CMIS 2016

CONTACT MECHANICS INTERNATIONAL SYMPOSIUM

Book of Abstracts

May 11-13, 2016
Warsaw, Poland

Flattening of loaded rough surfaces: normal contact versus sliding contact

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Summary: The problem of contact of deformable rough surface with rigid flat counterpart was investigated theoretically and experimentally. In the special experimental setup two modes of rough surface flattening were performed: normal compression and sliding (tangential load) in presence of normal compression. The resulting deformation of roughness zone has been analyzed.

Introduction

Flattening of rough surfaces due to contact load is a phenomena observed in different technical applications. Plastic surface deformation of metal parts is a process that lead to the smoothing of rough surfaces. In the case of purely normal load the problem was exhaustively investigated by many researchers [1-3]. When a tangential load with sliding is present the problem is more complicated. The number of detailed studies concerning the problem is not so large [4,5,6]. The analysis of such problem is important in manufacturing engineering (e.g. metal forming) where the surface quality is an important factor. A plastic smoothing tool should have high rigidity, precision, and wear resistance; its surface quality should be better (the roughness lower) than that of the part under machining. In this process the friction coefficient is also an important factor [7].

In the paper the deformation of roughness zone in contact with rigid flat surface is investigated. The deformed surface was next examined using scanning profilometry and the evolution of the real contact area (RCA) and surface parameters were specified.

Experiment and results

Samples were made of two kinds of steels (carbon steel C45 and s235) with different stress – strain characteristic and then were subjected to mechanical surface treatment (shot peening), that generates surfaces topography having similar characteristics on each steel. The experiment was carried out using a modified device described in [3] which enables precise measurement of the approach as a function of the contact pressure. Two kinds of experiment were considered: in the first the normal load was applied and in the second both normal load and tangential load resulting from sliding motion of the rigid plane were present. The second experiment was performed in two stages: first the normal load is applied and next maintained during sliding of contacted surfaces. In the experiment the approach of surfaces as a function of normal load was measured.

The roughness parameters have been measured on a scanning profilometer before and after loading. The changes of the height parameters and RCA are presented in the Fig.1 and Fig. 2 respectively. The procedure of RCA estimation based on the profilometric measurement of the surface is described in [3]. The results presented in Fig.2 show that there is not difference between RCA for investigated steels after loading with sliding but after pure normal loading this difference is evident. It has been observed that when the sliding take place, one can apply much lower normal load to achieve a similar deformation of the roughness zone as in the case of purely normal load (Fig.3).

The simple model based on statistical approach proposed by Greenwood Wiliamson in 1966 and finite element solution has been applied to predict the relations load-penetration depth and load-real contact area. The model prediction was compared with experimental results.

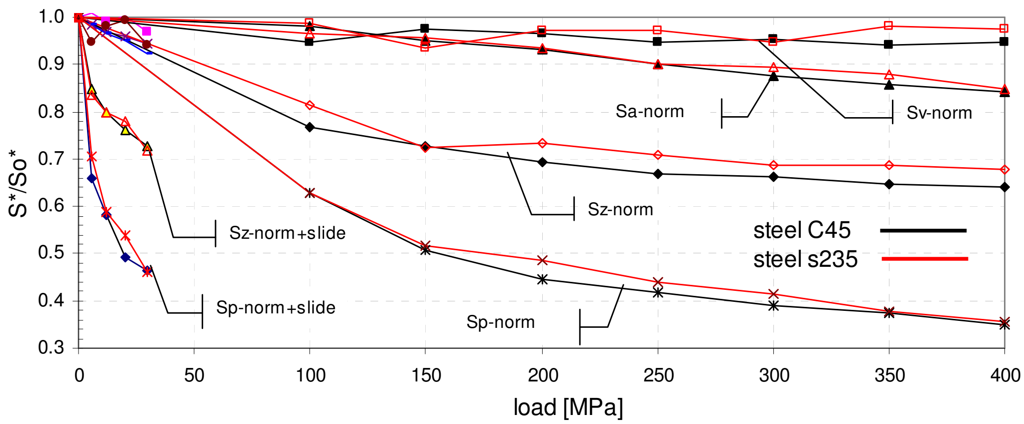

Figure 1: Height parameters vs. normal loading *(norm)* and loading with sliding (*norm+slide*).

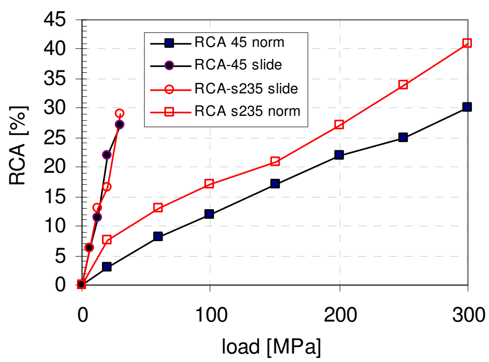

Figure 2: Real contact area (RCA) vs. normal loading and loading with sliding

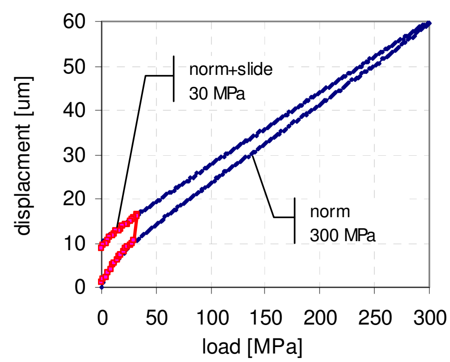

Figure 3: Displacement vs. normal loading and loading with sliding

Conclusions

The presence of tangential load (sliding motion) in the contact of rough surfaces loaded with normal pressure leads to a serious change of its plastic compliance. Applying a tangential force, one can diminish approximately ten time the normal load to achieve the same deformation of the roughness zone as in the case of purely normal load (Fig. 1,3). This effect has been confirmed both experimentally and theoretically.

References

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