INVESTIGATIONS ON FINE FINISHING OF SURFACES USING ELASTIC ABRASIVES

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by

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ABSTRACT

Surface roughness is an important factor deciding the tribological behaviour and functional performance of a manufactured component. To meet the stringent requirements in precision and meso/micro engineering, ultra fine finishing of surfaces without altering its form is needed. State-of-the-art methodologies and practices adopted for the generation of fine finished surfaces exhibit the successful use of abrasive grains in their loose as well as bonded form. Polymer-abrasive medium in abrasive flow finishing, magnetic-abrasive medium in magnetic abrasive finishing, magnetorheological medium in magnetorheological finishing and ice-abrasive tool in ice bonded abrasive polishing are representative examples. But many of these approaches are applicable for specific surface geometries, and do require special care in the preparation of abrasive carrier media. Degree of sophistication, tooling requirement and cost of finishing are also of great concern. Therefore, development of a multiple application oriented micro/nano finishing approach that can be applied to a wide range of surface geometries is of great practical relevance.

The main highlight of the present research is the introduction of such a finishing approach by means of *elastic abrasives*. The abrasive embedded elastomeric balls of average diameter in meso/micro scale are referred to as elastic abrasives in this thesis. The unique feature of elastic abrasive projected in this work is the elastomeric action, facilitating the refinement of surface profile without altering the basic form of surface. In addition, the elastic abrasives in the shape of balls can be re-configured easily in accordance with the finishing requirements and can be utilized for both abrasion as well as erosion based finishing systems. Size of the proposed balls, their elastic behaviour, and the characteristics of embedded abrasive grains are easily adjustable, thus making the approach more versatile. Simple and cost effective methods of preparing elastic abrasives are proposed in this thesis, followed by a detailed characterization study. The reusability of elastic abrasive balls is another important feature, substantiated through specific wear tests.

In this thesis, the usage of elastic abrasives are well demonstrated for internal as well as external surface finishing, both using abrasion as well as erosion principles. Dedicated experimental setups developed as a part of this thesis include *elastic abrasive-internal finishing setup* (with and without workpiece rotation), *internal circumferential groove finishing system*, *fluidized elastic abrasive finishing setup*, and *elasto-magnetic abrasive finishing setup*. The experimental setup and methodologies described in this thesis clearly illustrates the simplicity, effectiveness and convenience of using the proposed elastic abrasive balls. The range of work materials used for the experiments reported include magnetic as well as non-magnetic materials, both of ductile and brittle in nature, covering difficult-to-cut materials such as hardened steel and tungsten carbide. Experimental studies have been well substantiated through

theoretical study of the fundamental mechanisms involved as well as by the analysis of experimental data.

Among these, fluidized elastic abrasive finishing system use low velocity impact of proposed balls to get controlled erosion and fine finishing of surfaces. The problems associated with the fluidization of fine abrasive powders are fully resolved through the application of elastic abrasive balls, and can be used effectively further for the fine finishing of intricate free form surfaces. Elasto magnetic abrasive finishing is a variant of magnetic abrasive finishing performed using magnetic elastic abrasive balls (referred to as *elasto-magnetic abrasives* in this thesis).

Significant improvement in surface finish is achieved through the application of elastic abrasives, with a remarkable improvement in average roughness, peak to valley roughness and peak height. The average roughness obtained in accordance with the selected experimental conditions in this thesis is of the order 15 to 40 nanometres, from an initial range of 150 to 250 nanometres, after a processing time of 40 to 60 minutes. Simple, flexible and convenient application of elastic abrasive balls, minimal cleaning after processing, finishing of surfaces without altering the form, absence of liquid carrier medium, simple and cost effective experimental setups, etc. are the key operational features of the proposed approach.