Nano-finishing techniques: a review

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Abstract: The quality of surface is one of the significant parameters which affects the life and functionality of any product. Many products require nano-level surface finish as their functional indispensability. Those processes having flexible finishing tool can be employed for such type of components. These finishing processes can be classified into two categories: with and without magnetic field assistance. The former includes magnetic abrasive finishing, magnetorheological finishing, and allied processes, and the latter includes abrasive flow finishing. This article reports the critical review of mainly three processes: abrasive flow finishing, magnetorheological finishing, and magnetorheological abrasive flow finishing. In this article, the issues that need attention of the researchers have been categorically mentioned. This article provides a comprehensive literature review of magnetorheological finishing process in terms of rheological characterization of magnetorheological fluid, experimental investigation, theoretical analysis, and applications. This article deals with various advancements in abrasive flow finishing and hybrid processes. The developments in magnetorheological abrasive flow finishing and its allied processes have been discussed in detail. By suitable modification of magnetorheological abrasive flow finishing process, it can achieve surface finish up to nano-meter on different materials such as brass, aluminium, stainless steel, and silicon-nitride.

Keywords: nanofinishing, magnetorheological fluid, abrasives, surface roughness

1 INTRODUCTION

In the era of nanotechnology, high precision finishing methods are of utmost importance, and they are the need of present day manufacturing industries. There are noteworthy developments in high technology industries such as electronics, automobile, medical, and aviation, where the focus is to increase precision of the products at micro-/nano-scale to perform certain functions. Many products exist in the market where highest level of surface finish is necessary to increase their life and performance. Some of them are silicon in IC industries, micro-channels in micro-fluidics, optics and free-form surfaces in medical science, and moving assembly such as piston-cylinder and bearings in automobile. The traditional finishing processes alone are incapable of producing the required surface characteristics to meet the demand of nanotechnology. Many components require high level of surface finish to reduce fluid flow resistance, friction, and optical losses. Fatigue strength of a component is also affected by surface conditions. Usually, a surface finish improvement operation is required during or after fabrication of a part. Abrasive-based traditional finishing processes, such as grinding, honing, and lapping, are not capable of producing ultrafine surface on three-dimensional (3D) complex-shaped components and very hard material components due to the abrasives in the bonded form and high specific cutting energy requirement. Therefore, loose abrasive finishing processes, such as chemo-mechanical polishing/planarization, abrasive flow finishing (AFF), and magnetic field-assisted finishing processes, are preferable over the traditional finishing processes. However, many finishing processes, such as lapping, chemo-mechanical polishing, and AFF, are not deterministic in nature because the abrading forces acting on the

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