Discussion

We have assumed throughout that uniform circular impressions are being created in a random manner during shot peening. This is a simplification of the practical situation. Sophisticated techniques are available, for example those proposed by Knotek and Elsing (2), which enable computer predictions to be made of the shot peened surface topography. These techniques themselves often contain simplifications. For example the diameter of an impression may have been calculated using the "Intersecting Chord Theorem". This is illustrated in Fig. 6.

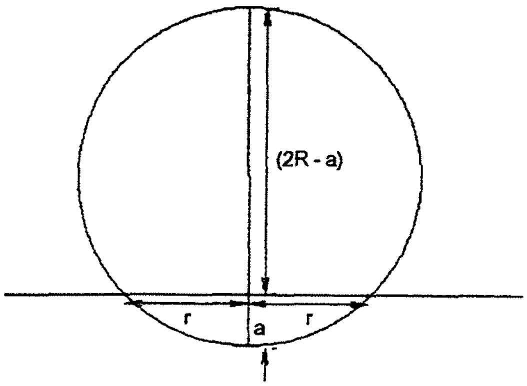

Fig. 6. Intersecting chords for circle of radius R

The intersecting chord theorem gives that $r^2 = (2R - a).a$ for the two chords shown as intersecting at right angles so that the impression radius r is given by:

$$r = \{(2R-a).a\}^{1/2} \qquad (7)$$

Fig. 6 does not represent the actual situation accurately for indentation by a spherical particle. A better model would be one which allows for the displacement of the material from the indentation to produce an annulet of the same volume, as shown in Fig. 7.

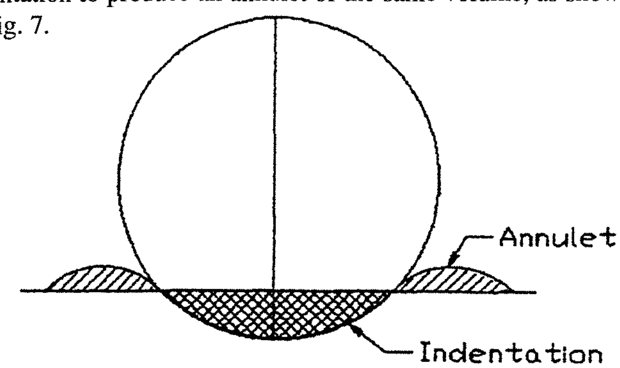

Fig. 7 Model of indentation with annulet of transposed material

The diameter of the impression may then be taken as either the diameter at the level of the original surface (when the intersecting chord theorem is valid) or as the diameter of the annulet. A search of the literature shows that there is some ambiguity as to which is taken as the impression diameter.

With respect to the validity of using the Avrami-type equation a comparison of the shape of this curve with published curves shows excellent agreement. Published curves, by their very nature, tend to derive from carefully-controlled shot peening situations. A feature of curve-fitting procedures is that, provided the model is sound, one can determine the nature of practical variations. Fig. 8 shows a situation in which the peening rate has been deliberately varied and the corresponding coverage rates determined experimentally using the assumption that displacement is directly proportional to coverage.

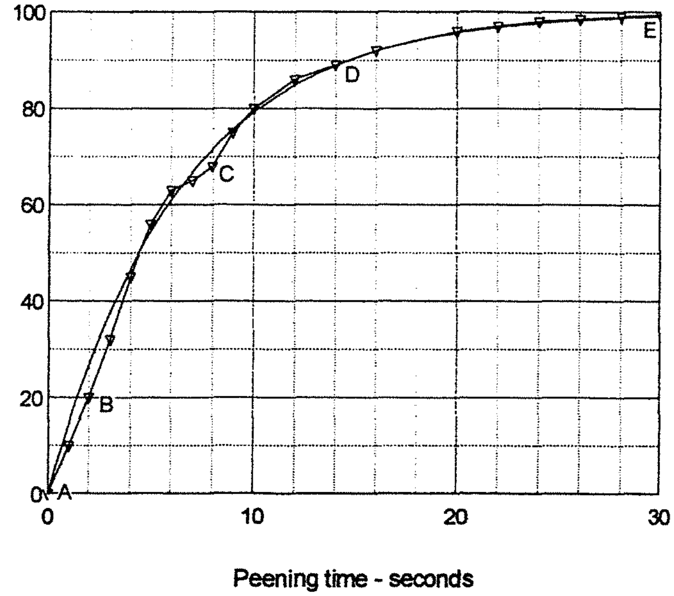

Fig. 8. Variable peening rate giving deviation from Avrami-shaped curve

In the example shown in Fig. 8 the section A-B corresponds to a relatively slow initial peening rate. Between B and C the peening rate increases and then falls followed by another increase at C falling again to D. A constant peening rate is indicated between D and E.

A set of Avrami curves can be matched against particular parts of the observed data curve in order to determine the corresponding peening rates.

Conclusions

The theoretical basis of coverage control has been analyzed using simple Avrami equations. This analysis has concluded that effective control can be based on employing a constant ratio of throwing rate/shot size. ❍

References

1. Avrami M., *J. Chem. Phys.*, **7**, 1103, 1939; Ibid., **8**, 212, 1940; Ibid., **9**, 177, 1941.
2. Knotek O., and Elsing R., *Computer Simulation of Different Surface Topographies of Metals Produced by Blasting Processes*, Proceedings of ICSP3, 361-368, 1987.