Three Dimensional Characterization of Surfaces for Sheet Metal Forming

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ABSTRACT

In the recent years a precise characterization of the surface' topography especially in sheet metal forming became more and more important. One of the reasons is the continously growing sophistication of the forming process facilitated not only by specific and closely tolerated properties of the sheet but by specific surface properties as well, given by the topography. Today quite different technologies for surface texturing are available yielding a broad diversity of topographies in practice. For that view, it is evident that the roughness characterization of technical surfaces based on a simple 2d description cannot be sufficient anymore. Additionally, some functional properties of the topography like the tribological behaviour in forming processes are almost impossible to be described using conventional 2d parameters. In response to the great importance of friction in forming processes the development of new and more intelligent 3d surface parameters is thus essential.

New functional parameters can be derived from a mechanical rheological model which is about to be developed in order to understand and to describe the complex interaction between tool and workpiece taking place at the interface. Within this model, the load on a surface is transmitted by three totally different kinds of bearing ratios. These are the solid contact area as well as the static and dynamic lubricant pockets. The ratio of solid contact corresponds to the relative amount of the real contact area. The dynamic lubricant pockets represent those regions of lubrication where during the forming process the lubricant can be squeezed out of the loaded area. In these regions the load can only be transmitted by a hydrodynamic pressure. In contrast to the dynamic lubricant pockets, the static lubricant pockets have no connection to the boundary of the loaded area. Thus the lubricant is trapped in these pockets and a hydrostatic pressure can be built up. To characterize the topography following the idea of the model, 3d surface parameters have to be defined. The relative amount of solid contact corresponds to the *material area ratio*. The 3d surface parameters for the static and dynamic lubricant pockets are the closed and the open void area ratio respectively. Refering to the model, the *closed void area* are those regions, which have no connection to the boundary of the evaluation area. In contrast, the *open void areas* are those regions which have a connection to the boundary of the evaluation area.

Fig. 1 shows the results of a calculation of the surface parameters for a single crater from a laser-textured surface with separated lasertex craters. The material area ratio corresponds to the Abbott curve which is well known from the 2d-surface analysis. The open and closed void area ratio also result as a function of the penetration of the surface. The area ratios are calculated within planes parallel to the mean plane. The first plane at a penetration of 0 % touches the highest asperity of the topography e.g. the last plane touches the deepest valley. On the first plane, at a penetration of 0%, only open void areas are present. With further penetration of the surface, the open void area ratio decreases as the material area ratio increases. In the third surface plot a section of the crater can clearly be seen. As there is no connection to the boundary of the evalation area, the crater is characterized by the closed void area. With further penetration, the open void areas disappear i.e. there are only closed void area ratio and material area ratio. At the end, 100 % material area ratio remains. At least, two significant surface parameters can be derived from this diagram. First of all, this is the maximum of the closed void area ratio ✂$_{clm}$. The other one is the closed void volume V_{cl} which can be calculated by intergration of the closed void area curve. It can be proved, that the parameters are within very small variations at an evaluation area of 9 mm^2 [1].

As it can be shown by the results of a strip drawing test as well as by the results of a ring compression test combined with torsion, both parameters are very suited to characterize the tribological properties. Additionally the superiority of the 3d surface parameters to the 2d parameters can be shown by the investigation of special effects as e.g. the mechanism of microfilm lubrication.

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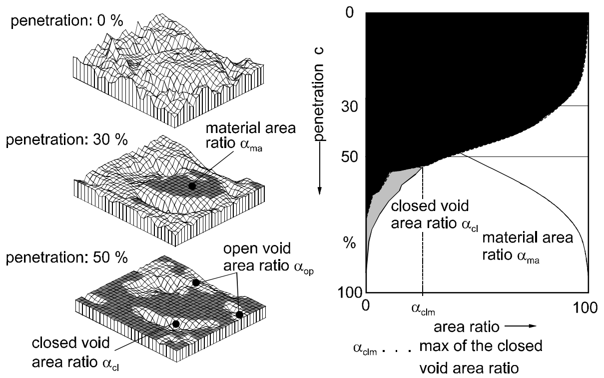

Fig. 1: 3d surface parameters at a lasertex crater

REFERENCES

(1) M. Pfestorf and U. Engel and M. Geiger, Proceedings of the 7th International Conference on Properties and Metrologies of Engineering Surfaces, 2-4April, Göteborg, 1997, to be published in: Journ. Engineer. Manufact. Tech