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Parametric Investigations into Internal Surface Modification of Brass Tubes with Alternating Magnetic Field

Harish Kumar[1*], Sehijpal Singh[2] and Anil Srivastava[1]
[1]*University of Texas, Rio Grande Valley, Edinburg, Texas, U.S.A.*
[2]*Guru Nanak Dev Engg. College, Ludhiana, Punjab, India.*
harishprashar@gmail.com, sehijpalsingh@yahoo.in, anil.srivastava@utrgv.edu

Abstract
The final finish operations have great significance in an overall manufacturing cycle of a product. The surface finishing and modification of surfaces have been the vital requirements of most of the products. The processes like shot peening, shot blasting, abrasive finishing and super finishing are being largely employed for such requirements. While final finishing of flat and outside surfaces are relatively easy and well established, the internal surfaces such as those of pipes is not so simple. In this paper, the application of low frequency alternative magnetic field has been explored for imparting surface modification including surface on the internal cylindrical surface. The cold drawn SUS304 stainless steel (SS) pins have been used as micro tools. The interaction of vibrating SS pins (due to AC magnetic field) with internal surface of rotating pipe has resulted in micro indentation of surface thereby improving surface characteristics. An experimental setup has been developed to investigate the effect of major process parameters on the percentage improvement in surface finish and surface hardness. Response Surface Methodology has been employed to design the experiment for demonstrating the effect of various process parameters on the surface finish and hardness of the processed surface. It is observed that SUS304 stainless steel pins are capable of improving the surface characteristics like surface finish and surface hardness in the internal surface of brass tube.

Keywords: Surface Modification, peening, AC magnetic field, Final finish operation, Surface hardness

1 Introduction

Surface modification is the physical transformation of a characteristic of a surface to improve its surface properties such as its roughness, hardness or fatigue strength etc. Surface characteristics can be

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modified by inducing compressive residual stresses on work surfaces. Shot peening or modified shot peening processes such as water jet peening, cavitation peening and ultrasonic shot peening are widely used to induce compressive residual stresses on the surface to improve the surface integrity and fatigue strength. But these processes are difficult to apply on internal surfaces such as high pressure liquid pipes and pressure fuel pipes. Surface characteristics of external as well as internal surface can be improved by a recently developed surface finishing/modification process called Magnetic Abrasive Finishing (MAF). In MAF, workpiece is held between the two poles of magnet. Magnetic Abrasive Particles (MAPs) used as finishing tool, are filled between the workpiece and the magnetic poles. The magnetic abrasive particles joined to each other along the lines of magnetic force and form a Flexible Magnetic Abrasive Brush. The flexible magnetic abrasive brush acts as a multi-point cutting tool for finishing process. The vibratory, rotary & axial motion is imparted to the workpiece to improve the performance of finishing operation. In magnetic abrasive finishing, magnetic field can be induced in three different ways i.e. by permanent magnets, direct current or by alternating current. At Initial stages, MAF was used only for finishing of flat surfaces but later this process was successfully utilized for finishing of external as well as internal surfaces (Shinmura, et al., 1985), (Shinmura and Aizawa, 1989). Magnetic abrasive finishing of internal surfaces is always a bit difficult task to deal with. Most of the researchers have utilized permanent magnets to induce magnetic field for internal surface finishing of metallic components made up of ferrous material like steel (Shinmura and Yamaguchi, 1995), (Yamaguchi and Shinmura, 2000) and non ferrous materials like aluminum alloy tubes (Yamaguchi and Shinmura, 2004), (Wang and Hu, 2005). Very small diameter SUS304 stainless steel capillary tubes were also successfully finished by MAF with permanent magnets (Yamaguchi and Shinmura, 2000), (Yamaguchi, et al., 2007), (Kang, et al., 2012), (Kang and Yamaguchi, 2012). Direct current is also successfully utilized by various researchers to induce magnetic field during magnetic abrasive finishing process for internal surface finishing of tubes (Yamaguchi, et al., 1996), (Kim, et al., 1997), (Yamaguchi and Shinmura, 1999), (Kim 2003). Only few researchers have utilized alternating current for internal surface finishing of tubes (Yamaguchi, et al., 2003), (Kumar, et al., 2012).

In a recent development in MAF with alternating current, Yamaguchi (Yamaguchi, et al., 2003) used cold drawn SUS304 stainless steel pins for surface modification of steel surface. It was concluded that surface characteristics can be modified by these pins if used in alternating magnetic field. Cold drawn SUS 304 stainless steel pins were also proved to be a good magnetic tool to induce compressive residual stresses and to improve microstructure of internal surface of brass tubes in magnetic abrasive finishing with alternating current (Kumar, et al., 2012). In present work, alternating magnetic field has been used for internal surface modification of brass tubes with the help of SUS304 stainless steel pin. The brass workpiece is chosen as it is non magnetic in nature. Moreover, due to its favorable mechanical/machining properties it has several applications in automotive, sanitary, and food processing industries. The aim of the present research is to investigate the effect of process parameters on surface characteristics like surface finish as well as surface hardness so as to explore the application of concept for internal surface finishing and modification of tubes.

2 Experimental Setup

An indigenous experimental setup has been designed and developed to carry out the detailed investigation. As shown in Figure 1, there are two coils which are in parallel circuit to each other. Cores in the coils facing each other act as N-S pole in alternating magnetic area. The gap between the poles can be varied axially to achieve the desired magnetic field. Work piece is to be kept in between the two poles. Magnetic coils are made up of 19 SWG copper wire (3000 Turns) wound around the core which is made up of SS400 rolled steel. The electromagnet is capable to induce alternating