Burnishing of metallic surfaces — a review

Roller burnishing is still a popular method for finishing bores and shafts. Reaming has had to be relegated in the tool-cutting hierarchy in automated cutting systems and roller burnishing has overtaken some of these applications particularly in cnc machining methods. In this article, **R.L. Murthy and B. Kotiveerachari*** *review the basic analytical and operational aspects of burnishing*

Burnishing is a method of finishing surfaces of revolution or plane surfaces by plastic deformation under cold working conditions by application of pressure through either a hard ball or roller. In a typical set-up shown in Fig 1, a hard roller is pressed against a machined surface. The roller axis is slightly skewed with respect to the work axis and is given the feed motion. The work is driven positively and the roller rotates as a result of frictional engagement. As each portion of the surface of the work is traversed, metal from the protrusions is displaced plastically and will fill the depressions.

Three zones in the 'tear drop' shaped contact area change the state of the metal surface. Disregarding intermittent loss of contact due to the rotary motion (this loss does not affect the result), the surface metal is first compressed, then plasticized and finally wiped to a superfinish as contact is progressively diminished and the stresses are gradually dissipated. The principal action takes place in the central plasticization zone, where the metal in both the peaks and the valleys becomes plastic. Flow is induced along the lines of least resistance down both flanks of the protrusions with the depressions filling as two opposed flow streams meet at the bottom. Since the action is local, the overall geometry of the work-piece is not changed. As metal is neither lost nor gained during the deformation, the final diameter is roughly the mean of initial peak and valley diameters.

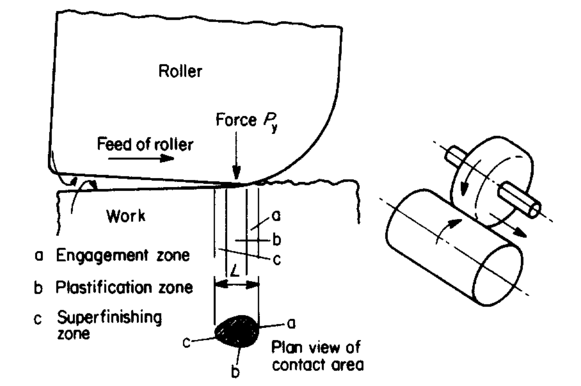

Fig 1 Working area of a roller finishing set-up in which feed is applied. The contact zone is of 'tear drop' shape and consists of three zones each of which brings about a change in state of the metal on the work-piece surface

Burnishing force

As burnishing is a plastic deformation process, the specific pressure between the burnishing-tool and work-piece must exceed the yield point of the work material. Normally, good burnishing occurs when the specific pressure $q = (1.8 \text{ to } 2.1)\ \sigma_y$ where σ_y = yield point of the material, kg/mm^2. (Formulae for obtaining burnishing load P_y in basic burnishing configurations are given in Table 1.) The specific rolling force, q, used in burnishing can also be obtained from Fig 2 which shows the variation of q with tensile strength of work material. The load to be applied in roller burnishing of work-pieces of different diameters and hardness values is also given in Fig 3.

For burnishing of steel of medium hardness, burnishing load P_y can also be calculated from the following empirical relationship:

$$P_y = (50 + \frac{D2}{6})\ \text{kg} \qquad (1)$$

where D = diameter of the workpiece, mm. Burnishing load should also take account of the initial surface. For rough surfaces, larger loads have to be employed than for relatively smooth surfaces. The recommended burnishing pressures for a few normally used materials subjected to various machining processes before being burnished are given in Table 2.

On the basis of an approximate solution to the problem of slipping of a rigid sphere over a plastic semi-plane, it is possible to propose a relationship for burnishing force P_y as

$$P_y = \pi \epsilon H R^2 \qquad (2)$$

where $\epsilon = h/R$, relative depth of penetration, h = depth of penetration, R = radius of the indentor (burnishing tool) and H = hardness of the work material (vickers hardness kg/mm^2). The maximum values of ϵ recommended for smooth vibration-free burnishing are given in Table 3.

When ϵ = 0.1 - 0.3, plastic flow starts to be accompanied by metal removal in the form of fine chips. When ϵ = 0.01 - 0.02, harmful vibrations occur. This value of ϵ = 0.01 - 0.02 can be considered to be the limiting value.

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