FINITE ELEMENT SIMULATION OF A ROLLING PROCESS OF ALUMINIUM

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SUPERVISOR DECLARATION

"I hereby declare that I have read this thesis and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Structure & Material)"

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DECLARATION

"I hereby declare that the work in this report is my own except for summaries and quotations which have been duly acknowledged."

Signature : ………………………….

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ABSTRACT

Rolling in metal forming process is the process of reducing the thickness or changing the cross section of a long work piece by compressive forces applied through a set of rolls. Outcome of the rolling process don't always turn out as they should be. It is important that the rolling process is simulated so that the outcome of the material can be examined so that time and cost can be optimized. There are two sets of results obtained in this study, static finite element analysis and dynamic finite element analysis of rolling process. For the static analysis, it is observed that the stress distribution along the arc of contact between roll and material (roll bite) is not uniform and increases from the entry to the exit of the roll bite. The strain that is produced by the force used in the static analysis is not as expected, because the force that moves and deforms the material is a combination of forces that acts with each other. For the dynamic analysis, it is observed that the exit thickness is not exactly as desired due to elastic relaxation of the material. Maximum stress occurs in the roll bite, and some stress is on the material after it has exited the roll bite. The strain in the material increases as it enters the roll bite and then decreases to a certain point as it exits the material. The velocity of the rolling process does not affect the deformation of the material because the stress and strain remains the same after a few trials in the analysis using different roll speeds. Careful application of stress and strain is important in the rolling process so that the outcome can be controlled to save time and cost during the rolling process and finite element analysis can be used to predict the behavior of material during the rolling process.

ABSTRAK

Rolling dalam proses pembentukan logam adalah proses mengurangkan ketebalan atau mengubah keratan rentas bahan oleh kuasa mampatan yang dihasilkan melalui satu set *roller*. Hasil daripada proses *rolling* tidak selalu berlaku seperti yang diinginkan. Proses simulasi *rolling* adalah penting untuk dijalankan supaya kesan *rolling* kepada hasil bahan boleh dikaji dan masa dan kos boleh dioptimumkan. Terdapat dua set keputusan yang diperolehi dalam kajian ini, analisis unsur terhingga statik dan analisis unsur terhingga dinamik untuk proses *rolling*. Untuk analisis statik, tekanan di antara *roll* dan bahan (*roll bite*) tidak seragam. Tekanan yang dihasilkan oleh daya yang digunakan dalam analisis statik tidak seperti yang dijangka, kerana daya yang bergerak dan merubah bentuk bahan adalah gabungan daya-daya yang bertindak di antara satu sama lain. Untuk analisis dinamik, ketebalan bahan yang telah melalui *roll bite* tidak seperti yang dikehendaki kerana kelonggaran elastik bahan. Tekanan maksimum berlaku dalam *roll bite,* dan terdapat tekanan pada bahan itu selepas ia telah keluar daripada *roll bite*. Tegangan pada bahan meningkat apabila ia memasuki *roll bite* dan kemudian berkurangan kepada tegangan tertentu apabila ia selesai melalui *roil bite*. Halaju *rolling* tidak mempengaruhi produk akhir bahan kerana tekanan dan tegangan tetap sama selepas beberapa ujian dijalankan dengan menggunakan kelajuan roll yang berbeza. Tekanan dan tegangan adalah penting dalam proses rolling supaya bahan yang dihasilkan dalam proses *rolling* boleh dikawal untuk menjimatkan masa dan kos semasa proses *rolling* dan analisis unsur terhingga boleh digunakan untuk meramalkan tingkah laku bahan semasa proses *rolling*.

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LIST OF SYMBOLS

h_0	Original thickness
h_f	Final thickness
V_r	Surface speed
V_i	Material entry speed
V_f	Material exit speed
μ	Coefficient of friction
σ	Stress
ε	Strain
R	Roll radius
F	Force
L	Roll-strip contact length
w	Strip width
Y_{ave}	Average true stress
K	Stiffness matrix
u	Unknown vector
t	Time
E	Modulus of elasticity
δ	Length
$\ddot{\varepsilon}$	Strain rate of the material
b	Final width of contact area
r	Radius

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LIST OF ABBREVIATIONS

FEA	Finite Element Analysis
FEM	Finite Element Method
NL	Non-Linear
FE	Finite Element
DOF	Degree of Freedom
3D	3 Dimensional
CAD	Computer-aided Design
CAE	Computer-aided Engineering

CHAPTER 1

INTRODUCTION

This chapter will cover on the objective of the project, the problem statement, and the project scope. Furthermore, the information of the project will be stated clearly to enhance the understanding as a method to achieve the project goal. In this research, the focus is given on the Finite Element Simulation of a rolling process of Aluminium.

1.0 BACKGROUND

Rolling in metal forming process is the process of reducing the thickness or changing the cross section of a long work piece by compressive forces applied through a set of rolls [1]. There are a many factors that involve in the rolling process, the main factor and will be studied in this study is stress, strain, and the roll velocity.

Parameter settings for industrial application usually are done through trial and error before the development of computer simulation methods. Computer simulation has been used to optimize the rolling parameters that will be used during production since the advancement of technology. The rolling process is analyzed by using finite element method so that the effect of the factors to the rolling products can be recognized. In this study a finite element simulation will be carried out using ANSYS to study the critical area of the product and study influence of pressure and roll velocity on the product which is pure aluminium.

1.1 PROBLEM STATEMENT

Outcome of the rolling process don't always turn out as they should be. Suitable pressure is important because excessive pressure can produce cracks on the material, while less pressure results in the material will not deform properly [1]. The rolling speed plays an important role in the process because the speed affects the strain rate [2]. The rolling speed also affects the productivity of the production line. It is important that the rolling process is simulated so that the influence the process parameters such as pressure and rolling speed on the outcome of the material can be examined.

1.2 OBJECTIVES

1. To investigate the influence of stress, strain and the roll velocity on the rolling process to the deformation in the product.
2. Applying the Finite Element Method for data analysis.

3. Run simulation in two parts which is Static Analysis and Dynamic Analysis.

1.3 SCOPE

1. The working material used in this study is pure aluminium
2. Modeling the geometry of the equipment and material by using SOLIDWORKS.
3. Utilization of analysis software (ANSYS) to simulate the effect of pressure and roll velocity on the product
4. The effect of temperature, rolling slip, deflection of the rollers, other mechanical components of the rolling mill, is neglected.

CHAPTER 2

LITERATURE REVIEW

This chapter will cover the literature reviewed for this study. The chapter will cover the basic knowledge on rolling process from reference books, introduction to Finite Element Method, and journal articles related to this study.

2.0 ROLLING PROCESS

Rolling is the process of reducing the thickness or changing the cross section of a long work piece by compressive force applied through a set of rolls. Most metal forming process involves rolling process. During the early development of sheet metal forming process, the knowledge on the metal forming process is devised step-by-step and acquired merely through trial and error [3]. Numerous trials are conducted under different operating conditions, and the best combination of parameters is selected. This is repeated again and again for individual parts.

The traditional way of optimizations has several weaknesses [3]:

i. Plant trials are expansive, time consuming, and block production capacities.
ii. Results are ambiguous; it does not allow a statically relevant evaluation.
iii. Results limited to specific equipment and materials used.

Therefore, it is more optimal to base models on the knowledge and quantitative description of the mechanical process parameters and its metallurgical effects. Once verified and established, the plant trials can be reduced thus saving time and cost.

2.1 TYPES OF ROLLING PROCESS

There are several types of rolling process that is used in industry, which included shape rolling, roll forging, skew rolling, ring rolling, thread rolling and lastly flat rolling.

2.1.2 Shape rolling

Shapes are made from material strips that undergo rolling process through a set of specially designed rolls [1]. The cross sections of the strip reduce non-uniformly, it takes experience of the mill operator to ensure that defects and roll wear does not occur [1].

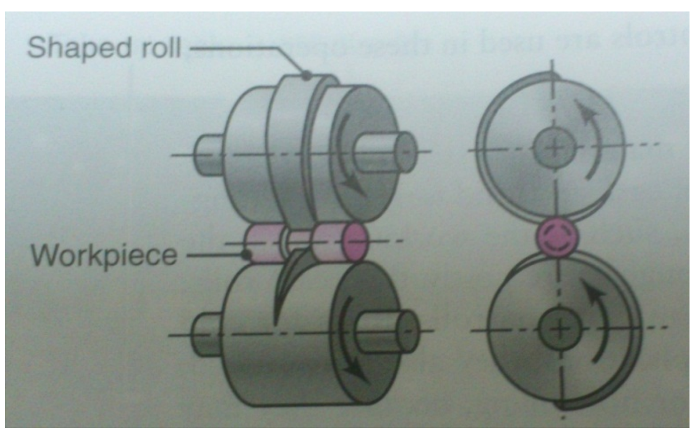

Figure 2.1 Shape Rolling Process [1]

2.1.2 Roll Forging

The cross section of a round bar is shaped by passing through rolls with profiled grooves [1]. It is usually used to produce tapered shafts, table knives and is also used as a preliminary forming operation that is followed by other forging process [1].

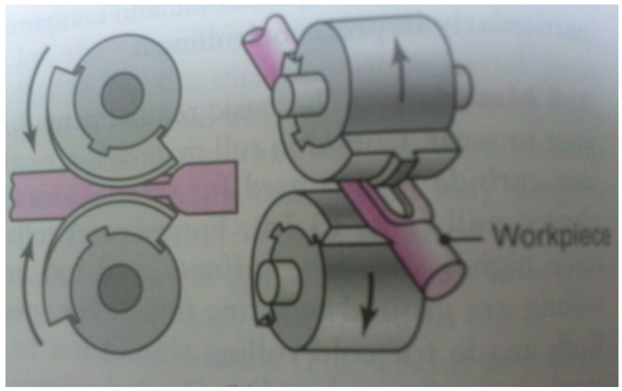

Figure 2.2 Roll Forging [1]

2.1.3 Skew Rolling

Similar to roll forging, skew rolling is typically used to make ball bearings. A round wire or rod is rolled through a gap, and spherical shapes are formed from the action of the rotating rolls [1].

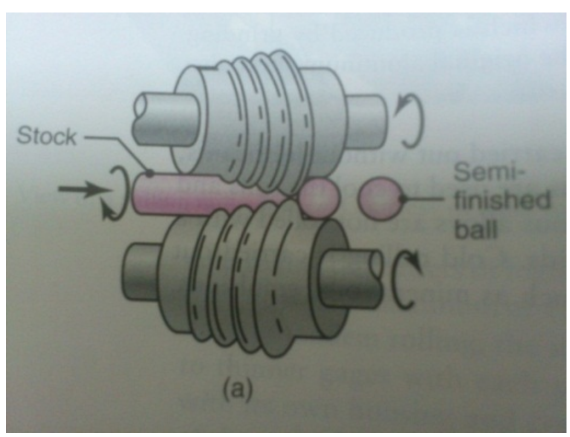

Figure 2.3 Skew Rolling [1]

2.1.4 Ring Rolling

In this process a thick ring is expended into a large-diameter thinner ring. The rolls operate with one roll rotating and one roll idle [1]. The thickness of the ring is reduced by gradually reducing the gap between the rolls. The reduction in ring thickness results in the increase of ring diameter, due to the constant volume of the ring material. The profile rolls design needs experience as the process can easily produce defects [1].

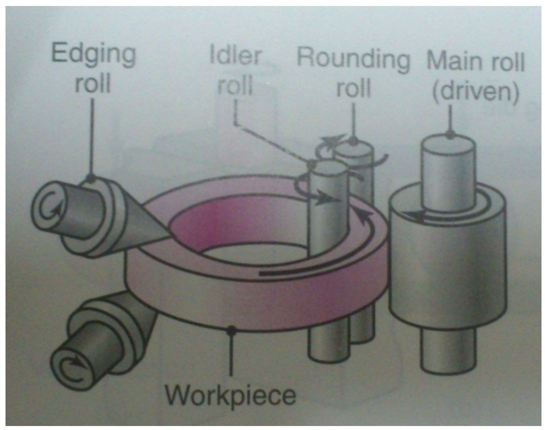

Figure 2.4 Ring Rolling [1]

2.1.5 Thread Rolling

This process involves straight or tapered wires that are formed from round or tapered wires [1]. The threads are formed on the rod or wire by a pair of flat reciprocating dies, and also can be formed with rotary dies. Typically this process produces screws, bolts, and other threaded parts. The advantage of this process is that it produces surfaces with good strength and without loss of material.

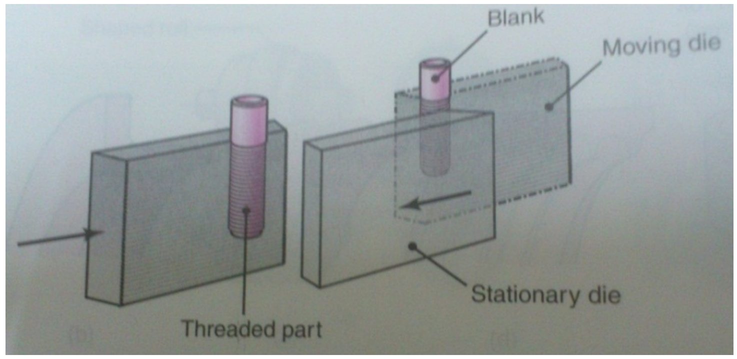

Figure 2.5 Thread Rolling [1]

2.2 FLAT ROLLING PROCESS

In flat rolling process, a flat plate thickness is reduced by applying force from a set of rollers [1]. The process works by running the plate through the gap between the rollers that reduced the thickness of the plate. The process is the most common in industry.

2.2.1 General Analysis

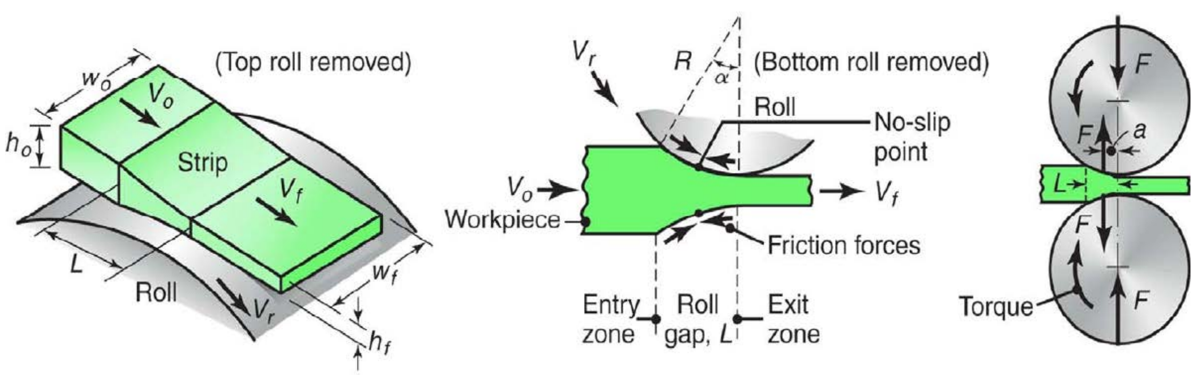

Figure 2.6 Flat Rolling Process Parameters [1]