UNIVERSITI TEKNIKAL MALAYSIA MELAKA

NUMERICAL INVESTIGATION ON DIFFERENT PENETRATION ANGLE IN BONE DRILLING

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Process) (Hons.)

by

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2016

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SESI PENGAJIAN: **2015/2016 Semester 2**

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This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Process) (Hons.). The member of the supervisory is as follow:

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(Project Supervisor)

DECLARATION

I hereby, declared this report entitled “PSM Title” is the results of my own research except as cited in references.

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ABSTRACT

Bone drilling is a common operation to fix the fracture of human bone. However, the concern comes from a problem arise when performing the drilling which is bone necrosis. Bone necrosis is the irreversible death of bone cells in the drilled hole due to a temperature raised above its critical value of 50 °C. Former research that had been conducted emphasize on bone drilling parameters such as drill design, drilling speed, feed rate, cooling system, and depth. This study is conducted to continue in finding the best condition for bone drilling. In this study, a bone drilling process is modeled to simulate the effect of different angle of penetration towards hole performances by means of temperature generation and force distribution. Speed and feed rate will remain constant for the whole model. The model is created using DEFORM-3D Software. Finite element method is applied to calculate the temperature and force. Validation with the experimental result is done by comparing the hole accuracy. Smaller angle is more desirable compared to reduce heat generation.

ABSTRAK

Penggerudian tulang adalah operasi yang biasa dilakukan bagi pemulihan tulang. Walaupun begitu, perkara yang membimbangkan datang apabila masalah timbul yang membabitkan penggerudian tulang iaitu nekrosis tulang. Nekrosis tulang adalah sel-sel tulang yang mati yang tidak boleh dipulihkan, belaku di lubang yang digerudi akibat kenaikan suhu hasil dari penggerudian melebihi nilai kritikalnya iaitu 50 °C. hasil penyelidikan lepas yang telah dijalankan memberi penekanan kepada parameter penggerudian tulang seperti reka bentuk gerudi, kelajuan penggerudian, kadar suapan, sistem penyejukan dan juga kedalaman. Kajian ini untuk meneruskan pencarian dalam mendapatkan keadaan terbaik untuk proses penggerudian tulang. Dalam kajian ini, proses penggerudian tulang dimodelkan untuk mensimulasikan kesan penembusan dari sudut yang berbeza kepada prestasi lubang dalam bentuk suhu yang terhasil dan kuasa. Kelajuan dan kadar suapan adalah dikekalkan untuk keseluruhan model. Model dicipta menggunakan perisisan DEFORM-3D. Kaedah unsur terhingga digunakan untuk mengira suhu dan kuasa. Pengesahan antara model dan eksperimen dijalankan dengan membandingkan ketepatan lubang.

DEDICATION

For my beloved parents,

Ab Razak Bin Md Isa

and

Zuraidah Ahmad

Thank you for always supporting and encouraging me.

For my beloved supervisor,

Dr. Raja Izamshah bin Raja Abdullah

Who guide me well in this research. Thank for your valuable advices and taught.

For my friends,

Thank you for your continuous support and cheer throughout completing this research

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AISI	-	American Iron and Steel Institute
AMG	-	Automatic Mesh Generation
CAD	-	Computer-Aided Design
DF	-	Degree of Freedom
FEM	-	Finite Element Method
P	-	Probability
PMMA	-	Poly (methyl methacrylate)
Rpm	-	Revolution per minute
STL	-	Stereo Lithography

LIST OF SYMBOLS

°	-	Degree
%	-	Percent
°C	-	Degree Celsius
ε	-	Plastic strain
$\dot{\varepsilon}$	-	Plastic strain rate
$\dot{\varepsilon_0}$	-	Reference strain rate
σ	-	Stress
A	-	Yield stress
B	-	Hardening modulus
C	-	Strain rate sensitivity coefficient
e	-	Power of ten
GPa	-	GigaPascal
g	-	Gram
g/cm^3	-	Gram per centimeter cube
J/kgK	-	Joule per kilogram Kelvin
J/m^2	-	Joule per meter square
kg/m^3	-	Kilogram per meter cube
$MN/m^{3/2}$	-	Mega Newton per meter power of three over two
MPa	-	MegaPascal
mm	-	Millimeter
mm/min	-	Millimeter per minute
mm/rev	-	Millimeter per revolution
m^2/s	-	Meter square per second
N	-	Newton
N/s/mm/°C	-	Newton per second per millimeter per degree Celcius
n	-	Strain hardening exponent
W/mK	-	Watt per meter Kelvin

rev/min	-	Revolution per minute
s	-	Second
T_{melt}	-	Melting temperature
T_{room}	-	Room temperature

CHAPTER 1
INTRODUCTION

1.0 Introduction

This chapter contains the background, problem statement, objective and scope of research. Background of bone, orthopedic, drill and parameter will briefly describe in the background section. Problem encountered before the study, objective and scope of the study will stated in this chapter.

1.1 Background

Most of the research involving drilling are carried out in the engineering area. However, drilling process is also utilize in the medical practice. The priority of the research in medical area emphasis on drilling of bone especially in dentistry practice. Besides, there are also a number of orthopedic and traumatology practice that concern in drilling are present. Bone drilling is nothing new in medical area. Back in the past, bone drilling was also present since ancient Egyptian, Greek and Roman medicine. There is sign of surgically pierced hole in the skulls of the human bone. Further development in medicine area results in great demands for research on bone drilling to assist in orthopedics and dentistry fields.

Modern application of bone drilling for traumatology and orthopedic is believed to begin around late 1840s. The management of fracture using screws were first introduced by French surgeons, (Cucuel and Rigaud, 1850). Not so long after, Hansmann in his report make an attempt of a new method to fix a rather complicated

fractures by using a malleable plate which is attached to each fragment by special screws as external fixation with screws and plates (Hansmann, 1886).

Bone is an organ which is form by grouping of tissue into distinct structure to serve a common function. Majority of the skeleton on most vertebrates are composed of the bone. Bone fracture is a medical condition where there is discontinuity in the bone structure due to a break. Healing process of fractured bones start naturally when the injured bone produce a new bone forming cells and blood vessel. The recovery of the fractured bone also can be done through bone fracture treatment. Treatment for bone fracture normally includes restoring the parts where the fracture occurs into its initial position and temporarily immobilize them until the healing process occurs.

The study in bone drilling is very important in orthopedic surgical and biomechanical engineering. In orthopedic surgery, fixation of fractured bone by means of implants and screws are done through drilling. Thus, producing correct holes size at prescribed positions throughout the surgery is critical to minimize the mechanical and thermal damage to the injured bone during the process. This increase the demand to study on the whole bone drilling process related with orthopedic for further improvement of the process. These demand also resulted for further research in biomechanical engineering area of study which includes performance of drilling and mechanical strength of bone. Drill bit design and operating conditions influence the performance of drilling. Therefore, to optimize the performance of drilling, the parameter should be considered.

1.2 Problem Statement

Problems that are commonly encountered during orthopedic surgery is estimate the drilling depth required due to unknown position of drill bit and the variation in bone thickness. This could contribute to damage of the tissue around the drill area if the drill bit is over-travel and do not stop at the required position. Khan R et al (1997) found the excessive protrusion of guide wires into pelvis suffered during the treatment of femoral neck fractures. Drill hole size is also critical in manual drilling of bone because it contribute to the holding power of insertion screws. Holding power of screws rely

on bone strength and thickness. Wrong sizes could affect the bone and screw and brings to failure. This task requires high level of accuracy in order to achieve the specific hole size. The size of holes that need to be produced during the drilling must refer to the size of screws for effective insertion of fixation screw. This can be done with proper guidance during the drilling process. Proper insertion of screws for fracture fixation are intricate task which need to be highly accurate and a reliable skills. However, there is no distinct research related to penetration angle required for bone drilling process. In specific, the report in this thesis highlight on one of the parameters in bone drilling which is the penetration angle to assist the medical personnel in their task.

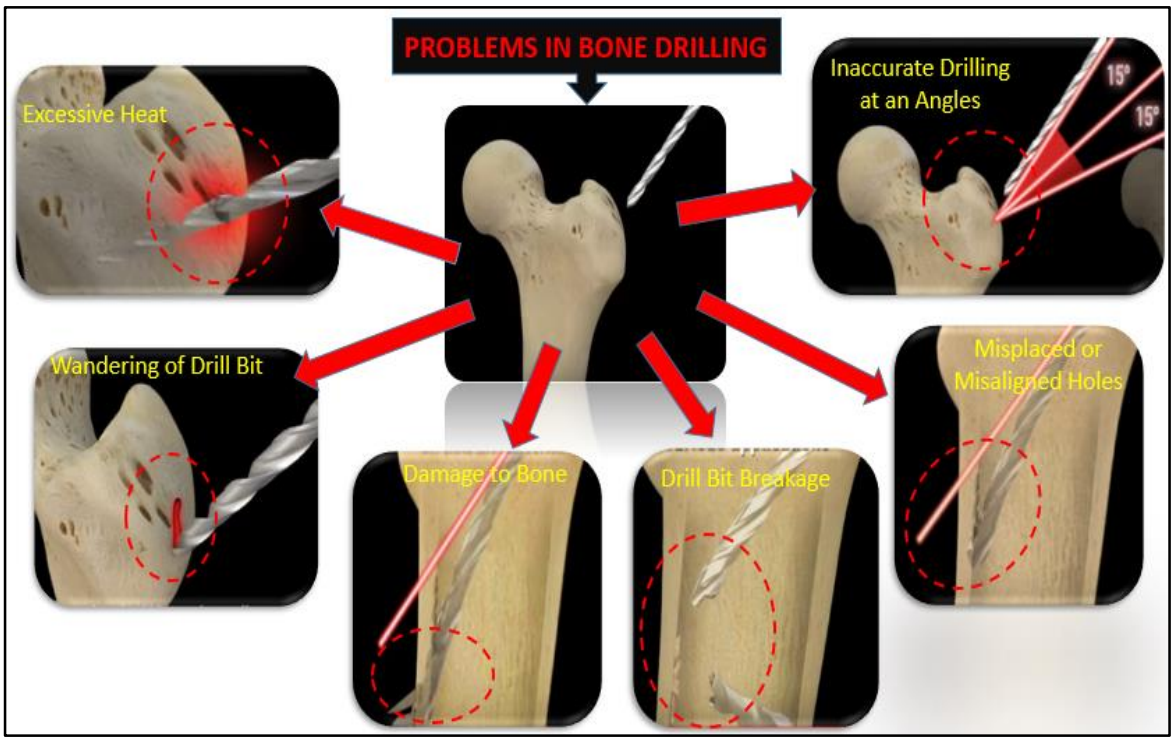

Figure 1.1: Problems Encounter during Drilling of Bone

The design of the drill bit plays effect the accuracy of the drilling while preventing the wandering of the tool bit during drilling process. Besides, the bone drilling process that required to be perform at an angles is a very challenging task in order to get a quality drilled holes. This holes must have no damage to avoid osteonecrosis. Moreover, inaccurate alignment of holes during drilling process of bones can affect implant process and further lead to breaking of the drill bit. This is due to high stress developed on the drill bit during drilling process. Meanwhile, inaccurate angle during