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High Frequency and Amplitude Effects in Vibratory Media Finishing

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Abstract
The vibratory media finishing process is known for its long process time and there is an industrial need to speed up this process. Increasing frequency and amplitude of vibration, beyond the current process window commonly used, is an option to reduce process time. Using a laboratory scale electro-magnetic shaker setup, the effects of increasing frequency and amplitude of vibration is investigated. By monitoring the surface roughness with processing time it is shown that, while for a given amplitude frequency has a strong effect, amplitude in general has a stronger effect in quickening the time to saturation. Using high-speed camera measurements in a transparent bowl it is also shown that the average media speed increases with increase in frequency and this can partially explain the resulting shorter process time.

Keywords: Vibratory media finishing, high frequency, amplitude

1 Media finishing process, parameters and usual parameter window

Vibratory media finishing systems produce a polishing action on various industrial components that is very thorough. The process removes material from pockets and recesses and inside bores, a task not easily achievable by other processes, so it can be used for very delicate or intricate parts(Holzknecht 2009). Vibratory finishing media consists of bonded abrasive or non-abrasive materials in preformed shapes where the material is in granular form and held together by a proprietary mix of binders. Although a variety of shapes are used, the most common include pyramids, triangles, cones, cylinders and spheres with the maximum size normally limited to sides of 25 mm or less. As no standard classification schemes

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exist, media are loosely classified based on cutting action and referred to as 'rough-cut', 'medium-cut' or 'finish-cut'. The key to the vibratory media finishing is pressure and speed. The higher the pressure exerted by the media on the parts, and the faster the media "rubs" on the parts, the faster the desired finishing results can be achieved.

There are several process parameters that influence the vibratory finishing process Gillespie (Gillespie 1975). Some of these parameters are inter-related as reported via detailed experimental investigation by Wang et al (Wang, Timsit et al. 2000). The changes in roughness were found to depend mostly on the lubrication condition, the media roughness, and the size of the media, since these influenced the interaction between the media and the work piece, and hence the extent of plastic surface deformation per impact. Sofranos and Taraman (Sofronas and Taraman 1979) experimented the effect of five variables of vibratory machining process such as work piece hardness, projection width, processing time, media size and vibration frequency on three responses such as projection height reduction, edge radius and surface finish reduction. They have used statistical approach known as response surface methodology to formulate a relationship between the above mentioned parameters. The examination showed that increasing the processing time, media size or vibratory frequency increases the effect on three responses. Their study revealed statistically that high frequency is important among all the processing variables considered. Baghbanan et al (Baghbanan, Yabuki et al. 2003) studied the tribological behavior of aluminum alloys in a vibratory finishing process. The nature of the normal and shear forces, and the variations in surface properties in a tub vibratory finisher were comparable to those in a smaller bowl finisher that had a much smaller amplitude and frequency as well as a completely different media bulk flow pattern (two-dimensional circulation in the tub and three-dimensional spiral flow in the bowl), which suggested that vibratory finishing data and observations can be generalized and are not specific to a particular machine, frequency or amplitude. Pradeep et al (Prakasam and Subbiah 2013) tried to understand the type of media motion and characterized the impact type and scratching type of media contact influencing wear mechanisms in vibratory finishing process by analyzing the acoustic emission signals. Work by Fraas(Fraas 1996) uncovered that by controlling the amplitude and frequency of the finisher, media particles can be fluidized and complex flow fields can be developed within the chamber. As a result, depending on the parameters of the process, this can produce a wide range of contact conditions involving varying degrees of rubbing, burnishing, ploughing, cutting and three-body abrasive wear. Work of Domblesky et al (Domblesky, Cariapa et al. 2003) reveals that material removal rate is directly proportional to the resultant bowl acceleration with higher accelerations giving increased material removal rates. Vibratory bowls in industries normally operate in a range of 30 Hertz to 50 Hertz and they vary in amplitude from 1.5 mm to 3 mm; these ranges represent the most common process window employed. The experimental findings reported in the literature tend to stay within this process window.

In summary, while both academic and industrial research in mass finishing focused on process parameter effects, the process parameter windows investigated has largely been limited to a narrow window. There have not been any reports that describe the effect of the frequency individually on media particle motions, nor investigate material removal characteristics at very high frequencies and amplitudes beyond the usual process window and explore relationship of these parameters with the lead time to attain saturation surface roughness. This research attempts to fill this knowledge gap. The objective of this research is to find the effect of increasing the frequency above the typical frequency/amplitude ranges used conventionally in the existing vibratory media finishing process practiced in industries.