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RESEARCH OF SURFACE CONDITION OF POWDER DETAILS

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ABSTRACT
Surface condition of powder details on the different stages of producing of joining elements is the important factor that influences on the choice of technological conditions of operations and end-use properties and running ability of product. Generally, the roughness, porosity and microstructure determine the surface condition. The results of investigation of surfaces of iron-copper details after compacting, sintering and infiltration are offered.
The influence of the technological process on the surface conditions was evaluated by comparison of the average 2D and 3D roughness parameters of iron-copper details after compacting, sintering and infiltration. The present surface roughness research is based on machine parts surface cross section profile analysis. However, in practical applications machine parts surface roughness behaves as a 3D object. Therefore, the "Taylor Hobson Ltd" 3D measurement system has been used. The analysis of the influence of the technological process on the surface roughness parameters is given.
Keywords: powder details, surface roughness, properties

1. 3D MEASUREMENT SYSTEM
The present surface roughness research is based on machine parts surface cross section profile analysis. But in practical applications machine parts surface roughness behaves as a 3D object. Therefore it is necessary to create a new theoretical and practical basis for machine parts surface assessment as a 3D quantity [1]. With a 3D measurement and modern analysis software the exact line of area to be assessed can be chosen so that meaningful data is produced. Another benefit of 3D systems is their ability to visualize surfaces to emphasize the surface features [2].
The "Taylor Hobson Ltd" 3D measurement system has been used (Fig.1).
This system consists of following main parts:

- The mechanical structure including two step motors, a support with setting and adjusting screws with an inductive sensor, stage (X-Y), gearbox, and column stand.
- The electronic part including a transducer, a frequency filter, a digitization and amplification circuitry. This unit receives the output signal from the sensor and transforms it into a form necessary to the computer to receive it, as well as controls the step motors.
- The computer which is used to control all operating procedures, to calculate parameters and to display drawings and results into the memory of PC. This system is capable of dealing separately with roughness, waviness, summary surface and also showing them by means of graphical images.

3D measurements with stylus instrument were achieved in our case by basic "stepping" method and data processing by computer (Fig.2).

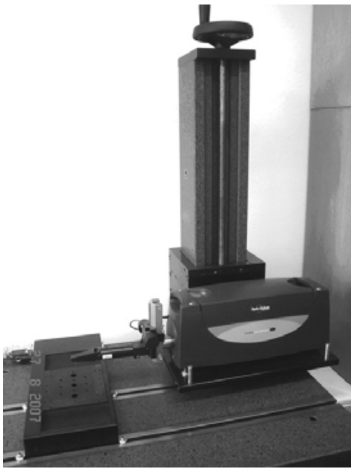

Figure 1. Taylor Hobson measurement system.

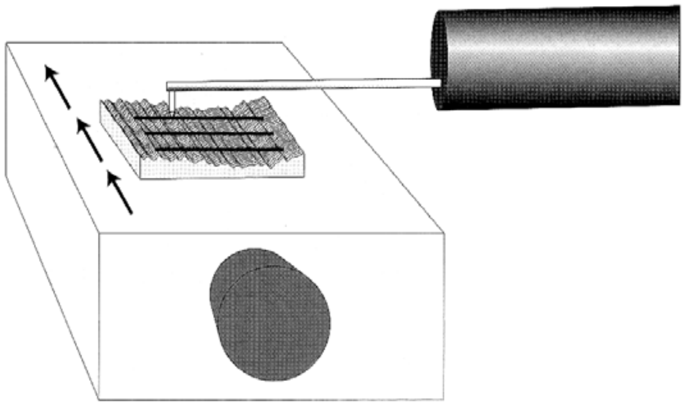

Figure 2. Basic "stepping" method used by stylus systems [2].

Such systems can offer a high degree of spatial resolution and can have a fixed resolution in both X and Y directions. Their disadvantage is that they are slow, and as a result can be prone to suffering from environment effects such as drift and vibration.

2. EXPLORING SURFACE ROUGHNESS

Surface condition of powder details on the different stages of producing of joining elements is the important factor that influences on the choice of technological conditions of operations and end-use properties and running ability of product. Generally the roughness, porosity and microstructure determine the surface condition. The results of investigation of surfaces of iron-copper details [3] after compacting, sintering and infiltration (Fig.3) are listed below.

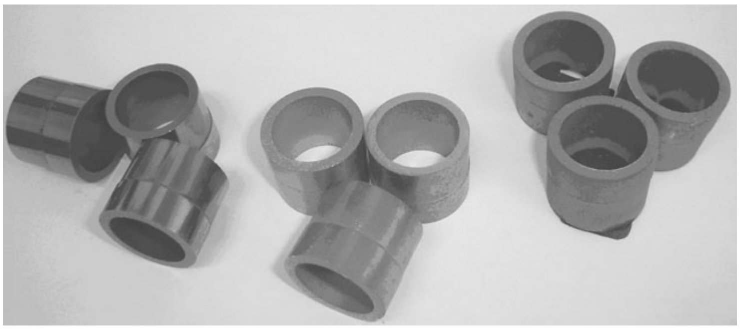

Figure 3. Iron-copper details after compacting, sintering and infiltration.

Achieved 3D surface image of the iron-copper detail after compacting is given on Figure 4, after sintering and infiltration is given on Figure 5 and Figure 6 respectively.

3. INFLUENCE OF THE TECHNOLOGICAL PROCESS ON THE SURFACE ROUGHNESS

The influence of the technological process on the surface conditions we can investigate by comparison of the average 2D and 3D roughness parameters of iron-copper details after compacting, sintering and infiltration.

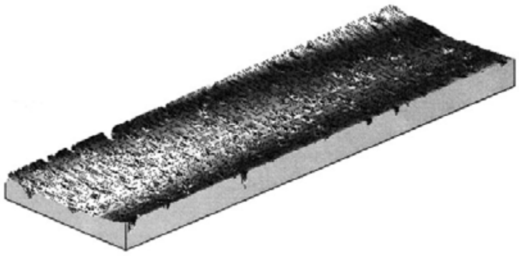

Figure 4. View of the 3D surface image of the iron-copper detail after compacting.

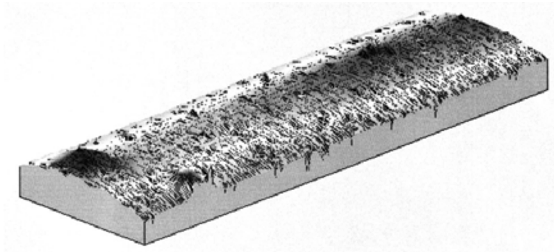

Figure 5. View of the 3D surface image of the iron-copper detail after sintering.

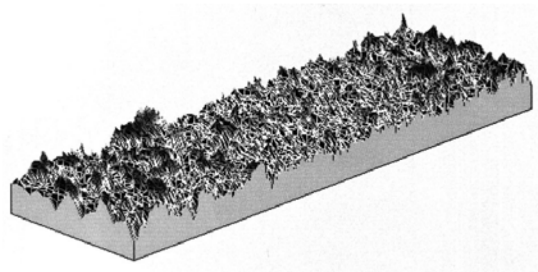

Figure 6. View of the 3D surface image of the iron-copper detail after infiltration.

3.1. 2D roughness parameters

For comparison the most amplitude roughness parameters: *Ra* and *Rz* were used. *Ra* is the universally recognized and most used international parameter of roughness. It is the arithmetic mean of the absolute departures of the roughness profile from the mean line:

$$Ra = \frac{1}{l}\int_{0}^{l}\left|z(x)\right|dx, \qquad (1)$$

where l – the sampling length corresponds to filter cut-off length. In our case there was 0.8 mm cut-off (Gaussian roughness filter).

Rz also known as the ISO 10 point height parameter in ISO 4287/1, is measured on the roughness and primary profiles only and is numerically the average height difference between the five highest peaks and the five lowest valleys within the sampling length:

$$Rz = \frac{1}{5}\left(\sum_{i=1}^{i=5} Z_{pi} - \sum_{i=1}^{i=5} Z_{vi}\right). \qquad (2)$$

Ra and *Rz* comparison of iron-copper details after compacting, sintering and infiltration is given in Table 1. As shown each step of the technological process the surface amplitude roughness parameters increase.

3.2. 3D roughness parameters

Parameters for 3D areal assessment are still under discussion by ISO and other standards organizations. However, at least 18 parameters currently defined in EUR 15178 EN. For comparison we use amplitude parameters: *Sa* and *Sq* and spatial parameters: *Sds* and *Str*.

All these parameters are defined in comparison with a mean plane obtained through levelling of the mean square plane of the measured surface and then through centring of heights around the mean.

Sa – average absolute deviation of the surface:

$$Sa = \frac{1}{MN}\sum_{x=0}^{N-1}\sum_{y=0}^{M-1}\left|z_{x,y}\right|. \quad (3)$$

Sq – root mean square deviation of the surface. Used to discriminate between different surfaces based on height informationa and to monitor manufactoring stability:

$$Sa = \sqrt{\frac{1}{MN}\sum_{x=0}^{N-1}\sum_{y=0}^{M-1}\left|z_{x,y}^{2}\right|}. \quad (4)$$

Table 1. 2D amplitude roughness parameters Ra and Rz comparison.

iron-copper details after:	*Ra, μm*	*Rz, μm*
compacting	0.721	6.6
sintering	0.946	9.1
infiltration	1.83	9.58

Table 2. 3D amplitude and spatial roughness parameters comparison.

iron-copper details after:	Amplitude parameters		Spatial parameters	
	Sa, μm	*Sq, μm*	*Sds, Pks/mm²*	*Str*
compacting	1.02	3.19	75.5	0.193
sintering	1.18	2.11	191.0	0.514
infiltration	2.0	2.6	218.0	0.547

Sds – density of summits of the surface. This parameter is used to evaluate the density of peaks and peats in the surface. *Str* – texture aspect ratio of the surface. This parameter measures the isotropy of surface.

Comparison of the mentioned 3D parameters of iron-copper details after compacting, sintering and infiltration is given in Table 2. As shown each step of the technological process the surface amplitude roughness parameters and spatial parameters increase as a rule. At the same time the parameter *Sq* (quadratic mean of the deviations from the mean) reduces after sintering. Especially significant changes occur with spatial parameters. Density of summits (*Sds*) increases in three times during stages of technological process: compacting, sintering and infiltration. An important point is that at the same time surface is more and more anisotropic since the value of parameter *Str* closer to 1.

4. CONCLUSIONS

1. The 2D and 3D surface roughness parameters of powder iron-copper details are measured and analyzed. It was established, that the values of 2D amplitude parameters and 3D amplitude and spatial parameters are increased during technological process: compacting, sintering and infiltration by copper of powder details. Especially significant changes occur with 3D spatial parameters: density of summits (*Sds*) increases in three times during compacting, sintering and infiltration. An important point is that at the same time surface is more and more anisotropic since the value of parameter *Str* closer to 1.
2. The reason for these changes of surface conditions is shrinkage of material during sintering and infiltration. So we can use measurement results not only for evaluation of details quality, but for prediction of shrinkage and consequently for pressing equipment design and choosing of sintering regimes.

5. REFERENCES

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