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THE PARAMETER RASH — IS THERE A CURE?*

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Summary

In recent years there has been a proliferation of parameters with which to specify surface texture. Some of these parameters are useful, but most are not. The result of this rash is confusion and expense. In this paper the cause of the growth of such parameters is identified and ways of minimizing it are explored.

At the turn of the century it became apparent that the surfaces of parts could be an important factor in determining how well the parts functioned. This seemed most true in cases where two components were in static or dynamic contact. It was not until the early 1930s, however, that any serious attempt was made to quantify the magnitude and nature of the relationship between surface texture and function.

Even earlier came the realization that no function of a part could be guaranteed unless the method of manufacture could be controlled. This was usually achieved in those days by including many details of the process on the engineering drawing. By carefully following the procedure laid down, some degree of control of the manufacture, and hence the function, could be achieved. This path to acceptable quality control became more involved as processes became more complicated, and reached a maximum during the 1940s and 1950s. More recently it became evident that this path could in some instances be short circuited by making use of the surface texture of the workpiece. It became apparent that the texture was in effect a "fingerprint" of the whole sequence of operations making up the process: if any change occurred in any of the constituent operations making up the manufacture it would show up in some way in the surface texture. From this observation came the realization that surface texture could be used as a "go

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gauge" for successful manufacture. Thus, checking the surface texture effectively vetted the manufacture which, in turn, ensured that the part worked satisfactorily. By this means some sort of balance was achieved between making the part and its function, a state of affairs which, unfortunately, was not always maintained as will be reported later.

At about the same time that this type of control was being considered, a number of other developments were taking place. There was a growth of interest in surface metrology in general, in digital computing techniques and also in the fundamentals of tribology, the science of rubbing parts. Although this interest was generally beneficial it did have the disadvantage that three important and complementary disciplines were evolving at the same time. This has led to many false paths being taken and much time being lost. As an example, it was never possible to measure all the parameters of the surface which might influence the outcome of a tribological experiment. Only those parameters for which instruments existed were investigated, and they were not necessarily the most relevant.

The criteria that determined which surface parameters would be used were quite different from those of today, and they often varied from country to country. First, it has to be possible to instrumentate. Second, the texture had to be measurable from a graph. In Gt. Britain the centre-line average (c.l.a.) deviation was adopted, which had the useful property of being a statistically reliable parameter. In the U.S.A. the r.m.s. value was adopted (although in practice it was derived from the average value via the scaling factor). In Europe, and particularly in the F.R.G., peak-to-valley measurements were preferred because of the opportunity to compare measurements taken with stylus instruments with those taken from optical instruments; it is much easier to measure the peak-to-valley height of a fringe than its average deviation. Both average and peak parameters were used more for control purposes than for their functional use. Needless to say, they were the only texture parameters measured in the early experiments in contact and rubbing.

In so far as these parameters were used as a control, a balanced state existed in the manufacture–function system. However, problems soon arose whenever the equilibrium was disturbed. All too often this disturbance was, and still is, brought about by economic pressures. The usual reason was concerned with manufacture: the production engineer needed more flexibility than was possible within the rigid constraints of the set-down procedures. Often, plant non-availability drove the engineer to use whatever machine tool was available. Sometimes, the production engineer decided the method of manufacture without regard to function.

Whatever the reason, the result was that the process was changed arbitrarily. Inevitably, the equilibrium was disturbed, in the sense that the specified texture was expected to control a different process. This was never a conscious decision. It was, and is, based on ignorance of the overall quality control loop between manufacture and function. In practice this often resulted in a serious failure when the part was used. A typical example of this is as follows.

In an automotive factory one line for making camshafts used grinding and lapping processes. For this line the texture specification was 10 - 20 μin c.l.a. The cams produced by this line worked perfectly. Another line was subsequently introduced in which the grinding and lapping processes were replaced by turning and roller burnishing. No change was made in the specification of texture. Because the texture produced by turning is much rougher than that produced by grinding, the burnishers had to produce an enormous amount of plastic deformation in order to get the cam roughness down to the specified value. This deformation ruined the surface, which caused the cams to fail in large numbers of cars. Furthermore, the roller burnisher was damaged. Instead of going to the root of the problem, that each process needs a specific texture associated with it for a given function, the manufacturers began to look for a *different parameter* with which to specify the texture. Worse still, they applied the new parameter to both the old and the new lines. Eventually, neither worked. The result was economically disastrous. All that was needed was a short controlled experiment to determine a revised c.l.a. value for the new line. Ultimately this is what happened, and a satisfactory outcome in terms of production was realized. All sorts of economic excuses were put forward to avoid doing the controlled experiment but, as it turned out, not doing it proved to be far more costly. This is typical of what can happen in practice. The tendency to look for magic parameters to solve production problems rather than to get down to bedrock has been a worldwide phenomenon and is a symptom of industrial "fire fighting". It has resulted in an unfortunate growth of many parameters the significance of which is questionable, to put it mildly.

Another way in which the balance between the manufacture–function chain can be disturbed is if the function of the part is changed. The change can be insidious, such as when there is a change in the type of oil used in an engine, or it can be more obvious: for example, when the working speed of an engine is increased by 50% or the measurement system has been changed. Whatever the reason, the balance has been upset just as effectively as if the process had been altered.

When any variable has been changed or is likely to be changed, the foolproof way to prevent problems developing is to test (under controlled conditions if possible) the workpiece functionally under the new regime. If it works satisfactorily the texture is then measured and used subsequently on the specification. Which parameter is used is rarely vital. What is vital is to use it consistently.

Unfortunately, this is not what has happened in practice, and consequently many variants based on existing parameters have emerged. No doubt there has always been this parameter growth tendency, but the trap has to a large extent been avoided in practice because of the instrument maker's inability to respond with a suitable instrument for every whim. With the advent of cheap and powerful microcomputers and minicomputers this is no longer true. Many of today's instruments look more like aircraft consoles than measuring instruments. This is definitely not the fault of the instrument maker: a company has to respond to market pressures in order to exist.

What is the answer? It would be to everyone's benefit if parameters such as R_{3z} and R_{tM} could be dispensed with, but unfortunately this is not easy. Many such parameters are now embedded in various national standards, and it is common knowledge that it is easier to introduce a parameter into a standards document than it is to get rid of it. The result of this state of affairs can be chaos because the standards are sometimes taken up, without test, by industry. This can become serious when the company is a multinational and is having difficulty with exchange of parts between countries, or when litigation over product liability is imminent. A conflict between irrelevant parameters can be the result. This is even more serious in those countries where use of a standard is mandatory.

The cure therefore for this rash of parameters is not likely to be short term because of the standards situation. Hopefully, no more parameters will be adopted without serious research. What is needed is more basic investigation into the functional significance of sophisticated parameters. We now have the tools and, unless this is carried out, confusion will continue to grow until economic considerations force the issue.