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Original Article

Optimization of Rolling Process Parameters using ANOVA and FEM Simulation

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Abstract - *A brass material, C377, was rolled to reduce the thickness to form a plate. In this investigation, a simulation is carried out for the flat rolling process of brass material to find the influence of various process parameters on the hardness (Hv). Von Mises stress (MPa) has been analyzed. The parameters considered for this investigation are roller diameter (mm), temperature (°C), percentage reduction (%) and speed (RPM). The effect of these input parameters has been critically analyzed using the Taguchi method. It has been found that roller diameter and temperature are the most crucial process parameters affecting the hardness value. It is analyzed for different parameters. Taguchi technique is used to find out the best parameter value for roller diameter, temperature, percentage reduction, and speed of the rollers to optimize the hardness and Von Mises stress. The rolling of brass produced a 175Hv hardness and a spread of 1.6mm at a 64 MPa Von Mises stress level when the process parameters were at optimum values.*

Keywords - *Design of experiments, Finite Element Method, Metal forming, Mechanical testing, Simulation.*

1. Introduction

Metal forming is one of the primary manufacturing processes. Rolling is the reduction of the thickness of a work piece by passing it through the rolls [1]. Metal rolling is a necessary process controlled by a number of parameters, accounting for more than 80% of all metal working processes. Metals, when passed through the rollers, change mechanical and metallurgical properties. The rolling parameters can be used to enhance the properties depending on the application.

Copper alloys can be used in several applications [1]. There are mainly two types of alloys in copper, namely brass and bronze. Brass is the type of alloy when copper is mixed with zinc [2]. Depending on the application, the zinc percentage can be varied. High-strength brass is suitable for engineering applications where high strength is required to sustain heavy loads and resistance to wear and corrosion [3].

The advantage of brass is that the mechanical properties can be enhanced by further processing and heat treatment, and they are low in cost [4–6]. In the present work, C377 Brass alloy has a chemical composition of Cu 58-61%, Pb of 1.5 - 2.5% and Zn. This material has excellent corrosion resistance and vibration-absorbing properties. They are used as rod bases for hammer and press forging machines, in the plumbing industries in value bodies, fitting and other hardware. It also has extensive usage in marine applications because of excellent corrosion resistance [7].

There are many process parameters which govern the quality of rolling. Spread is nothing but an increase in the bar's breath when passed between the rollers. In hot rolling, the sheet spread is negligible because the cylindrical rolls compress the material, and the frictional resistance in the rolling direction is lesser than the transverse direction [8–11]. In general, the quality of a rolled sheet is known by testing the hardness of the sheet. Other parameters, such as Von Mises stress and temperature at which it has been deformed, help determine the quality of rolled sheets [12].

The simulation helps predict quality and optimize the process before the actual manufacturing process without actually spending any physical resources. Taguchi Optimisation technique is one of the most widely used optimization techniques and has been used to find the rolling parameters through experiments [13, 14].