CHAPTER 1

INTRODUCTION

1.1 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 rolling machine in a rolling mill with cylindrical tools, the work rolls. While casting and forging are old technologies going back more than 3000 years, rolling 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 rolling for various reasons, e.g. to achieve a better shape and profile, because of mechanical properties, surface conditions, etc.

Among the various metal cutting processes available, grinding is one of the important metal cutting processes used extensively in the finishing
operation of discrete components. Grinding is the indicated process when the work piece demands good surface, dimensional and geometrical quality (Malkin 1989). Due to this, the grinding process is usually one of the last steps in the machining operations chain. When the work piece reaches this point, it has high aggregate value, which leads to a possible rejection and it is very expensive. Most of the production processes are incomplete without grinding process. According to Subramanian (1999), it is a major manufacturing process, which accounts for about 25% of the total expenditure on machining operations in industrialized countries. Almost all the engineering components are processed in grinding machines at some stages of their production.

Owing to the increasing quality standards, special attention must be paid to the design of roll grinding processes. Besides the quality of the work rolls, the grinding process must be sufficient for economical requirements. The quality of the work rolls depends mainly on technological aspects, like the specification of the grinding wheel, dressing parameters, material removal rate, cooling lubricants etc., which influence the surface roughness. In precision grinding operations, it is often important to set the correct grinding machine parameters so as to produce parts with required quality. In order to decrease the cost and increase the production rate, the grinding machine must be set to operate within the shortest possible grinding cycle time. Hahn and Lindsay (1966) identified the quantitative relationships between the various important process parameters. According to them, grinding performance (surface finish, wheel wear and stock removal rate) will differ from one machine to another, even though the same wheel and work material are used.

1.2 PROBLEM STATEMENT

Flat rolled strip production employs various types of steel and cast iron work rolls and backup rolls to reduce the thickness of steel slabs to the
desired finished product thickness and width of flat rolled strip in coil form. The reduction in thickness employs high forces in both hot mills and cold rolling mills to elongate the steel bar and strip while delivering the desired physical and metallurgical properties to the strip product. Flat rolling employs both continuous and semi-continuous rolling processes in hot mills and cold mills. The critical importance is the thickness control, the shape and flatness, and the surface condition of the flat rolled strip. Variations in quality of these factors can result in processing cost increases, extra maintenance of equipment, production losses, and late deliveries of products to both downstream internal customers and external customers.

Various types of rolls are used in flat rolling, including cast iron, cast steel, high chrome iron, forged steel, tool steel and high speed steel. Rolls come in various sizes depending on the mill design ranging from 75 mm diameter to 2000 mm diameter and with a body length ranging from 1000 mm to 2500 mm. Rolls are commonly made from a variety of processes including: static casting, centrifugal spin casting, electro slag re-meltcasting.

Roll performance is commonly evaluated by measurements including: total tonnage rolled, tonnage rolled per campaign, tonnage rolled per inch or mm of roll consumption, or specific roll force (force per unit width). Roll performance is affected by mill operation, rolling schedule, mill equipment condition, practices and procedures, product type and chemistry, roll inspection methods, roll maintenance procedures, roll use practices and roll inventory. Rolls are highly susceptible to damage from a variety of failure modes, including: spalling, breakage, cracking, fatigue, wear, surface roughening, impression marks, bruising, hardness variation, or expression marks. Detection of defects is critical.

Mill rolls come in a variety of sizes and shapes according to the product being made and are useful for continuous operations for various
lengths of time. Periodically, they are removed from service and maintained using a roll grinding machine. The roll grinding machine is used to return the rolls to their specified condition, and remove any surface defects after inspecting the rolls for damage. The roll grinding machine accommodates a roll, which is driven by motors on a horizontal axis. The grinding machine is normally controlled by a manual or automatic system that powers and manipulates a grinding wheel that is used to remove material from the roll.

In past decades, selecting the grinding conditions strongly depended upon an expert’s judgment. So it was very difficult for beginners or unskilled workers to determine the proper grinding conditions to satisfy all demanded constraints such as the surface roughness, the material removal rate and the grinding power required. Analysis of these parameters would be very much needed to improve the efficiency of the work roll grinding machine and the quality of the work rolls.

1.3  RESEARCH OBJECTIVE

Grinding is a complex machining process with a lot of interactive parameters, which depend upon the grinding type and requirements of products. The surface quality produced in roll grinding is influenced by various parameters given as follows (Jae-seob kwak 2005)

i)  Wheel Parameters: abrasives, grain size, grade, structure, binder, shape and dimensions, etc.

ii) Work piece parameters: fracture mode, mechanical properties and chemical composition, etc.

iii) Process parameters: wheel speed, work speed, depth of cut, table speed, and dressing conditions, etc.

iv) Machine parameters; static and dynamic characteristics, spindle system, and table system, etc.
Several efforts were made by various researchers namely Brown (1969), Peters (1974), Malkin (1975), Lal and Shaw (1975), Rowe (1988), Tonshoff (1992), Sakakura (1992), Inasaki (1996), etc., as described in the Literature survey in the Chapter 2 to design a suitable model for grinding process such as, using parameter optimization, analytical and numerical approaches etc., Furthermore, intelligent approaches were also adopted by many researchers to optimize the conventional grinding process conditions. However, only a few isolated attempts have been reported on considering dressing conditions on grinding wheels and ideal passes which have significant influence on roll grinding process. At this point, it appears that practical optimization strategy and reliable mathematical models are required to analyze the surface quality of the work rolls, grinding power requirements and material removal rate to enhance the production efficiency of the roll grinding.

The above said problems cause one to investigate the following aspects to obtain better surface finish in work rolls with higher productivity.

i) During rolling process, work rolls for cold rolling of steel show less wear but the roll surfaces lose their roughness and this influences the finished product as well. Work rolls periodically grind to required surface finish while leaving the surface free of feed, chatter marks and surface irregularities. Selection of process parameters in grinding of both rough and finish work rolls is so critical that it may affect the surface quality of the product. Since different surface roughness values are required for rough and finish work rolls, the investigation must be carried out separately for both the work rolls to obtain optimal machining parameters.
ii) To analyze effectively the grinding power required during the process, surface roughness of the ground work roll and material removal rate in grinding of D2 steel work roll, it is essential to develop a model, which includes wheel dress conditions for evaluating the performance of the work roll grinding machine. Only a few isolated attempts (i.e., Sakakura and Inasaki (1992), Jae-Seob Kwak (2005)) have been reported on considering dressing conditions on grinding wheel, which has significant influence on grinding process besides other machining conditions. Mathematical model is also required for evaluating the performance of the work roll grinding machine. This requires multi-objective optimization strategy to analyze surface roughness on finish work roll, power required by the wheel spindle and material removal rate during the process.

1.4 OVERVIEW OF THE DISSERTATION AND SPECIFIC CONTRIBUTION

The Second Chapter describes the comprehensive review of the literature on grinding, optimization techniques used in grinding process. Deficiencies in the literature that have motivated this work are highlighted. As a foundation for the various studies in this dissertation, first, the fundamental concepts of grinding, optimization techniques, design of experiments and artificial intelligence tools used in this study such as artificial neural network and fuzzy logic are reviewed in this chapter.

The Third Chapter deals with the details of equipments used, grinding wheel used for the experimentation and work rolls specification. Details of the measuring instruments used in the experimentation for
measuring surface roughness and power required at wheel spindle are also described in this section.

The Fourth Chapter explains the optimization strategy adopted for obtaining required surface finish in the work rolls. Since rough and finish work rolls require different surface roughness values, the investigations have been conducted separately for both types of work rolls. The results of the investigations are also presented.

The Fifth Chapter depicts the Multi-objective optimization strategy adopted for optimizing the machining parameters for grinding finish work rolls considering three objectives such as minimization of surface roughness, power required at wheel spindle and maximization of material removal rate. This optimization strategy described the Taguchi and fuzzy logic tools used for optimizing the multi-objectives mentioned above. Details of the experimental results and validation experimental runs are presented in this chapter.

The Sixth Chapter elucidates the development of mathematical models for surface roughness and power required at wheel spindle using response surface methodology and the multi-objective optimization strategy considering the three objectives using genetic algorithm. The results obtained and the validations of the models are discussed in this chapter.

The Seventh Chapter summarizes the major conclusions arrived due to this research work and also describe its potential contribution to the rolling industry. The future scope of the research work is discussed at the end of the chapter.
1.5 CONCLUSION

In order to predict component behaviour during use or to control the roll grinding process, it is necessary to quantify the surface roughness, which is one of the most critical quality constraints for the selection of grinding factors in the process planning. The aim of this research work is to study the work roll grinding process so as to obtain a required quality of the work rolls with higher productivity.