Optimize the Rolling Process Parameters for Material AA1100 the usage of Metal Forming Simulation

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Abstract:

Metal forming plays a very important role in the manufacturing. Simulation of manufacturing process aids in the improvement of quality, reduce energy and resource consumption and helps in visualization of the process. The design of experiment helps in optimization of the parameters in any processes. In this paper, Taguchi optimization technique is used to predict the best results for the given inputs such as roller diameter, friction value, velocity of the rollers and percentage reduction to the forming process and get the optimized values for spread, hardness, effective stress, power required, strain rate and torque using the manufacturing simulation software. It is found that the important parameter is percentage reduction affecting the effective stress. Optimal parameters with desirability value of 0.87 have been obtained.

Keywords*:* Metal Rolling, DOE, Optimization, Aluminum **AA1100**

1. Introduction

According to Schroder (2003), most technically used metals (iron, aluminum, magnesium, titanium) and most alloying elements (silicon, manganese, chromium, nickel, molybdenum, tungsten, etc.) are found in nature in a chemical stable form as ore. To acquire technically useful metals and their alloys, ore has to be reduced (and alloyed) and primarily shaped by casting and sintering. These processes are suitable only for achieving almost finished shape for 'small' contact parts. For other products the primarily shaped metal needs secondary forming: forging in case one dimension of the product is very much bigger than the others, then the secondary forming is done in a Cold working machine in a Cold working mill with cylindrical tools, the work rolls. While casting and forging are old technologies going back more than 3000 years, Cold working assumed major importance in the industrialized world. Initially, steel was the only product to be rolled to profiles (rails, beams, channels, rounds) but since about 1930 flat products (steel and strip) have become increasingly dominant. Profiles and flats are hot rolled (the latter to a minimum size). Thin flat products are finished by Cold working for various reasons, e.g. to achieve a better shape and profile, because of mechanical properties, surface conditions, etc.

2. Literature review

The success of any grinding operation depends on the proper selection of various grinding parameters, like wheel speed, work speed, transverse feed, and in-feed area of contact, grinding fluids, balancing of grinding wheels and dressing etc. Subramanian and Lindsay (1992) have given the concept of grinding system approach that addresses four key inputs to the grinding process viz. machine tool, wheel selection, work material properties and operational factors (Figures 2.4 and 2.5). Inadequate attentions to details in any one of these systems input parameters can result in uncertain grinding results.

2.1 Influence of input process parameters

A very large number of widely varying parameters affects the grinding process. Unlike most of the input values like the machine, grinding wheel, machine setting, etc., which can be optimized, the work material whichis selected in view of the required properties of the finished product, cannotbe changed. Therefore, in order to achieve a well-adjusted grinding process, the variable process input values must be adapted to the material. The grinding process is characterized by grinding power, forces, vibration, temperature, wheel wear and wheel loading (Figure 1).

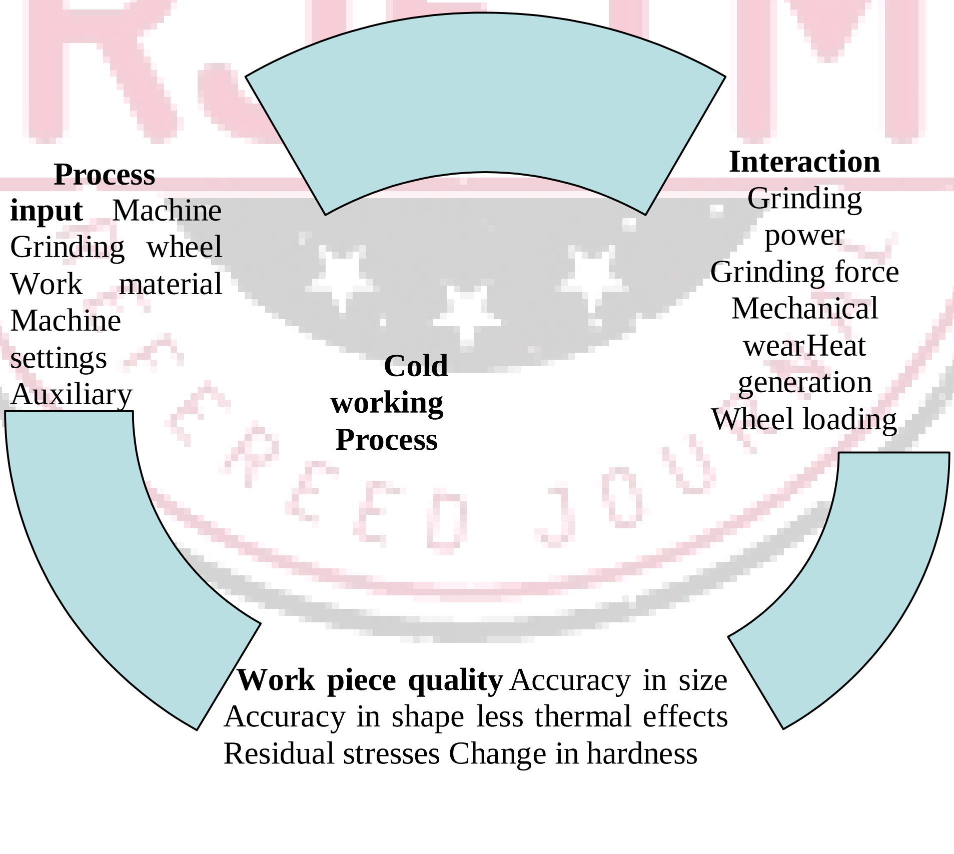

Figure 1 Influences of process input on Cold working process and workquality

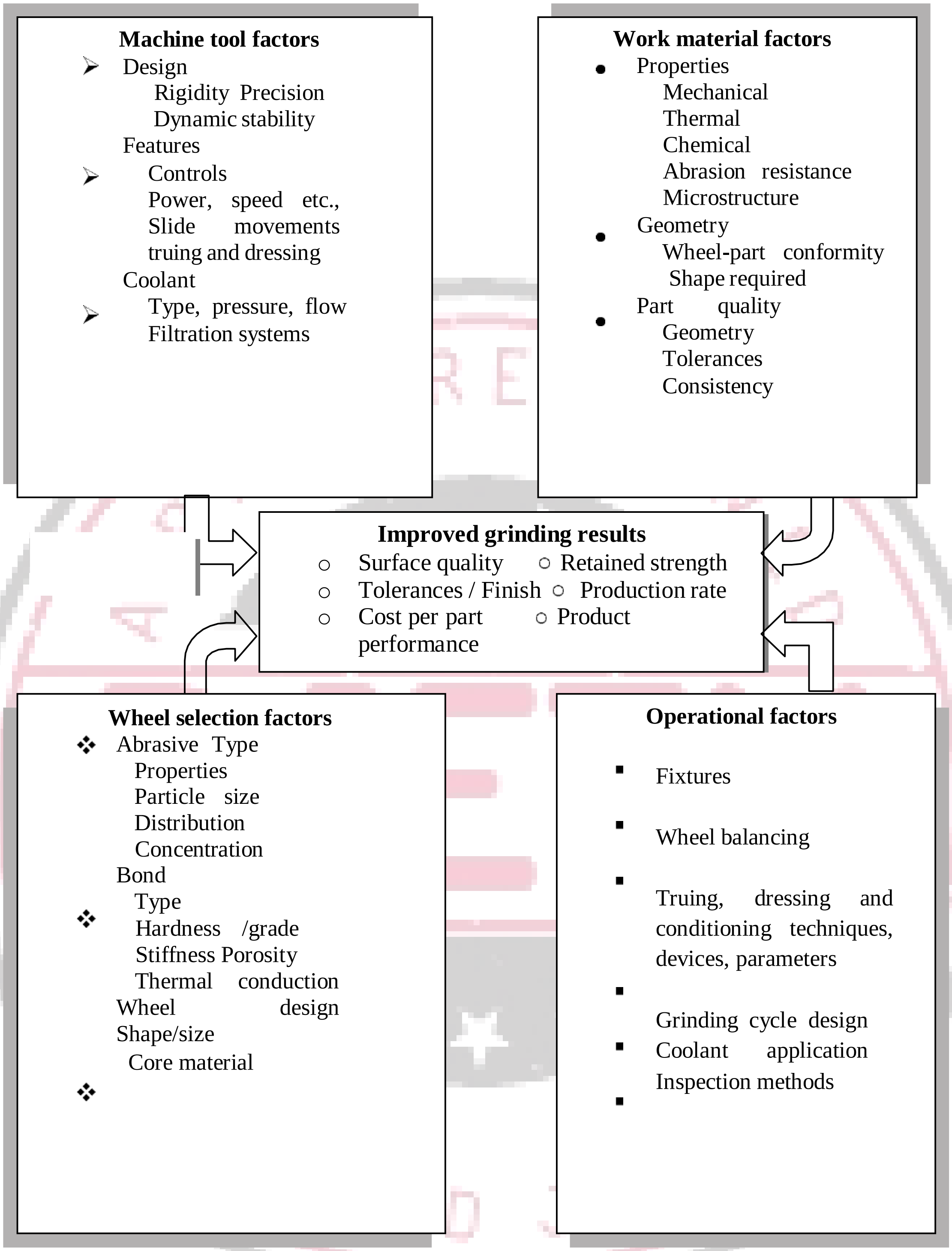

Figure 2 Variables influencing the Cold working process

2.2 Wheel wear

The geometry of grits on the wheel surface continuously alters due to the influence of cutting mechanisms and forces. The condition of the wheel is also altered due to the wear of the grinding wheel and by the loading of the work material into its pores. Wheel wear and loading bring down the cutting efficiency and the grinding forces increase gradually (Chander et al 1978).

Wear of grinding wheel may be defined as the loss of abrasives from the surface of the wheel and are due to

(i) Attritions wear of grains.

(ii) Mechanical grain fracture and

(iii) Rupture of bond or gross pullout of whole grain (Pande and Lal 1976).

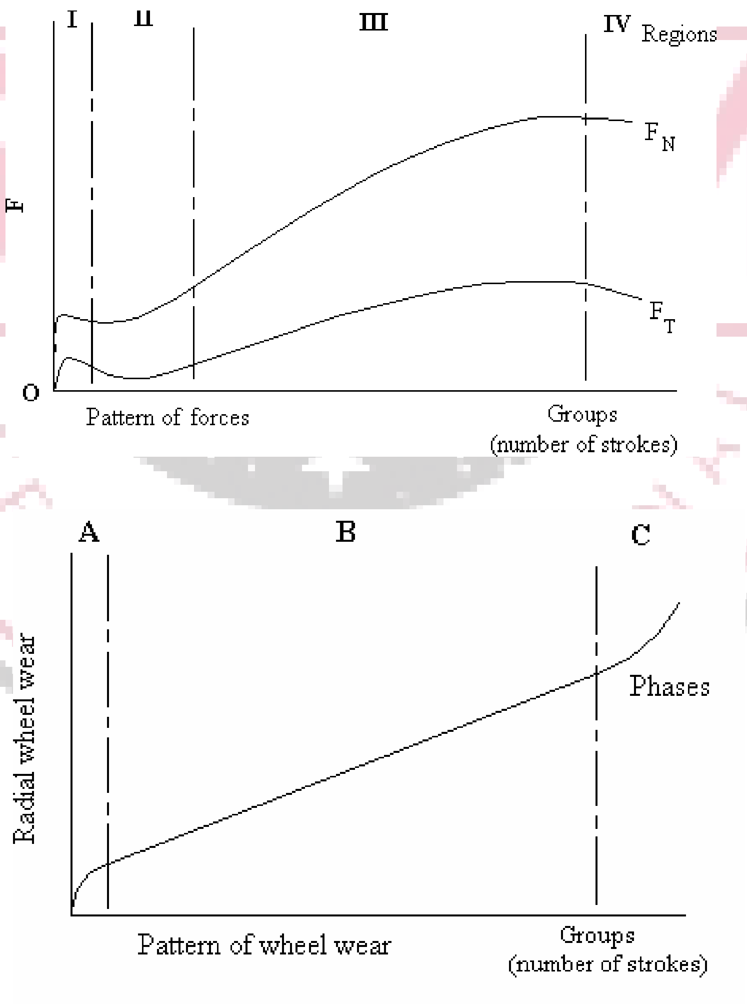

Figure 3 Relative patterns of wheel wear and forces

3. Loading of Grinding Wheels

The quality and efficiency of grinding process is largely dependent on the condition of the cutting edges as well as on the condition of the pores on the wheel surface (Konig and Aachen 1978). Frequently, loading of the grinding wheel with chips occurs when ductile or high adhesion materials like aluminum, titanium and stainless steel are machined. Wheel loading is one of the important parameters, which determines the useful life of a wheel in precision grinding (Srivatsava et al 1985). Due to loading, the outer surface of the wheel becomes glazed and results in excessive rubbing. Chips in the grinding wheel will alter the grain edge geometry and the friction process occurring during grinding operations. The loaded wheel will result in increased cutting forces and grinding power consumption, which in turn may lead to a breakdown of the grinding wheel structure.

The loaded wheel also generates more heat, which in turn affects the surface integrity of the work-piece such as surface roughness or surface topography and surface metallurgy. Alterations of the surface layers include plastic deformation, micro cracking, phase transformation, micro-hardness changes, tears associated with built up edge and residual stress distribution (Shah and Chawala 1979). To ensure consistent results in grinding, one has to continuously investigate the condition or the modifications occurring on thewheel and control them suitably.

3.1 Cylindrical Grinding

Cylindrical grinding designates a general category of various grinding methods, which have the common characteristic of rotating the work- piece about a fixed axis and grinding outside surface section in controlled relation to that axis of rotation. In plunge type grinding machines the wheel is plunged into the work at a predetermined feed rate and is withdrawn at the time the work piece reaches the correct size.Table 2.1 gives general guideline about the depth of cut conditions followed in plunge grinding.

Table 1 Plunge grinding- Depth of cut conditions

Work material	In-feed per revolution of the work (mm)	
	Roughing	Finishing
Steel soft	0.0125	0.005
Plain carbon steel hardened	0.005	0.00125
Alloy and tool steel hardened	0.0025	0.00065

3.2 Selection Of Optimal Cold Working Parameters To Obtain Required Surface Roughness In Rough And Finish Work Rolls

In precision grinding operations, it is often important to set the correct grinding machine parameters so as to produce a product of required quality. The selection of cold working parameters if it is done on hit and miss technique not only wastes time but also leads to an inefficient process. To overcome this difficulty, Gupta et al. (2001) in their work optimized the cold working process parameters using the enumeration method. Experimental investigations are conducted separately for rough and finish work rolls and their results are reported in this chapter.

Process parameters for grinding are classified based on its wheel characteristics, work characteristics, machine characteristics and operating conditions. Wheel characteristics depend on wheel diameter, grit type, grit size, wheel grade, bond, dressing method and degree of wheel balance. Work piece hardness, structures and chemistry affect characteristics of the work.

3.3 Research Methodology

Although the best parameter setup in the factorial design combinations can be successfully identified by applying the Taguchi method, the real optimal values in the completed explored region cannot be guaranteed (Pignatiello 1988). To overcome this shortcoming, a new approach for planning a design of experiments, a neural network was proposed. In terms of training on the data set used in the Taguchi analysis, a neural network was constructed. Several extra experimental results, which were not included in the full factorial design combinations, were collected and used to test the constructed neural network. The strong functional mapping capability of the neural network model does provide a feature in which neural nets and traditional experimental design methods can be combined to make a new andmore effective experimental design methodology.

Conclusion

In this work, optimum grinding conditions for the desired surface roughness were found with a minimum number of experimental runs using Taguchi's orthogonal array. In a neural network modeling, more the data for training the network, higher will be the accuracy of the prediction. But the data generations are costly and time consuming. The proposed methodology overcomes this problem by systematic procedure for data collection for training the neural network using design of experiments using less number of experimental runs. Additional data were included for training based on those factors that have more significant impact on surface roughness using Taguchi methodology. It is observed that the present methodology is able to make accurate prediction of surface roughness by utilizing small sized training and testing datasets.

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