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High Precision Measurement and Evaluation of the Fine Mould Surface Structures

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Abstract. Surface structure is a suitability state that must be pursued closely workpiece components which work under severe conditions. It is a fact that high-precision forming component's surface roughness affects the product's nature that is being formed. In this scientific perspective, measurement and evaluation of the surface roughness and surface texture diversities during manufacturing and the effects of these diversities on material performance and product suitability has a significant importance. The first objective of the present project is to define surface modification treatments and the surface characteristics which will improve the performance of forming dies particularly for the glass industry. In this experimental work the results of the high-precision measurements on the mould surfaces discussed in detail and the surface characteristics of DIN 1.2080 steel and the surface boronized one of the same material are compared and the effects of surface roughness and surface texture are investigated in a wide perspective.

Introduction

Surface Roughness is a suitability state that must be pursued closely workpiece components which work under severe conditions. It is a fact that forming component's surface roughness affects the product's nature that is being formed. In this scientific perspective, monitoring the surface roughness diversities during manufacturing and the effects of these diversities on material performance and product suitability has a significant importance. Surface Roughness is an important relevance condition has to be evaluated in the frame of "Geometric Product Specifications" standards like form, dimension, direction and location tolerances.

Every process is to be expected to obtain an identified roughness limits in technical drawings. Considering the history of a manufactured component first the production process has to be investigated; if the part has been produced correctly it can be put into use along with any other parts of the same design. However, no process remains constant and has to be monitored to detect changes which could affect performance.

Boronizing was carried out in a solid medium consisting of EKabor powders at 850, 950 and 1050°C for 2, 4, 6 and 8 h. After boronizing, FeB and Fe_2B phases were formed on the surface of the steel substrate. The measured thickness of the coating layers ranged from 8 to 386 µm . The hardness of the boride layer under the loads of 0.5 and 1 N was found that ranged from 1407 to 2093 HV. The fracture toughness of borided surfaces was measured with a load of 10 N. It was observed that the fracture toughness of the boride layer ranged from 1.39 to 6.40 $MPa.m^{1/2}$. A longer boronizing time results in a greater boride layer thickness. Lengthwise cracks were formed on the samples that were borided at 1050°C for 6 and 8 h.

A long life high performance is expected from a finished surface in tolerance limits determined in technical drawings. Formability, hardness, thermal expansion, thermal conductivity, polishing and easy welding capability and corrosion resistance are the general basic specifications expected from lots of workpieces that works under severe conditions. High and sharp surface roughness peaks

causes important negative effects not only on the effective lifetime of materials but also product quality. High roughness and waviness results, limit the mould lifetime and product quality, are accepted as the major defects for workpieces especially assembling components.
In this study the surface and material properties of DIN 1.2080 steel and the surface boronized one of the same material are compared. The material is solid boron carbide coated at 900°C for 6 h. The paper follows with the experimental details in section 2, the experimental results and discussion in section 3 and conclusions in section 4.

Experimental Detail

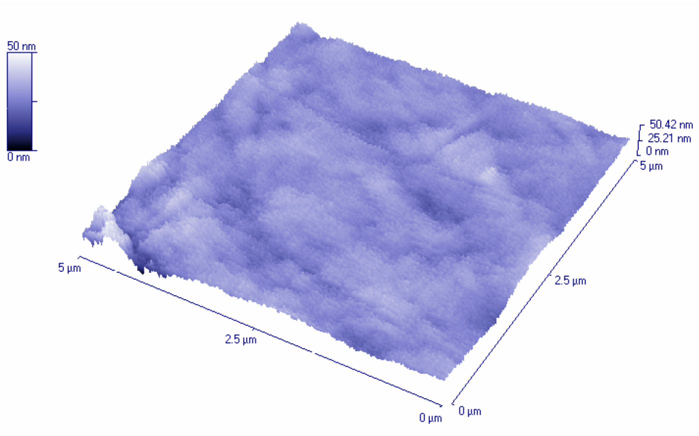
Every unsuitability and negative effect of surface conditions moves to the final product and it results as performance losses and lack of conformities not only in manufacturing but also in usage processes of products. Comparison of different surface roughness alterations of stainless steels helps to find an optimum solution of selection of materials which could supply at desired quality surfaces in manufacturing operations. Today boronising is commonly preferred coating operation in manufacturing industry to remove such negative effects.
The two samples prepared by high speed machining and polishing techniques for DIN 1.2080, and one of them is solid boron carbide coated at 900°C for 6 h. In this study the surface and material properties of DIN 1.2080 steel and the surface boronized one of the same material are compared. The chemical analyze of subjected material is given in Table 1.
Table 1. The chemical analyze of DIN 1.2080

Chemical Analyze	C	Cr	Si	Mn	P	S	Ni
%	1,87	11,41	0,318	0,253	0,026	0,003	0,158

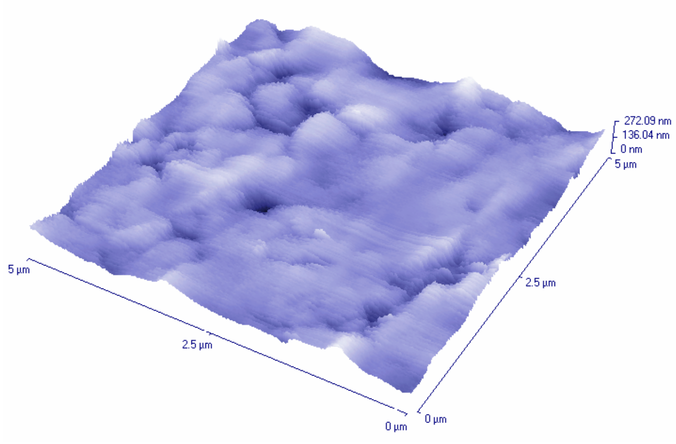
Required surface texture parameters are determined in nano scale with a high precision AFM (Atomic Force Microscope), has 100x100 μm^2 scanning area and 10 μm z axis access capacity, contact type scanning microscope and in micro scale with a precision tactile measurement profilometry, Form Talysurf INTRA. Surface roughness measurements of samples are being done also with an tactile profilometry. R_a, R_{sk}, R_p, R_q, R_{ku}, R_v, R_t, R_z, R_c, W_a, P_a and *mr2%* surface roughness parameters are calculated and evaluated. The profilometry using in concurrent measurement of dimensions, forms and surface conditions of workpieces in 1.0mm range 16nm resolution, a tactile surface inspection device.
In addition, the “Secondary Electron Image” of boronised steel captured by Jeol 6360LV, Scanning Electron Microscope.

Experimental Results and Discussion

Real surfaces, as a rule, contain at least two levels of asperities, such as waviness plus roughness or roughness plus subroughness. The AFM images represent the surface textures of a metal surface formed by various processes (machining, failure, oxidation etc.) [8].
The initial data represent the matrix of surface height deviations [4]. The existence of the boride atoms on surfaces like a brittle layer is known as a limiting disadvantage of boronizing applications [5]. Because of the extra thickness of that brittle boride layer on second sample, the most of the surface roughness parameters of sample B are determined greater than the other sample (Figure 2/b).



(a)



(b)

Fig. 2 a) Initial surface topography of the material 1.2080
b) Initial surface topography of the material 1.2080 / Boronized

Secondary Electron Image of boronised steel is given in Fig. 3. The thickness of single phase boride layer (FeB) is measured approximately 15 µm.

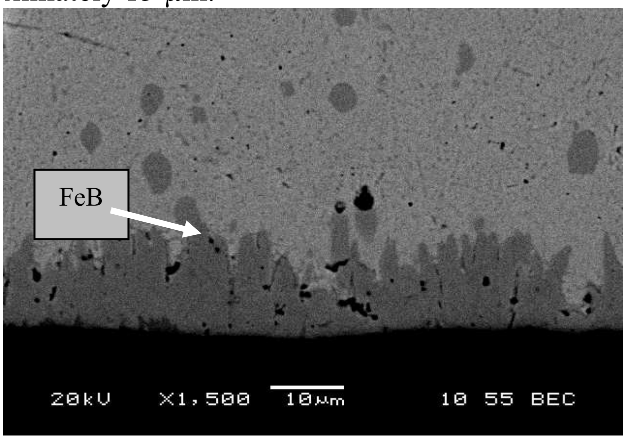


Fig. 3. Boride layer on the material (lateral cross-section)

The waviness parameters of sample A and B are determined the values between 0,0-0,4µm. But the waviness parameter of sample B against number of cycles is determined as dramatically increased to 1,64µm value. Waviness, limits the mould lifetime, is a major defect not only for glassware group but also for glass containers. It might be thought that 1.2080 steel and boronized one exhibits their resistivity against unstable conditions especially for thermal stresses. The reaction of sample C against thermal stresses might be strong. To prove that idea the thermal stress reactions of both steels have to be determined clearly at further research works.

Determined roughness characteristics of the surfaces are given in Table 2. Very result in every cell is an arithmetical average of ten, five of at x, 5 of at y direction, measurement results.

Table 2. Surface roughness parameters

Sample	Ra (µm)	Rsk (µm)	Rp (µm)	Rq (µm)	Rku (µm)	Rv (µm)	Rt (µm)	Rz (µm)	Rc (µm)	Wa (µm)	Pa (µm)	mr2 %
DIN 1.2080	0,0237	0,3415	0,0682	0,0294	2,9341	0,0531	0,1621	0,1213	0,0779	0,1689	0,0566	95,8
Boronised	0,1186	-0,2438	0,2994	0,1487	2,9472	0,3491	0,8191	0,6484	0,4029	0,0918	0,2067	91,5

Surface hardness measurement of DIN 1.2080 steel is conducted under the load of 25 g with microhardness measuring machine and determined 268 HV. The appropriate load for boronised steel is determined 200 g for hardness measurement. The hardness of the boride layer under the load was found 1663 HV.

For selected surface roughness parameter R_a, the SPSS statistical software package was used to derive the required mathematical model, using a regression method. First of all, correlation coefficient analysis was run to determine the effectiveness of dependent variable on the roughness parameter.

Concluding Remarks

In this experimental work the parameters which could performances during process are determined by precision measurement techniques and evaluated. A high-precision AFM for nanometrology of large area micro-structured surfaces has been implemented, the fine structured surface has been successfully measured and evaluated. Considering that this material will be used as a mould material, the hypothesis “mould surface roughness parameter value is acceptable” the Likert scale is being created and given in Table 3.

It was observed that some of the surface roughness parameters of the boronized 1.2080 steel were higher than the DIN 1.2080 steel as accepted. Contrary to this, in some parameters, affirmative values that increase performance have been monitored.

In this experiment, parameters scored by considering the predict lifetime for mould and the quality of final products. The number of parameters and their varieties, whose alterations are pursued and evaluated, can be increased according to the usage features that are expected from work pieces. Manufacturers could privatize this Likert Table by determining the importance level of related parameters for their manufacturing field.

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