DETERMINATION OF THE SURFACE ROUGHNESS PARAMETERS

By

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The graphical analysis of the profile curve of surfaces enables the determination of the geometry of the asperities which constitute the profile of the surfaces. Profile curves by themselves may not always be sufficient since these, as traced out by the profilometer, are generally too minute in dimension for an accurate graphical treatment. Further magnification of the profile curve is, therefore, necessary which can be done by using a profile projector. The magnified impression of the profile curve enables to determine the maximum height of asperities of surface, the base angle of the asperities assumed to be of conical shape, the radius at the tip of asperities, and the bearing area curve of the surface and the equation to the curve. In the following a determination method will be described.

The pitch of asperities

The distance between the lines, parallel to the length of the profile curve, and touching the highest and the lowest point of asperities, gives the pitch of asperities. Obviously, in such cases, the isolated asperities of unusual heights are to be omitted.

The base angle θ of the asperities

Let the apex of an arbitrary conical asperity be 0 (Fig. 1), and let the cone touching the straight portions of the sides of the asperity be ABC. Then the base angle θ of the cone ABC will be given by

$$\tan\theta = \frac{AD}{BD} \cdot x$$

where x is the magnification factor. x is given by the ratio of the combined magnifications of the profilometer and the profile projector in the horizontal direction to that in the vertical direction. AD and BD are obtained by direct measurement.

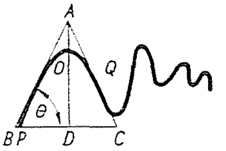

Fig. 1. The conical profile of an asperity as obtained from the profile projector

The radius, R, at the peak of the asperity

It is assumed that the peaks of the asperities are spherical. Fig. 2 represents one such peak PSQ of radius R. From the properties of the circle

$$ST : PT = PT : (2R - ST)\,.$$

Erom the above it follows that

$$R = \frac{PT^2 + ST^2}{2ST}$$

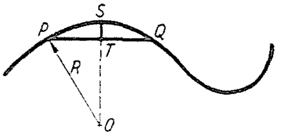

Fig. 2. The spherical peak of an asperity

In order to obtain PT and ST, it is first necessary to measure off the corresponding lengths from the magnified profile curve. Dividing these by the appropriate magnifications could then lead to the required values of PT and ST. As in the previous case the magnification on either direction is equivalent to the combined magnification of the profilometer and the profile projector.

Determination of the bearing area curve

DJACHENKO, TOLKACHEVA, ANDREEV and KARPOVA illustrated profile curve and the accompanying bearing area curve in the manner indicated in Fig. 3. This would suggest the following method for the construction of the curve.

Parallel lines 00, 11, 22 . . . nn are drawn (Fig. 4). The profile curve makes a number of intercepts on each of these lines at various regions as in the case if line 33 in the figure. The length of each intercept ab, cd etc. are

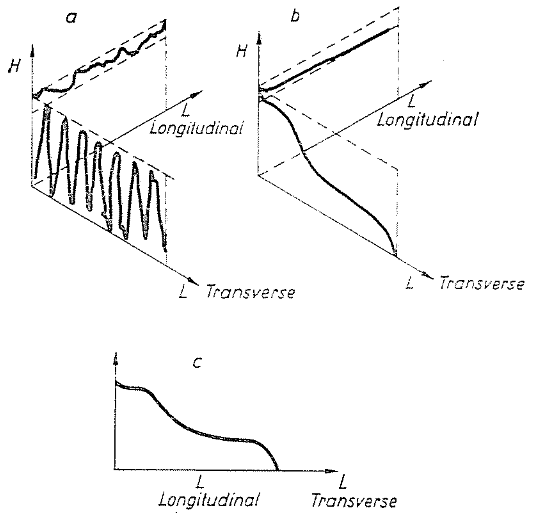

Fig. 3. Schematic diagram for the area of supporting surface

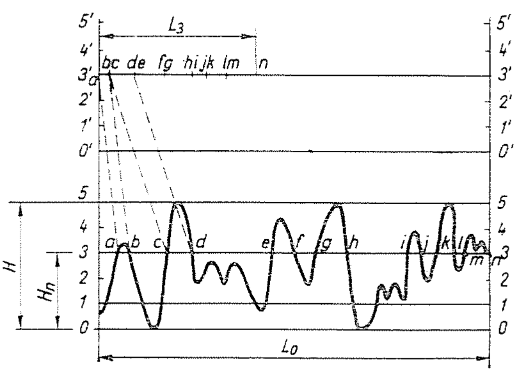

Fig. 4. Determination of total length of contact for different approaches by an idealsurface

marked off in the corresponding line 3′3′. Thus the length L_3 as measured on 3′3′ would represent the total contact length for an approach corresponding to the line 33 of an ideal surface.

In order to obtain the picture of the area of contact, the profile curves in two perpendicular directions are necessary. In this case the parallel lines, for the determination of contact lengths at different approaches should be such, that their distances from the line touching the highest peaks are the same for both the profile curves. This is necessary to ensure common approach for each set of contact lengths. The procedure for finding the contact lengths for different approaches is the same as before. For any given approach the contact area is the product of the contact lengths in the two directions.

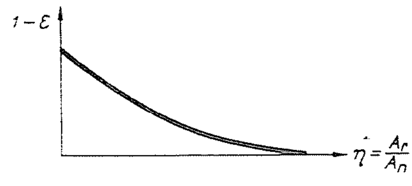

Fig. 5. Bearing area curve

Sometimes the maximum heights of asperities for the profile curves in the longitudinal direction is much smaller than that in the transverse direction. Hence the contact area when the approach exceeds the maximum height of asperities in the longitudinal direction, is equivalent to the product of contact length in the transverse direction and the nominal length of contact in the longitudinal direction.

With the data for the approaches and the contact area corresponding to these approaches at the disposal, it is possible to draw the bearing area curve (Fig. 5), in which the approach occurs in the form of $1 - \varepsilon$ in the ordinate; and the contact area, in the form of η in the abscissa. ε is equal to $\frac{a}{H}$ where a is the approach and H is the maximum height, and $\eta = \frac{A_r}{A_n}$ where A_r is the contact area and A_n is the nominal area of contact.

Determination of the equation of the bearing area curve

A portion of the bearing area curve satisfies the relationship $\eta = b\varepsilon^{\nu}$. Taking logarithms of both sides reduces the relationship to the form of $\log \eta = \log b + \nu \log \varepsilon$. Any two points (η_1, ε_1) and (η_2, ε_2) in the relevant portion of the curve will lead to two simultaneous equations in b and ν whose solution will give the constants of the equation of the bearing area curve.

Summary

Some methods have been presented for the evaluation of the parameters such as the maximum height, base angles, etc. of the asperities in a surface, from its profile curve. Thereafter the process of plotting the bearing area curve and the subsequent determination of the constants occurring in the equation of the bearing area curve will be described.

References

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DJACHENKO, P. E., TOLKACHEVA, N. N., ANDREEV, G. A., KARPOVA, T. M.: The actual contact area between touching surfaces. Consultants Bureau, New York, 1964, P. 31.

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