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A METHODOLOGY FOR INTERRELATING MANUFACTURE, CHARACTERIZATION AND FUNCTION FOR ENGINEERING SURFACES

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ABSTRACT

The problem of interrelating the functional performance of a component with the manufacturing process and surface characterization has recently gained emphasis as a vital activity of research claimed by industry. The objective of this work is to present an orderly scientific approach for this problem especially in view of the "rash" of surface parameters and the few proposals for the cure. Such methodology will ultimately be a sure help to researchers in a difficult and time-consuming area.

INTRODUCTION

The view that there was still insufficient work being carried out on the relationships linking manufacture, surface characterization and functional performance has been recently expressed by many industrialists. Thus a balanced state in the loop of function - parameter - process should be the goal of research in this area. While there exists an abundance in surface texture instrumentation and characterization; plant non- availability for the proper machine tool can seriously upset such balance. Economic pressures sometimes drive the production engineer to adopt the process with available machine tools without due regard to function. Serious failure can be the ultimate fate for the processed component. An example has been recently presented as follows : (1)

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In an automotive factory one line for machining camshafts used grinding and lapping processes. The texture characterization was 0.25 - 0.5 μM CLA. The cams produced proved satisfactory. Later a new line was introduced with turning and roller burnishing instead of grinding and lapping. Texture characterization was not duly modified and thus the balance was seriously disturbed. The decision makers proved ignorance with the simple fact that surfaces exhibiting quite different functional behaviour can have the same CLA value. Burnishing rough turned surfaces resulted in large plastic deformation that ruined the surface and cuased cam failure in large numbers of cars. Instead of realizing that each process with its texture characterization is suited for a given function, the manufactures looked for a different parameter for both old and new lines of production: Neither worked and the result was economically disasterous. Ultimately, controlled experimentation had to be carried out and a revised CLA value proved to be the appropriate characterization for the new line to prove satisfactory.

OBJECT

The objective of this article is to present an orderly scientific approach for the problem of associating function with both process and surface characterization. The approach entails the analysis of the basics for a specific functional requirement followed by systematic experimentation to establish appropriate relationships between surface parameters, manufacturing and functional behaviour. Two cases are presented for illustration.

ILLUSTRATIVE CASE STUDIES

Case I: Static Friction and Surface Characterization for Conventional Machining Processes.

Tribological analysis had proved that the contact between engineering surfaces can be explained by the interaction of their peaks through the upper decile of the texture (2,3). Consequently experimentation was focussed on the influence of the geometry and distribution of such peaks on the static friction. The ratio of the depth of smoothness (G) to the CLA value proved to be a "Shape Factor" strongly related to the peaks and is usually referred to as the "smoothness Index" (4-6). Thus the smoothness index (G/CLA) and the standard deviation of peaks distribution were expected to be significant surface finish parameters affecting static friction. Such effect was thoroughly investigated.

Besides, and in order to show beyond doubt that the usual standard parameters have no direct effect on static friction, their possible relations were also examined. Surfaces were prepared with various conventional processes namely; shaping, milling, grinding, polishing and lapping. The value of the smoothness of the index or peaks shape fact or was combined with the peaks standard deviation (σ_p) and were plotted against the values of the coefficient of static friction (μ_s). The results for the various processes are given in Fig.1. and point to a direct relation. The relation varies for different processes; thus ($\sigma_p \frac{G}{CLA}$) can be considered a "specific process parameter" affecting the static friction.(7). These specific relations for the various processes support the basic concept of the British standard for the assessment of surface texture by specifying the process in conjunction with a single controlling measure. The results proved that the usual standard parameters viz., CLA, RMS, R_{max} ... etc. did not correlate with respect to μ_s. However, a direct relation existed between the CLA vaue and μ_s for ground surfaces. That was explained by the fact that such surfaces have a fairly uniform ratio between the pitch of their irregularities and their depth resulting in a relation between the CLA value and the specific process parameter. Thus characterization of ground surfaces with the CLA value can be adequate regarding static friction.

Case II: Fatigue Damage and Surface Integrity for EDM Surfaces.

Since fatigue is basically a surface phenomemam, then fatigue damage can be attributed to the main changes in the surface due to the thermal action of the EDM process namely:

1- Tensile residual stresses created in the surface due to local thermal expansion with ensueing plastic flow and subsequent contraction in cooling

2- Deep structural change in the form of white layer due to melting of metal and diffusion of pyrolysis gases.

3- Surface finish deep grooves due to preferred channels of electric sparks.

Meanwhile, the thermal action is highly locatized within a layer of marked hardness. (8). It follows thus that the "Hardness Depth" can be expected

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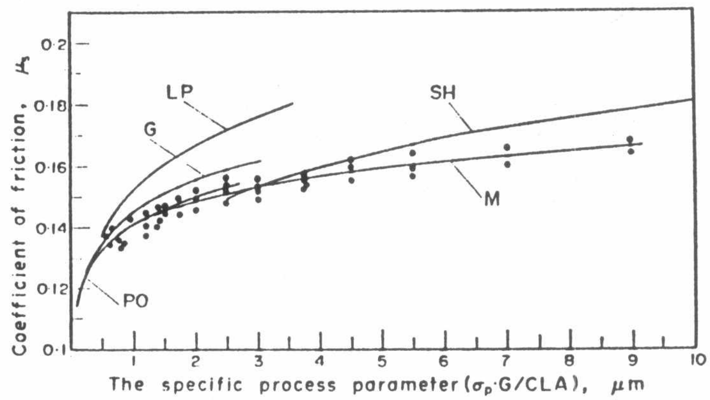

FIG. 1

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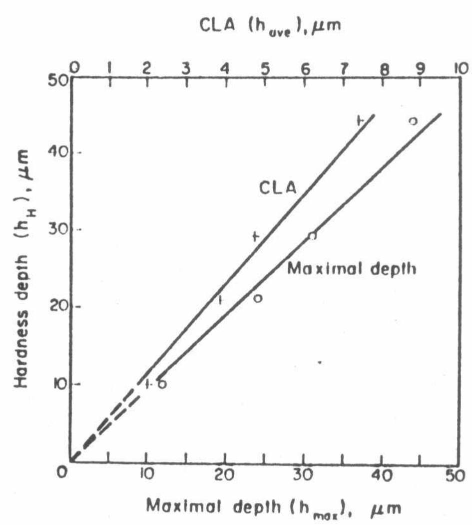

FIG. 2. Relations between hardness depth and surface finish parameters.

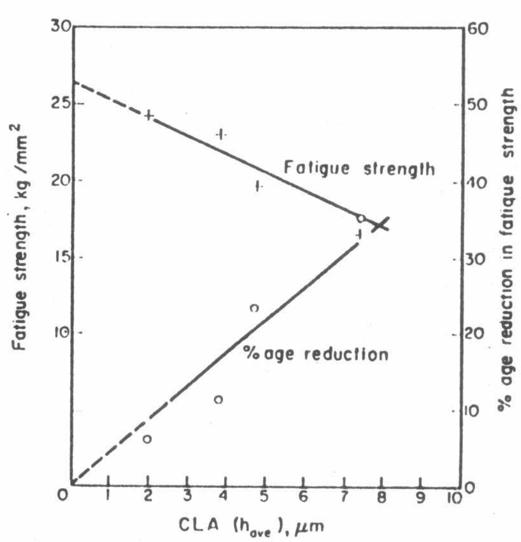

FIG. 3. Relations between fatigue strength, its percentage reduction and the CLA value.

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to be a significant measure of the resulting fatigue damage. Experimentation was then carried out to establish the prospective relationships between the hardness depth and the expected fatigue damage. Besides the hardness depth was found to be practically equal to the maximal depth. Fig.2. Thus the maximal depth was a significant parameter strongly related with the drop in the fatigue strength of a spark-eroded component. More over for spark eroded surfaces the ratio of the maximal depth to the CLA value was found to vary from 6 to 6.6. (An average value of 6.2 was given by Wirkelmann). (9). Thus, it was concluded that the CLA value for spark eroded surfaces could be the right characterization parameter related to the ensueing fatigue damage Fig. 3.

CONCLUSION

Such illustrations are intended to provide avidence that adopting such a methodology can be a useful approach in the search for the cure for the parameters rash and thus ameliorates mutual understanding and co-operation amongst manufacturers, metrologists and designers.

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