

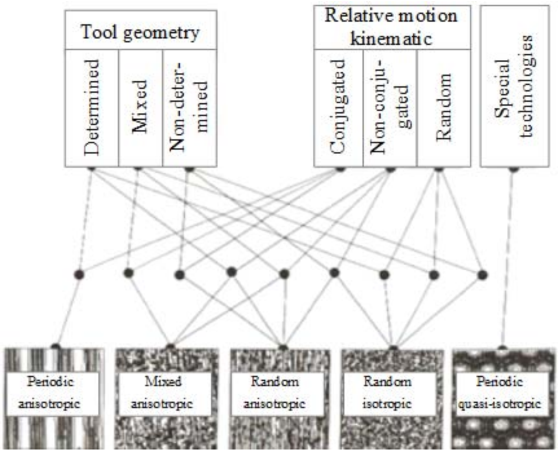


Fig. 5. Types of GSS which arose as a result of various methods of machining [basic on 7]

3. EFFECTIVE AREA OF DAMPER AFTER BEAM MACHINING AND ANALYSIS OF GEOMETRIC STRUCTURE

In order to obtain damper smooth effective area were applied by laser machining. In experimental studies was used a fiber optic laser pulse with a power of 500 W. The basic variable parameters of laser are: pulse frequency [kHz] and scanning speed [mm/s]. The laser beam impact on the object at a point, and the density and nature of the decomposition of outbreaks of impact depends on the speed of the head (the beam) relative to the object and the pulse frequency and a scanning speed (Fig. 6) [8].

By means of 2D measurement is defined roughness of surface, which is obtained in process of machining. This measurement is relatively simple; it can be prepared by using devices which are commonly used such as Surtronic 3+.

In this way, the damper's surfaces were prepared by laser beam with a founded constant pulse frequency of 200 kHz and a variable scan rate. By means of 2D measurement system defined surface roughness, which is obtained in the process of machining.

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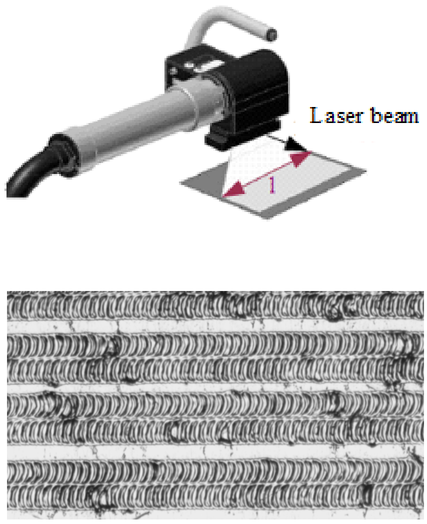
In this way, the muffler prepared surfaces measured with a laser beam with a founded constant pulse frequency of 200 kHz and a variable scan rate. In this way, the damper's surfaces were prepared by a laser beam with a pulse founded constant frequency of 200 kHz and a variable scan rate.



a)

b)

Fig. 6 specificity of pulsed laser: a) motion of beam diagram; l - scanning width, b) the nature of wavy finish after machining

The results of the measurements for the six variants of the variable scan rate are given in Table 1.

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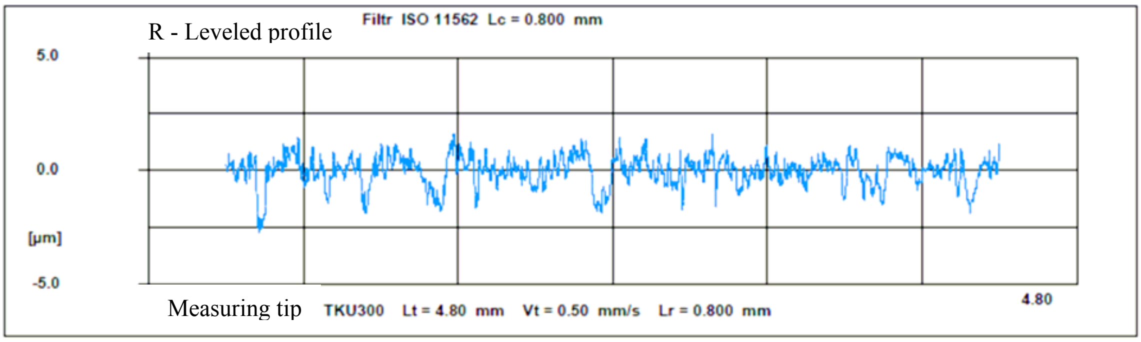
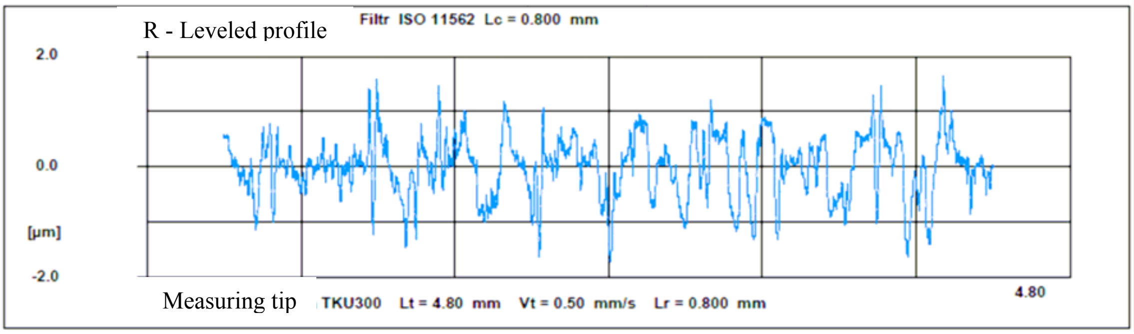
Table 1. Machining variants and results

Number of test	Scan speed [mm / s]	Ra [μm]	Rz [μm]
I	8000	0,58	4,47
II	6000	0,50	3,41
III	4000	0,72	4,45
IV	2000	0,72	4,68
V	1000	0,64	3,76
VI	100	0,43	2,85

Table 1 shows that it is easy to identify this variant of machining for which were achieved possible the smoothest surface (variant VI and II). However, made in a 2D roughness profiles do not show any specific ways of surface shape (Fig. 7).



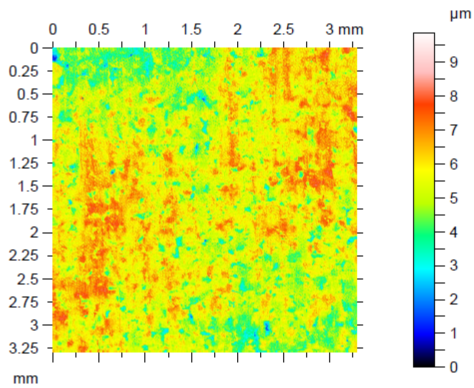
a) variant II



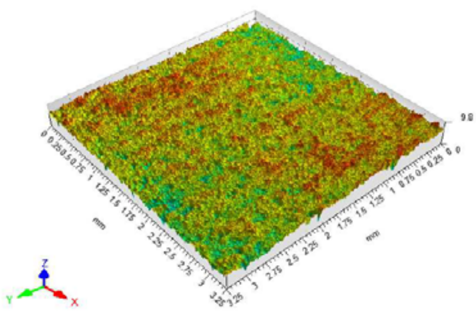
b) variant VI

Fig. 7. Examples of roughness for variants II and VI

Measurement of roughness in 2D system does not inform about pits in the surface in space. It is drawback during the laser processing. Wavy finish of processing is specific, which can be determined after evaluation of the surface structure in 3D system. Examples of the results of measurements made on a Talysurf profilometer CCI is shown in Fig. 8 and 9.



a)



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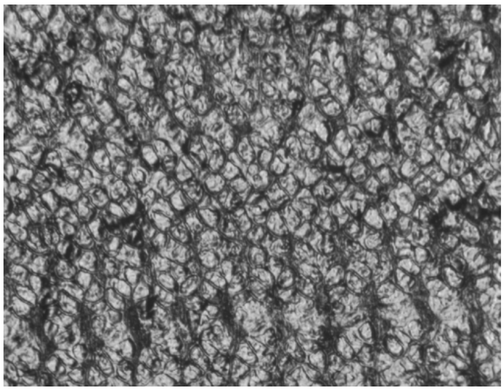

c)

Fig. 8 3D measurement results for the variant II - post-processing invisible wavy finish: a) contour map, b) 3D surface view, c) microscopic picture of structure

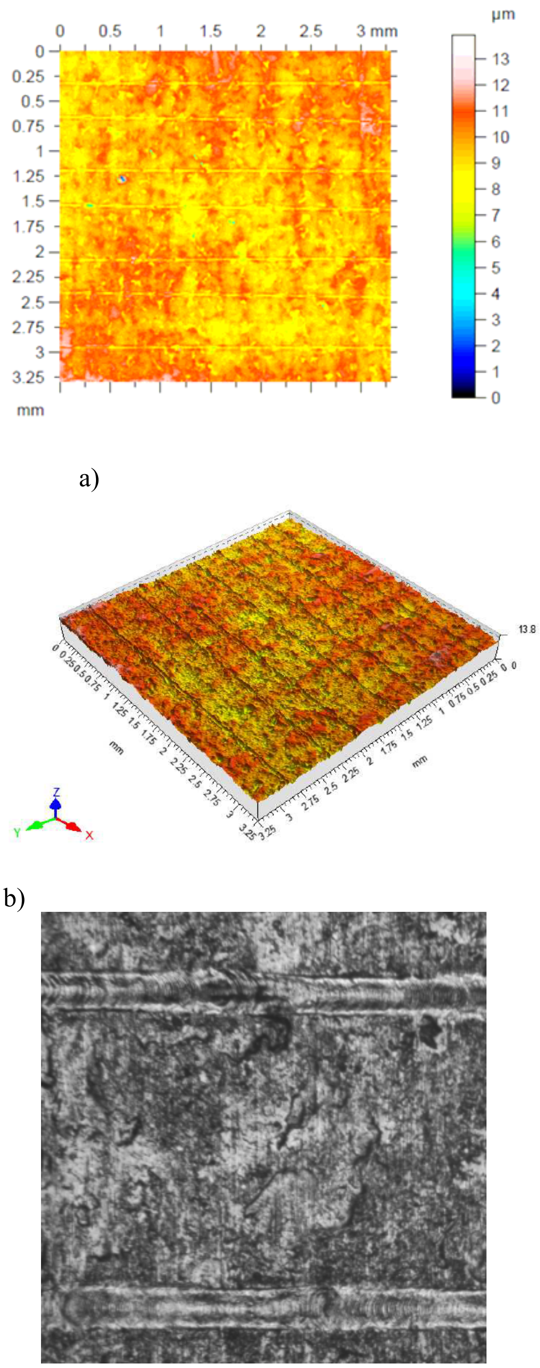

Fig. 9. 3D measurement results for the variant VI - post-processing invisible wavy finish: a) contour map, b) 3D surface view, c) microscopy picture of structure

In variant II was achieved even recesses coverage of surface after impact of laser beam. In variant VI, however, due to the machining parameters, the structure is clearly determined and directional. In addition, as shown in the picture of the surface (Fig. 9b) surfaces that are not processed which have a roughness suitable for processing proceeding, they are clearly visible, relevant to preceding processing which may in turn distort the measurement result and decide on admission to the exploitation of incompatible with the requirements of damper. Analysis of the surface structure in 3D allows to identify the above-mentioned directivity structure and allows to selection of the proper positioning damper during processing. In this way, can be provided machining process by which obtained the best properties in terms of both installation and subsequent operation of the damper.

4. CONCLUSIONS

When considering how to obtain a certain surface roughness rubber torsional vibration dampers should be pay attention not only to the required value of roughness parameters given in the specifications, but also to the wavy finish position of installation. The device of type 2D, measuring tip shows the mapping of the surface being tested, but does not give information in a holistic perspective, which would allow to choose the method of machining process.

The position of the laser wavy finish can be crucial. As the results of experiment, it is possible to obtain surface roughness, which is preferable for installation of dampers. Simultaneously, thanks to the 3D test results, it is possible choose the right direction of motion of the laser beam, due to the positioning wavy finish and subsequent operation.

REFERENCES

1] Homik W.: *Projektowanie wiskotycznych tłumików drgań skrętnych*. Przegląd Mechaniczny 10/2007
[2] Jenzer J.: *Influence of natural cylinder output imbalance and network configuration on the torsional vibration calculation of diesel-electric installations*. New Sulzer Diesel Report, 1996
[3] Homik W., Skrzat A.: *Analiza wytrzymałościowa tłumika drgań skrętnych z tłumieniem wewnętrznym*, XXIII Sympozjon Podstaw Konstrukcji Maszyn, Rzeszów-Przemyśl, 2007
[4] Homik W.: *Drgania skrętne wału korbowego silnika z gumowym tłumikiem drgań*. XVIII Międzynarodowa Konferencja – SAKON Metody obliczeniowe i badawcze w rozwoju pojazdów samochodowych i maszyn roboczych samojezdnych. Rzeszów 2007
[5] Kacalak W., Tomkowski R., Lipiński D., Szafraniec F.: *System to the analysis and the evaluation of the topography of surfaces after grinding process*. Mechanik 9/2014, pp. 219-226
[6] PN-EN ISO 4287:1999 *Specyfikacje geometrii wyrobów. Struktura geometryczna powierzchni: metoda profilowa. Terminy, definicje i parametry struktury geometrycznej powierzchni*
[7] Oczoś K., Liubimov V.: *Struktura geometryczna powierzchni. Podstawy*

klasyfikacji z atlasem charakterystycznych powierzchni kształtowanych. Oficyna Wydawnicza Politechniki Rzeszowskiej, Rzeszów 2003
[8] Ciecińska B. *Konstytuowanie swobodnej energii powierzchni wiązką lasera. Innowacje w zarządzaniu i inżynierii produkcji*. T.I. Monografia pod red. R. Knosali. Oficyna Wydawnicza Polskiego Towarzystwa Zarządzania Produkcją, Opole 2014

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