OPTIMIZING OF STUD CONFIGURATION ON SOCCER BOOT: A FINITE ELEMENT METHOD

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This thesis is submitted as partial fulfillment of the requirements for the award of the Bachelor of Mechanical Engineering (Hons.)

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JUNE, 2013

EXAMINER'S DECLARATION

I certify that the project entitles "Optimizing of Stud Configuration On Soccer Boot. A Finite Element Method" is written by Nurul Jasmie Binti Che Ahamed. I have examined the final copy of this project and in opinion; it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering. I herewith recommend that it be accepted in partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering

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Specially dedicated to

My beloved family and who those have guided and inspired me throughout my journey of learning

Che Ahamed bin Che omar

Rohani binti Ali

ACKNOWLEDGMENT

Alhamdulillah, the highest thanks to God because with His Willingness I can complete the final year project in time. I would like to express my gratitude to my dedicated supervisor, En. Zulkifli bin Ahmad @ Manap by guiding this project with clarity and that priceless gift of getting things done by sharing his valuable ideas as well as his knowledge.

My special thanks to staff in Mechanical Engineering Department, UMP, and members of Centre of Sport Engineering (CEnSE) who helped me in many ways, for their valuable comments, sharing their time and knowledge on this research project during the project was carried out. They have contributed towards my understanding and thoughts.

I acknowledge my sincere indebtedness and gratitude to my parents for their love, dream and sacrifice throughout my life. I am also grateful to family members for their sacrifice, patience, and understanding that were inevitable to make this work possible. I cannot find the appropriate words that could properly describe my appreciation for their devotion, support and faith in my ability to attain my goals. Special thanks should be given to all my friends. The great cooperation, kindheartedness and readiness to share worth experiences that have been shown by them will be always appreciated and treasured by me. Once again, thank you very much.

ABSTRACT

Soccer is one of the famous game in the world and has different boot design for related game. Many design of boot in market that has many functions for every boot. The objectives of this study are to investigate the different materials and designs of stud and to analyze the stud configuration. The materials of the stud between metal and rubber points in the bottom of soccer boot. Three types of football shoes have used to finish this project that are rounded, blade and combination of rounded and blade. The method uses during this research that experiment on force plate and simulation using ALGOR. This study focused on different material on the stud designs which are thermo polyurethane and metal. The design of the stud are rounded, blade and combination rounded and blade using Solidwork. The numbers of stud configuration are 12, 13, and 14. The design from Solidwork based on the already design in laboratory. The result value 977 N/m^2 showed the lower stress on the blade design with number of stud is 12. Based on the result, blade design is the higher stud traction due to the lower stress result than the other two design.

ABSTRAK

Bola sepak adalah salah satu permainan yang terkenal di dunia dan mempunyai reka bentuk but yang berbeza untuk permainan yang berkaitan. Reka bentuk banyak but di pasaran yang mempunyai pelbagai fungsi untuk setiap boot. Objektif kajian ini adalah untuk menyiasat bahan-bahan yang berbeza dan reka bentuk stud dan untuk menganalisis konfigurasi stud. Bahan-bahan stud antara logam dan mata getah di bahagian bawah but bola sepak. Tiga jenis kasut bola sepak telah digunakan untuk menyelesaikan projek ini yang bulat, bilah dan gabungan bulat dan bilah. Kaedah ini menggunakan dalam kajian ini bahawa percubaan pada plat kuasa dan simulasi menggunakan ALGOR. Kajian ini memberi tumpuan kepada bahan yang berbeza pada reka bentuk stud yang termo poliuretana dan logam. Reka bentuk stud yang bulat, bilah dan gabungan bulat dan bilah menggunakan Solidwork. Bilangan konfigurasi stud adalah 12, 13, dan 14. Reka bentuk dari Solidwork berdasarkan reka bentuk yang telah di makmal. Nilai hasil 977 N / m ^ 2 menunjukkan tekanan yang lebih rendah pada reka bentuk bilah dengan bilangan stud ialah 12. Berdasarkan keputusan ini, reka bentuk bilah adalah tarikan stud lebih tinggi disebabkan oleh hasil tekanan yang lebih rendah daripada dua reka bentuk yang lain.

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A	Cross Sectional Area
F	Force
P	Pressure
T	Time

LIST OF ABBREVIATIONS

3D	3 Dimensional
UMP	Universiti Malaysia Pahang

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The introduction of this thesis can be divided into four major parts. Each subsection will discuss the background of the project, problem statement, objective and scope of the project.

1.2 PROJECT BACKGROUND

Recently, football is a very popular game. Football is a tough, physical game requiring a wide range of attributes including explosive power, strength, agility, speed, and physical and mental toughness

The main characteristic of football boots is that they have studs on their soles for the purpose of improving their hold on the ground, usually natural turf. In soccer boots, studs are the elements responsible to traction on the natural turf or artificial turf. Nearly almost all boots in the market has similar soft ground stud configurations and for different design it will have different functions.

Different surface condition will determine the number, type and configuration of the studs on the sole of the boot. Typically, softer, wetter surfaces will require boots with fewer, longer studs, while firmer surfaces need a greater number of small studs.

Nowadays, the design of stud on conical cleats may be either rounded or bladed. Certain rounded design can be removed or screwed in stud with a specially designed wrench, while other conical stud are rounded to the base of boot and cannot be removed. Most studs are made up from hard plastic. Metal studs are also available but are sometimes prohibited in recreational sport due to the possibility of injury on the player.

1.3 PROBLEM STATEMENT

The football players are different in size that means the every single player is different in terms of weight and height. Those differences cause the players to have different stability and force in the performance on the plantar pressure also on the turf.

In the market there are many designs of soccer boot which have the functional benefit of the design. When the players perform, they will find the most suitable shoes or boots to make them comfortable and also for the purpose of preventing injury. The injuries that happened on player during running, braking and direction changes during performing are mostly related to the design of stud itself.

The different design of stud configuration can affect the performance of players. Stud configuration determines whether the players are comfortable or not during performing in running, walking, braking or changing the direction. When the players selected the wrong boot, it will cause injury on the players. The movements of players on the field are highly depending on the stud configuration.

1.4 OBJECTIVE

The aim of this study is to optimize the stud configuration on soccer boot by using finite element method. The specific objectives of this study are as follows:

i. To identify the different materials and designs of the stud.
ii. To analyze the stud configuration with different number of stud.

1.5 SCOPE OF PROJECT

The scope of this project can be narrowed down into three points. They are as follows:

i. The different of material on the stud design which are thermo polyurethane and aluminium alloy.
ii. The design of the stud is rounded, blades and combination rounded and blades.
iii. The numbers of stud configuration are 12, 13, and 14.

1.6 ORGANIZATION PART

Chapter 1 of this thesis is about the background of the project that is soccer boot and also the different designs of soccer boot available in the market. This chapter also includes the problem statement which is caused by stud configuration and the objective of this study which is to optimize the stud configuration on soccer boot using different design of soccer boot and different movement. The scopes of this project are to study on different material, design of stud and different number of stud configuration with different movement of the players.

Chapter 2 presents the literature reviews which focus on the recent studies or research by authors related to stud configuration of the soccer boot. The formation about the materials that always used in fabricates the stud on soccer boot. The literature review can be approximately close to the titles of the project also. From this chapter, the author will get more knowledge about the results of the previous researches and can predict the result of the project.

Chapter 3 is the overview the preparation of the title project that can run with simulation and experiment. This chapter can overview of software application to simulate the force of the footwear in gait is presented .Three soccer boots that already selected with different stud configuration can use in an experiment and simulation by the drawing in Solidwork. This project has one experiment that is experimenting on a force plate. After getting the data from the experiment on force plate, the simulation can run using the ALGOR software.

Chapter 4 focuses on the outcomes of the research and discussion. High speed camera is used to detect the movement of the player when different designs of soccer boot are used. The result need to compare for the experiment and simulation. This project is on making comparison on stud configuration between different brands and function by using finite element method. The configurations are related to the stability of player. Develop finite-element model will be validated with experimental data. The model was developed to understand the better design of stud that will use to the players.

Chapter 5 focuses on the conclusions of the project and recommendations for future work. This chapter also will summarize both the results from experiment and simulation. The result must be validated between experiment and simulation. The conclusion of this chapter when objectives of the project that can achieve.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The literature review of this thesis is divided into five parts. The first part of the literature reviews is on the introduction to material of stud configuration. It also includes the type of material that usually use in stud or cleat. The second part of the literature review give the different design of soccer boot stud that are rounded, bladed, and the combination of rounded and bladed. This part can explain detail the function or application of their design. The third part discuss about the movement in playing football and the reaction between shoe outsole and the surface of the turf. Then the fourth part can discuss about force plate use as an equipment to run this project. The last part will discuss about the Algor Software. The sources of the review are extracted from journals, articles, reference books and also internet.

2.2 MATERIALS OF STUD CONFIGURATION

Three different designs of soccer boot available in the laboratory are used in completing this study. The studs of two of the three designs are made up of rubber type and the other one is made up of aluminum. Different materials of stud will affect the soles grip on the field's surface. For synthetic field, in order to get a good grip, the surface must use the blades of hard plastic hard stud. Good surface condition will offers the optimum adhesion in translation and most probably the lowest in rotation (Vachon et al 2002). According (Grund and Senner, 2010) the test must include the material that usually interacts the force between athlete and surface but the design of apparatus as laboratory device is the best method for testing the football shoes.

2.2.1 Rubber Stud

The rubber is the main material used in the outsole of soccer boot. Thermo polyurethane is one of the rubbers that are used in the design of rounded and bladed. This is a softer material that can offer a greater degree of comfort to the user. It is named as bladed because they look like knife blades that are attached to the sole of the shoe in a circular pattern. This type can suit in firmer condition or surface. On these surfaces, the heels face greater impact with the surface. So, the studs will be slightly longer on the hill than the front area of foot and around the toes.

Figure 2.1: Rubber blade design

Source: (http://www.google.com.my/search?q=rubber+stud+design)

2.2.2 Steel Stud

The steel stud is a minor material for football boot studs and is nearly always removable or screw in stud so that different length can be utilized depending on the surface of the pitch. It is required on soft ground as their grip is deeper. On soft ground, the user will not feel the effect of the reduced comfort found in steel stud.

Figure 2.2: Steel rounded design

Source: (http://www.google.com.my/search?q=steel+stud+design)

2.3 DESIGN OF SOCCER STUD

There are three different designs of soccer boot which are rounded, bladed, and the combination of rounded and bladed. Every design has different functions so that the players can choose the most suitable design depending on the surface condition. The most specialized piece of equipment for football is the boots that players will wear during playing and training. This is also likely to be the largest single expense for player’s so it is important that the players get a pair of boots they will be comfortable wearing for long periods of time and which are versatile enough to adapt to the many different surfaces they will play on throughout a season.

Design of stud plays an important role in games for traction and penetration of the surface. It also to grip the football boots that enhance the performance of the activities, and especially during acceleration (sprints), brake and change direction. The types of studs are the most important elements and also to avoid the injury occurred (Gonzalez et al 2008). The normal load on studded boot can generate the traction and the interaction between shoe surface interfaces. Increasing the number of studs give effects on the decreased in the performance of the subject.

2.3.1 Rounded design

Football boots with rounded studs are usually best used on dry pitches. They tend to have more studs than other football boots and provide better support over a wider area, also reducing blisters. This is because the larger number of studs distributes the pressure more evenly on your foot. If feet are suffering on hard pitches with blisters, then rounded studs or using shorter screw-in studs that are designed for harder pitches is preferable.

Figure 2.3: Rounded design

Source: (http://www.google.com.my/search?q=blade+stud+design)

2.3.2 Bladed design

Football boots with a bladed soleplate are most frequently used on surfaces which are somewhere between soft and hard, although some bladed football boots now have interchangeable blades to better suit the surface. The blades are designed to make turning easier. Studies done on two different types of fields shows that their complex geometry of blades stud has good penetrating properties (low cross sectional areas) than that round stud but its perpendicular to the shoe sole under normal impact. The design of the blade is believed to precipitate more injuries and its react like a knife in contact situation (Bently et al 2011).

Figure 2.4: Blade design

Source: (http://www.google.com.my/search?q=blade+stud+design)

2.3.3 Combination of rounded and bladed design

Most popular with the amateur, the screw-in studded boot can be interchanged depends on the surface conditions. For example, in wet conditions with very soft ground, long stud is required whereas in dry conditions, a shorter stud is used. Usually, the positions that use the combination is shooter long range. These easy to grip the surface when shooting the ball.

Figure 2.5: Combination of rounded and blade

Source: (http://www.google.com.my/search?q=combination+stud+design)

2.4 FINITE ELEMENT ANALYSIS

Finite element analysis (FEA) consists of computer model of a material or design that is stressed and analyzed for specific results. It is used in new product design, and existing product refinement. In other words, FEA is a numerical method to find out an approximate solution for variables in a problem which is difficult to obtain analytically.

The concept of the finite element analysis is solving a continuum by a discrete model. It is done by dividing the problem into several small elements. Each element is in simple geometry and this is easier to be analyzed than the actual problem or the real structure. Each element is then applied to known physical laws.

The aeronautics, automotive, defense, and nuclear industries had started using the finite element application since early 70's. However, this is limited to expensive mainframe computer. Zienkiewicz and Cheung was the important person in developing the finite element technology at that time. But later, Hinton and Crisfield carried out the finite element into modeling and solution of nonlinear problems (Reddy, 1993).

With the development of the CAE technology, engineering drawing can be produced. Besides, the analysis can be carried out and also the Finite element modeling can be done. The finite element becomes more and more important today which can simplify and solves various types of engineering problems.

2.4.1 Finite Element Analysis

FEA uses a complex system of points called nodes which make a grid called a mesh. This mesh is programmed to contain the material and structural properties which define how the structure will react to certain loading conditions. Nodes are assigned at a certain density throughout the material depending on the anticipated stress levels of a particular area. Which regions will receive large amounts of stress usually have a higher node density than those which experience little or no stress. Points of interest may consist of: fracture point of previously tested material, fillets, corners, complex detail, and high stress areas. The mesh acts like a spider web in that from each node, there extends a mesh element to each of the adjacent nodes. This web of vectors is what carries the material properties of the object, creating many elements (Peter Widas, 1997).

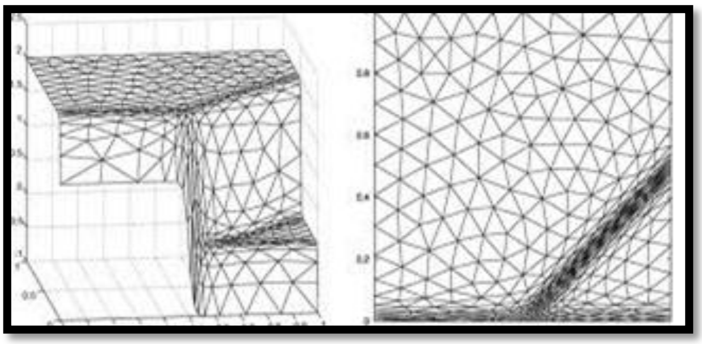

Figure 2.6: Mesh diagram in 3D model

Source: (http://www.google.com.my/search?q=meshing+design)

The powerful design tool has significantly improved both the standard of engineering designs and the methodology of the design process in many industrial applications. The FES has substantially decreased the time to take products from concept to the production line. It is primarily through improved initial increased accuracy, enhanced design and better insight into critical design parameters, fewer hardware prototypes, a faster and less expensive design cycle, increased productivity (Peter Widas, 1997).

2.4.2 Meshing

The significant requirement of the FEA is the need to split the solution domain (model geometry) into simply shaped subdomains called 'finite elements'. This is a discretization process commonly called meshing and element are called finite because of their finite, rather than infinitesimally small size having infinite numbers of degree of freedom. Thus the continuous model with an infinite number of degrees of freedom (DOF) is approximately by a discretized FE model with a finite DOF. This allows the reasonably simple polynomial functions to be used to approximate the field variables in each element. Meshing the model geometry also discretized the original continuous.

2.5 BENEFIT OF PARAMETRIC DESIGN ANALYSIS

Parametric analysis is excellent to get accurate information about the influence of all parameters on the design objectives, such as system performance with respect to stress, loading, deflection of the structure and other variables. With this information, the design team can make informed decisions throughout product development. In addition, the design teams also can respond quickly to any modification due to external constraints for example, manufacturing (Thieffry, 2008).

2.6 TYPE OF GROUND

2.6.1 Field Turf

Field turf is one of the newer artificial turf surfaces which are made to mimic natural grass. According to "USA Today," as of 2008, field turf was dominating the turf market with over 1,900 football fields using the product. Field turf is made with polyethylene blades that range up to 3/4 of an inch and a mix of crushed tires, or crumb rubber, to soften the surface. According to "USA Today," underneath the field, field turfs use a base of crushed stone and drainage pipes.

The field turf surface and matching cleat pattern are for firm ground. This will cover any type of field that is mostly dry, in any kind of climate where it rains less than 150 days of the year. There are two different types of firm ground cleats, rounded studs, and long narrow bladed studs. Rounded studs are better for damp ground, and blades are better for dryer surfaces and overall stability.

Figure 2.7: Field turf

Source: (http://www.livestrong.com/article/403387-types-of-football-turf)

2.6.2 Soft Ground

Soft ground cleats are usually metal, rounded cleats with few points of contact with the ground. These cleats are ideal for wet surfaces and climate where it rains a lot. They’re very popular in England, and all of Northern Europe, and are also well suited to the areas around Seattle, Portland, and anywhere else along the Northwest coast of North America. These cleats are designed to cut through the sludge and give you the grip under wet conditions, and they work really well. But, the reason they are banned is because of the damage a metal cleat can do a players leg, especially during a reckless challenge.

2.6.3 Indoor Court

These shoes are designed for the smaller soccer game. Futsal is played on a material similar to a basketball court. They have a flat bottom, with fins or flex point running across the bottom of the shoe, and tend to be very flexible and comfortable. For better performance wear them as sneakers. They are ideal for anything indoor and work alright on firm ground surfaces, but are not recommended for it.

Figure 2.8: Artificial turf for indoor game

Source: (http://www.livestrong.com/article/403387-types-of-football-turf)

2.6.4 Sprint Turf

Sprint Turf is artificial turf that is manufactured from Pennsylvania that makes a variety of artificial surfaces. According to the company, the Sprint Turf offers five kinds of synthetic blade systems and six options for infilling the field such as rubber or sand. The company advertises its fields are being used by numerous high school and college football teams from across the country.

2.7 DIFFERENT MOVEMENT

In the game of football there are several main movements and runoff. Beside that in this project have three types of runs that are straight run, slalom run and turning run. Run in a straight football game means players ran straight to move forward if the ball or catch the ball. Players usually divided front often do run. The aims are improving performance during displacement and particularly during acceleration, braking and change the direction during performance from the effect of stud (Brizuela et al 1998). The effect of different configuration on performance, stability, plantar pressure distribution and comfort during football practice (Brizuela et al 1998).

Although the difference of performance also found in the similar number of stud but depending on their distribution for external front studs showing higher forces and the move during the movement studied. Forces in the rear studs are very low on the heel contacts in a zigzag (Gonzalez et al 2008)

Grip rotation is important and is often associated with reducing injuries from improving performance. Excessive traction may be one factor contributing to the cause of anterior cruciate ligament (ACL) injury during turning movements. Rotational traction is that rotation is placed near the center of the middle forefoot that allows configuration stud be oriented to reduce rolling resistance of the front foot rotates about the center point, but did not provide any evaluation stud configuration rotating about different locus (Driscoll, Kirk et al. 2012). Major risk factor for non-contact injuries of the anterior cruciate ligament when get the excessive rotational traction (Grund and Senner, at al 2010)

2.8 FORCE PLATE

Force plate one of the measurements that used to measure the force involved in motion or movement that usually used in biomechanics lab. The main function or purpose is to show how the force plate works to instruct and demonstrate the relationship between force, acceleration, velocity and displacement. The additional also used for showing the condition when walking, running, and jumping also provide application and illustration.

Additionally, the force wave form can be verified and measured indirectly to show either qualitative or quantitative relationships between force, acceleration, and displacement. Bently said after the combination of measuring, seeing, and feeling the forces involved must strengthen the connection between the experienced world and the world measured by instruments.

A force plate is simply a metal plate with one or more sensors attached to give an electrical output proportional to the force on the plate. The sensor can either be a strain gauge or a piezoelectric element. At frequencies less than about 100 Hz, the output of a force plate is accurately proportional to the applied force and can be monitored on a storage oscilloscope or fed to a data acquisition system for display and further analysis. Force plates are generally not suited for studying impacts of duration less than a few m/s, since most plates are large and flexible and vibrate at a frequency of about 400 Hz. These vibrations are normally of no consequence in biomechanics applications since they are strongly damped if foot contact is maintained for several m/s or more.

The cost to build the instrumented force plate in the biomechanics lab is at least $30 000 (Rod Cross et al 1998). The instrument consists of two parallel aluminum plates, one in each corner. The other four elements were connected in parallel by direct contact with the upper and lower plate.

Figure 2.9: Force plate

2.9 ALGOR SOFTWARE

ALGOR Simulation is a general purpose finite element analysis. This is provided as a mechanical simulation tools to help designer and engineers make a simulation to find the critical solution in the design process. It is distributed in a number of different core packages to cater to specific applications, such as mechanical event simulation and computational fluid dynamics**.** The typical uses of ALGOR’s consist of mechanical contact, bending, thermal (conduction, convection, and radiation), fluid dynamics, and coupled or uncoupled multi physics. The ALGOR's library of material models contains metals and alloys, plastics, glass, foams, fabrics, elastomers, Concrete (with rebar), soils and User-defined materials. The ALGOR's element library depends on the geometry and the type of analysis performed.

2.10 INJURY

Playing football is the one main factor that caused the injury when performance. The player very phobia in this case because it is can affect their career or income. Most of the players can get the experience in real injury and take time to really heal. In this case, the soccer boot plays an important role to avoid injury.

The one of the injured in football game that anterior cruciate ligament (ACL). The Major risk factor for non-contact injuries of the anterior cruciate ligament (ACL) when get the excessive rotational traction (Grund and Senner, et al 2010). According to Shorten, while excessive rotational traction can cause foot fixation that severe the knee injuries. The normal load on studded boot can generate the traction. The other factors when the player changing their direction rapidly or stopping suddenly. This case is when the foot not ready to stop and caused the ligament injured. Other cause when the player landing from jumping incorrectly that always happens when the players head the ball.

The boot selected must consider all factors that caused the injury. The soccer boot that appear to change their predictable frequency has more to do with looks than a players functional needs to preventing injury. Poor boot selection can predispose a player to unnecessary long-term injury. The selection of boot just not based on the design, brand or sponsorship, but rather on proper fit, the performance enhancement and injury prevention. The English professional and league football have 86% of all injuries were on the leg and 59% were from non-contact mechanism (Bently and Ramanathan, et al 2011)

The surface also might be taken noted because that is one of the factors the injury. The selection of surface is related to the suitable soccer boot in used. These factors make an interaction between the surface and boot in other traction. The composition and arrangement of the outsole and stayed that influencing the grip on surfaces. When the weather changes like raining, the selection of boot design must change to protect their players. Often, the design of stud used in above condition like rounded with material build is steel. This more appropriate than other design.

2.11 STABILITY WHEN PERFORMANCE

Every football player has different physical size and weight. This might affect the performance of the player in stability or reaction. Stud configuration is the one factor that influence of the stability of the player. The design of the stud must consider the criteria of the player that are size of foot, weight and the position in playing game.

When the player running, sprinting, tackling, kicking and goal keeping movement, the function of the boot automatically changes. These, the normal load also changes with the different pattern loading condition (Grund et al 2010). The performance of the players and the aspect such as lateral stability of the foot and comfort could be affected by the both of the number and the distribution of the stud on the sole (Gabriel et al 1998).

The distribution of forefoot loading was significantly different on the turf with the magnitude of loading being lower compared to the treadmill. The pressure distribution was mainly related to individual foot and landing characteristics and the surface, but no relation was found with both conditions (Coyles et al 1999).

2.11 PREVIOUS STUDY ABOUT STUD CONFIGURATION ON SOCCER BOOT

2.11.1 Traction behavior of soccer shoe stud design under different game-relevant loading conditions

Major risk factor for non-contact injuries of the anterior cruciate ligament when get the excessive rotational traction. According to Shorten, while excessive rotational traction can cause foot fixation that severe the knee injuries. The purpose of study to know the interaction between shoe surface interface and certain outsoles are dangerous or not for athlete. The normal load on studded boot can generate the traction. As Nigg state that include appropriate test will lead the correct result and avoid error conclusion such as testing with suitable material for surface and shoes. The test apparatus design more important than the material testing by Grund. The purpose is to investigate the shoe interaction under different game relevant loading condition using a newly developed test device.

2.11.2 Effect of studs on performance and injury prevention

This journal is on the effect of stud on performance and injury prevention also to improve their hole on the ground usually natural turf. The aims is on improving performance during displacement and particularly during acceleration, braking and change the direction. The objectives are to study the effect of different configuration on performance, stability, plantar pressure distribution and comfort during football practice. The first to study on obstacle-course running by means the circuit was delimited of cones and line. The subject of each prototype must complete the circuit as fast as possible. To study the stability of movement which place on prototype boot by choose the similar force change of direction to avoid adversary during game. Third is to study the plantar pressure distribution when the all prototype subject test of running on natural grass including the right foot boot an insole instrument with 64 piezoelectric sensors with sampling frequent of 100 Hz. Lastly to study the comfort provide by each prototype by filled the questionnaire include the general opinion of the prototype. This concludes that when the number of stud increase, the performance of the player decrease automatically.

2.11.3 Forefoot plantar pressure distribution inside the soccer boot during running

Study that distribution on loading under the boot cleated footwear. The plantar measured were recorded during treadmill and over ground running in subject wearing soccer boot with different cleat configuration. The review of this study to determine whether localized in-shoe pressure differences could be identified in different commercially available soccer boot outsole designs, taking into consideration individual foot structure. The distribution of forefoot loading was significantly different on the turf with the magnitude of loading being lower compared to the treadmill. The pressure distribution was mainly related to individual foot and landing characteristics and the surface, but no relation was found with boot conditions. This may be explained by some similarity in number (11 to 13) and location of the cleats on the outsoles. For the boots examined, the combined influence of both sufficient cleat number and sufficient outsole plate stiffness may have been adequate to distribute the pressure across the forefoot.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This study focused on experiment and simulation. The experiment that conducts on a force plate while the simulation using the Algor Software. The methodology flow chart of this study is summarized in Figure 3.1.

A second experiment using the force plate that is measuring instruments that measure the ground reaction forces generated when a body standing on or moving across them with running, stepping or jumping. The simulation using Algor software and Ansys software can run after finish the drawing of different three designs of soccer stud. Also the simulation can run after the experiment done.

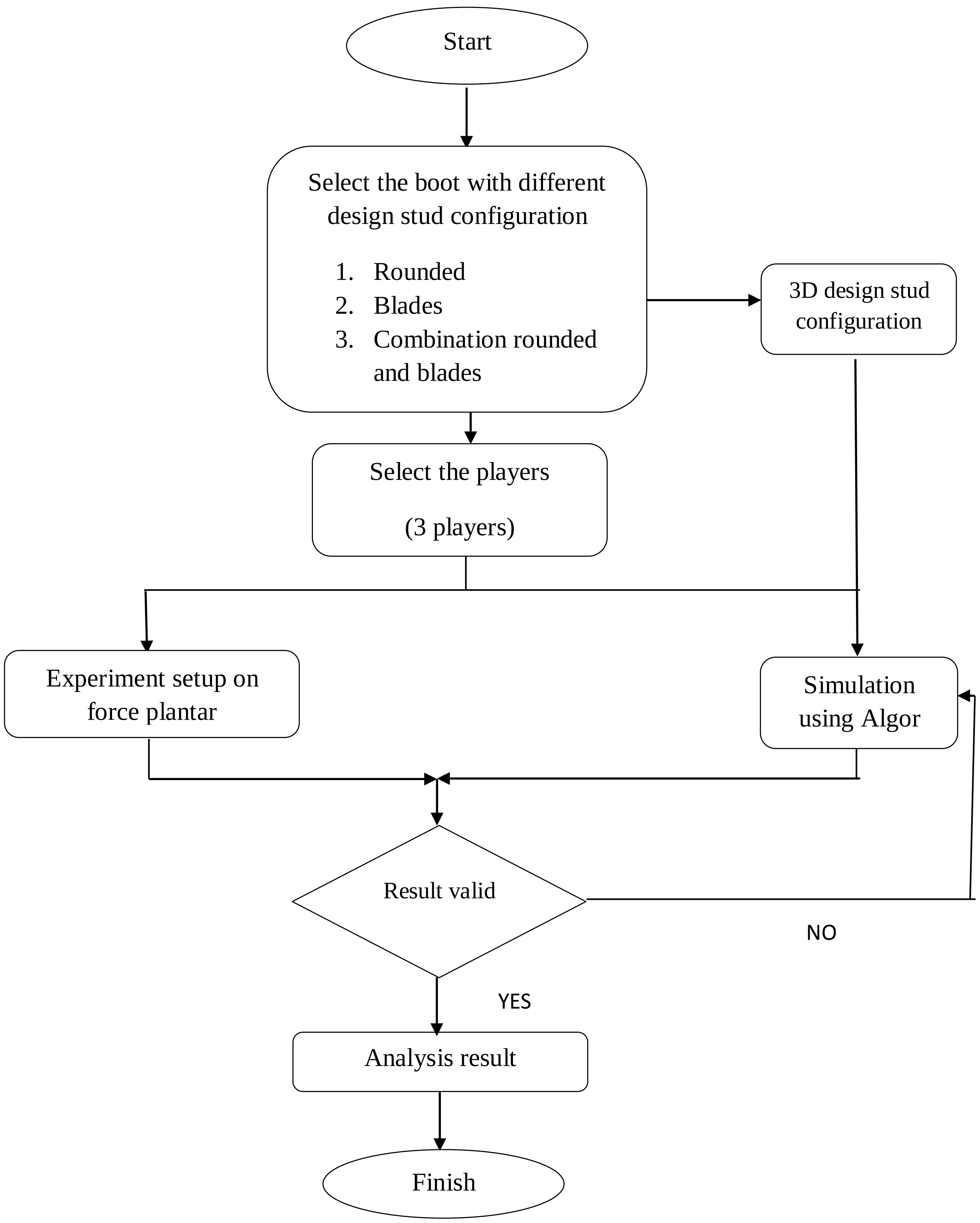

Figure 3.1: An overview methodology for this study

3.2 FLOW CHART DESCRIPTION

The flow chart above describes the overall flow of process in step by step. Each step in the flowchart will be discussed briefly in the upcoming sub-topic. The flowchart very important to show the method that has done to finish the project.

3.2.1 Collecting Information

Three designs of soccer boot that already selected with different design of stud configuration. The first designs of soccer boot with rounded stud from Nike brand. The second designs are bladed stud also from Nike brand. The third design with combination of rounded and blade of Adidas Brand. Three of them with different designs of stud and also the material used to fabricate the stud.

3.2.2 Design Preparation

The design that has been done by drawing the three designs of stud configuration using Solidwork. The design is rounded, blade, and combination. The different numbers of stud that are studied are 12, 13, and 14. The drawing based on the design of soccer shoes that already in the laboratory. The drawing of the design used when to run the simulation using ALGOR software. The dimension all design must be same with original dimension because of that to get the results validate with experiment. The simulation is the main target of the project title.

3.2.3 Experiment Preparation

This project has experimented on force plate that can measure the force on the outsole of the foot. The purpose of experiments carried out to compare the simulation result with the experimental result to get the exact result. The equipment that used in this experiment is a high speed camera and to take the picture of the movement. The force plate is already set up on laboratory.

3.2.4 Simulation

After running the experiment and get results on the force plate, the value force plate that without shoes used to run the simulation. Firstly the design of the stud must be mesh before insert the material properties and the ideal force. The design must be separated into three parts and imposed their force based on force plate data. The simulation will be run after the finish insert the data. The time taken to simulate the simulation based on the node of the design. A very complex part needs longer time to finish the simulation.

3.2.5 Analysis Result

The experimental data and simulation data was analyzed by comparing which one the soccer boot can perform better. The design will propose to use when the tournament. The best result will show where the soccer boot can prevent the injury of the players. From the simulation result, that find the point of the stud has higher stress. The conclusion is that the boot can give more traction on the surface.

3.3 DESIGN PREPARATION

Often many design of soccer boot in market based on ability of buyer. The design of soccer boot also based on function and position of the player. Material of stud is very important point to improve the performance of the player and prevent injuries. The three design of soccer boot just redesign back of stud based on the soccer boot that already have in lab.

3.3.1 Rounded design

The design is using Solid word and the numbers of stud is thirteen. The dimension and position of the stud based on the original shoes. The dimension takes using the automatic vernier caliper. From the dimension and picture try to draw the assembly of stud first. After that, draw the outsole of the shoe using the arc. After finish all, make the assembly of the designs.

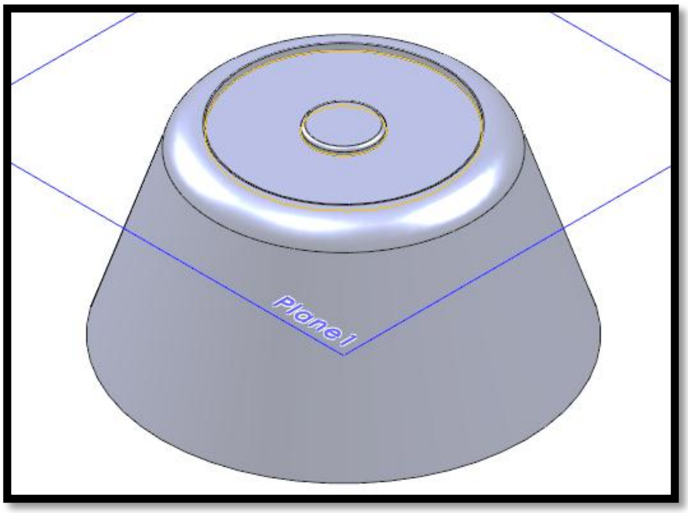

Figure 3.2: Rounded part

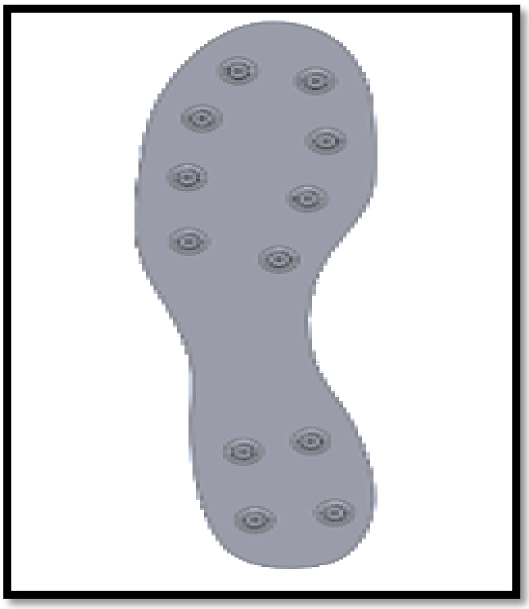

Figure 3.3: Rounded design

3.3.2 Blade design

The design is using Solidwork and the numbers of stud is fourteen. The dimension and position of the stud based on the original shoes. The dimension takes using the automatic vernier caliper. From the dimension and picture try to draw the assembly of stud first. After that, draw the outsole of the shoe using the arc. After finish all, make the assembly two of the designs.

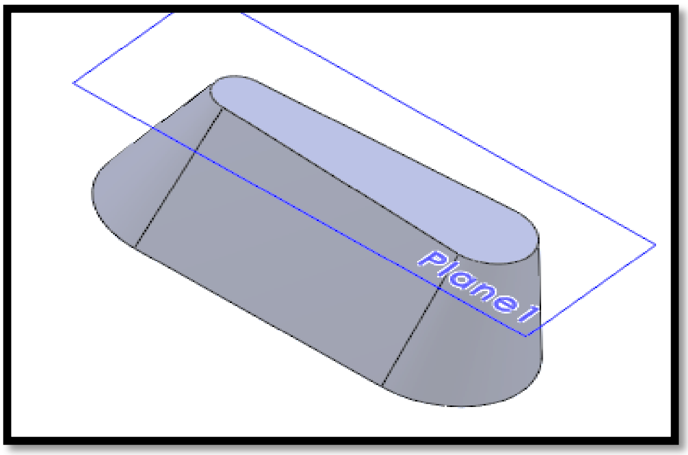

Figure 3.4: Blade part

Figure 3.5: Blade Design

3.3.3 Combination of rounded and bladed

The design is using Solid word and the numbers of stud is twelve. The dimension and position of the stud based on the original shoes. The dimension takes using the automatic vernier caliper. From the dimension and picture try to draw the assembly of stud first. These designs have a combination of three designs of the stud. After that, draw the outsole of the shoe using the arc. After finish all, make the assembly of all of the designs (Figure 3.7).

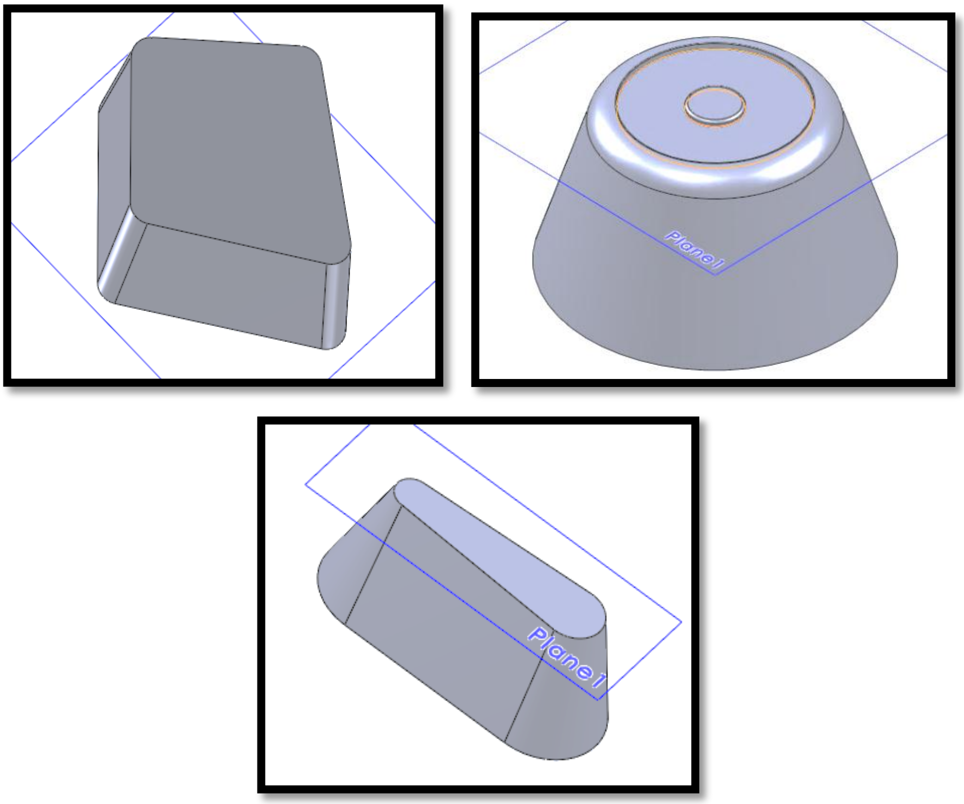

Figure 3.6: Rounded and blade part

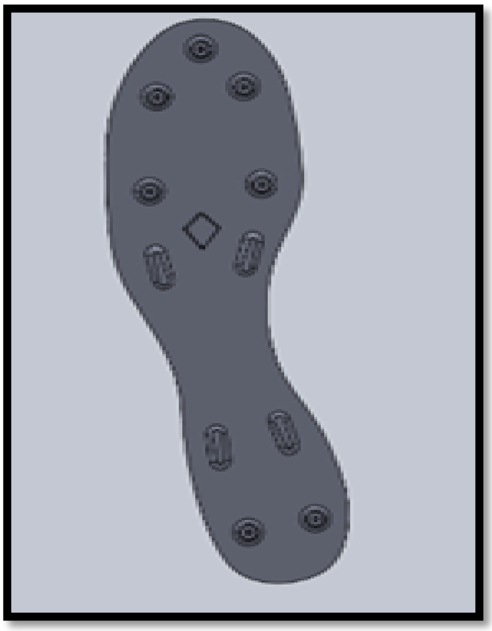

Figure 3.7: Combination of Rounded and Blades

3.4 PREPARATION BEFORE EKSPERIMENT

One experiment is cancelled on natural turf because the cause is not enough space to experiment in natural turf, artificial turf is decided to be used to place\ on a force plate. Purchasing grass is really relevant to real turf on the football field.

The purpose to put the grass on a force plate is to make the real condition when running on a force plate. Because of that, the force that produces when the player running is relevant to the real game. When the players run on the force plate, the real force can be measured same place on the natural turf.

Before starting the experiment, a meeting with focus group is done to plan the experiment. This experiment involves the football player from Majlis Sukan Negeri Terengganu (MSNT). The purpose of this experiment to make an analysis or review that the design of stud always related to get injuries when performance.

Figure 3.8: Artificial turf

The football player from MSNT stayed one week at Ump to run our experiment that related to soccer like kicking technique and heading technique. The players can thoroughly briefing with the person in charge.

3.5 EXPERIMENTS ON FORCE PLATE

Three football players were selected from “Majlis Sukan Negeri Terengganu” (MSNT) to do the testing on force plantar. All players use the shoes with different design of stud configuration. A first design with blade, second design with rounded and third design with combination of blade and rounded. All football boot already in the biomechanical laboratory. The velocity of all players when running on the plantar is normal.

Three football players were used in this experiment that no specific for weight and age. All players use the shoes with different design of stud configuration. A first design with blade, second design with rounded and third design with combination of blade and rounded. All football boot already in the biomechanical laboratory.

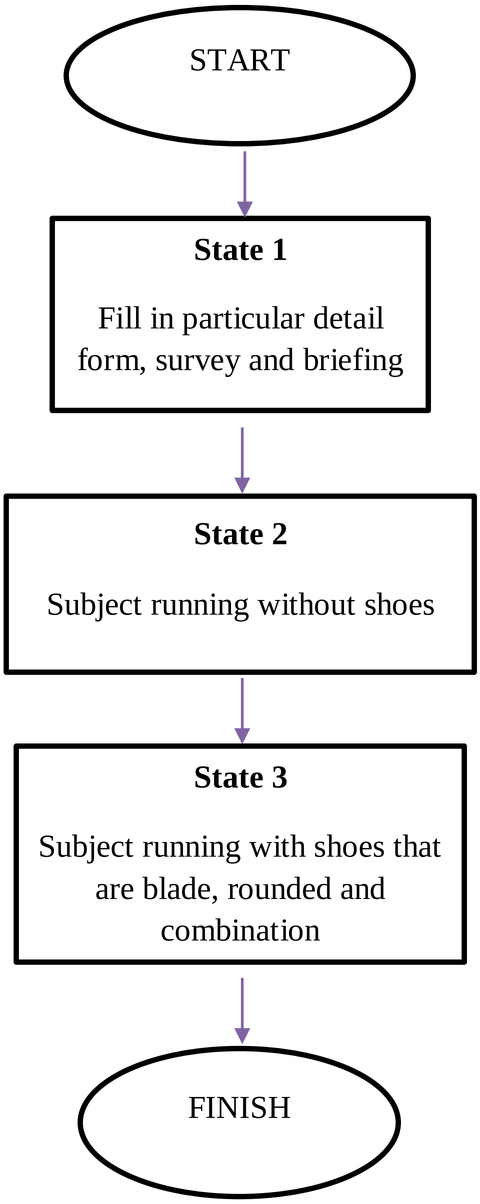

Figure 3.9: Flow chart of experiment

First design with blade that are designated to provide grip while also providing superior turning ability, but don't provide the same amount of stability that traditional round cleats do. Second design with rounded. They tend to have more studs than other football boots and provide better support over a wider area, also reducing blisters. This is because the larger number of studs distributes the pressure more evenly on your foot. The third design with combination of blades and rounded. This combination design that rounded locates in front and back of shoes and blade locates at the middle (Figure 3.17).

The force plantar already set up in a lab with camera to pick up the picture and measure the force when the player step on the two sides of force plantar. The term plantar forces refer to the forces occurring on the undersurface of the foot which includes shear forces but in the context of this report refers only to vertical forces. These forces are not constant and can vary greatly both in magnitude and distribution depending upon the actions of the subject and can total between zero and five times the weight of the human body. Even these defined sets of motions do not produce consistent plantar force distributions between subjects, as the posture and structure of the foot also affect these values.

The force can measure automatically on the measurement testing. When the result not valid, turn back to early experiment and get the new result. From the result we can analysis and conclude that which design the boot perform better or not. Also we can compare the result with another method to get the better soccer boot.

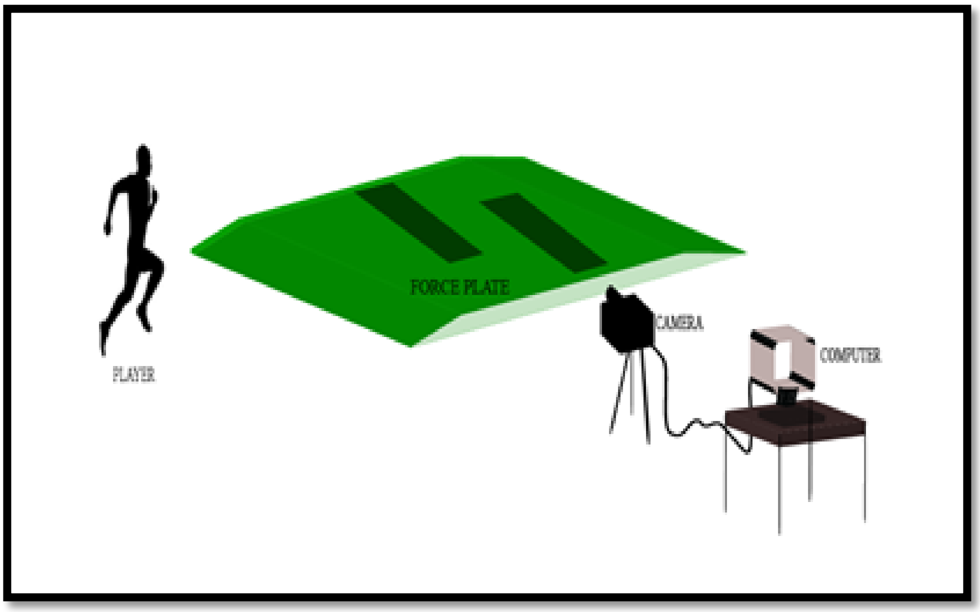

Figure 3.10: Experiment setup on force plate

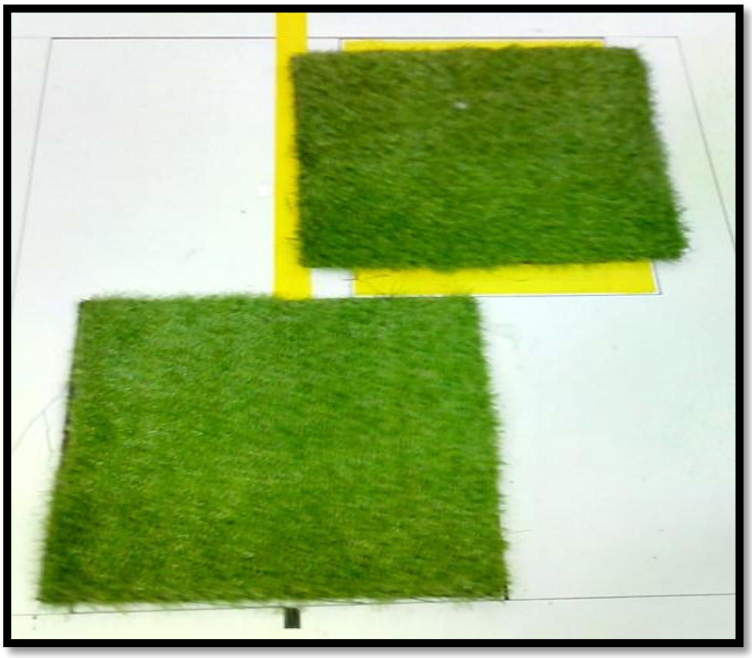

Figure 3.11: Platform on force plate

Figure 3.12: Subject from MNST

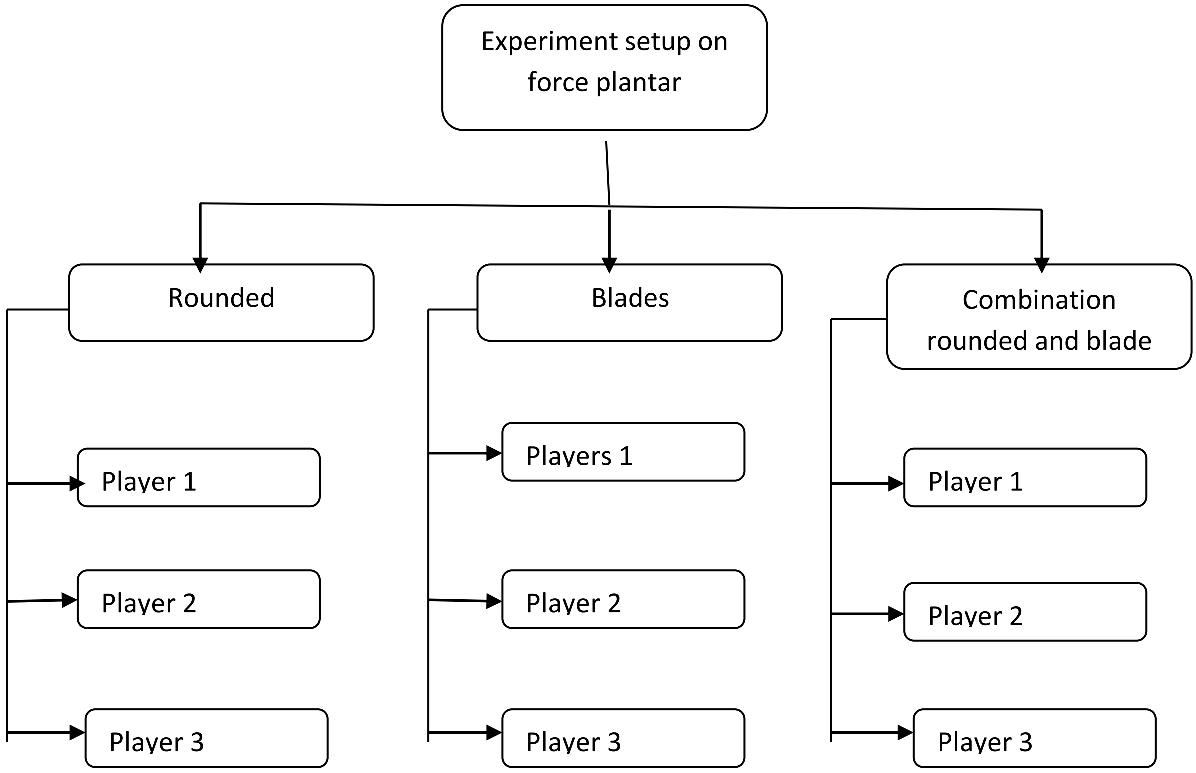

Figure 3.13: Flowchart of experiment setup on force plate

(a) (b) (c)

Figure 3.14: (a) Rounded design, (b) Blade design, (c) Combination of rounded and blade

3.6 SIMULATION USING ALGOR

Three designs of football shoes draw using Solid work. The dimension of the shoes must same with the example. After the drawing finish, the simulation can run using the suitable force that can fix after the experiment done.

The analysis in ALGOR uses static structure analysis because the limitation in ALGOR to using dynamic structure analysis. The drawing in Solid work must be separated into three parts (Figure 3.19). The drawing format must change in IGES before add in ALGOR. Then insert the material properties based on the already design in market. All parameter of the simulation must be select before apply the force.

The value of force obtains from the experiments are used to apply on the outsole of the boot in simulation. Different value of force can apply only on three parts that has been separated in Solid Work. The force can apply at the same time with different value on different part. After finish apply force, run the simulation and analysis the result.

In this report, the used of new simulation techniques is proposed as a viable alternative to the procedures currently used for footwear assessment. In particular, the Finite Element Method (FEM) used to simulate the contact between the foot and the shoe upper, and to predict the pressures exerted on these contact areas while running condition.

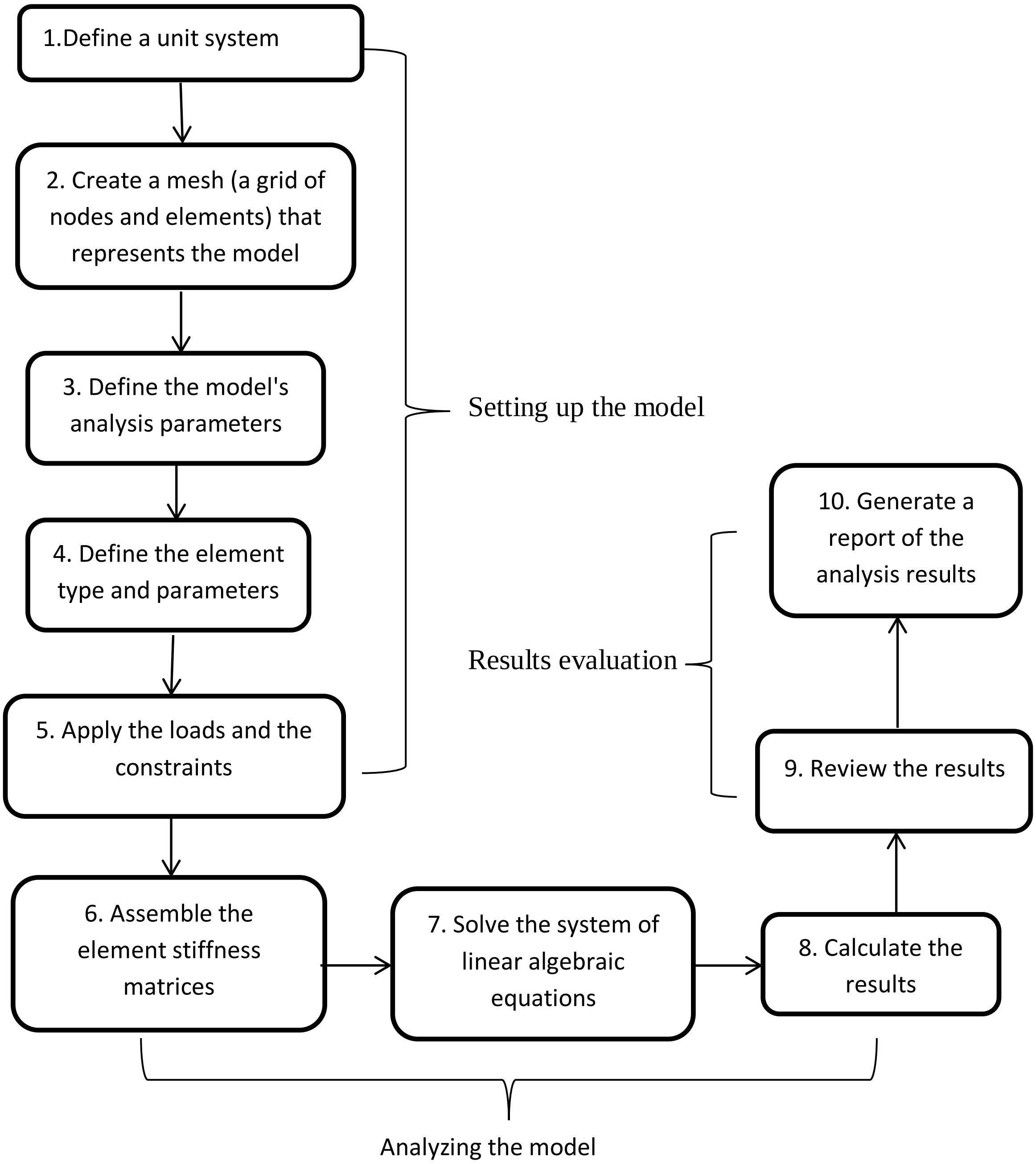

Figure 3.15: Step in Algor Simulation

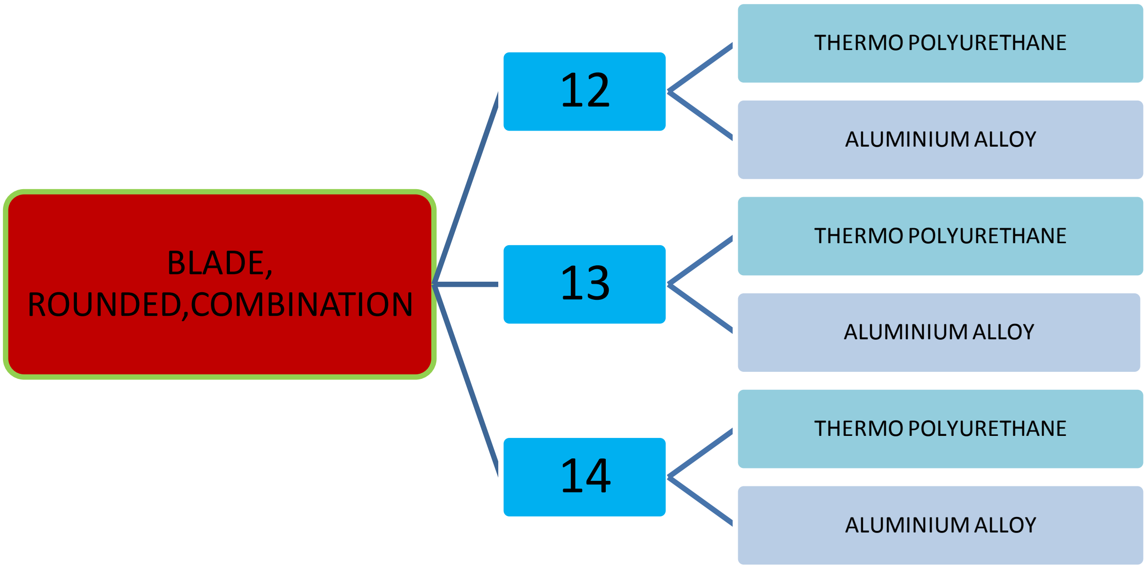

Figure 3.16: The flow chart of experiment

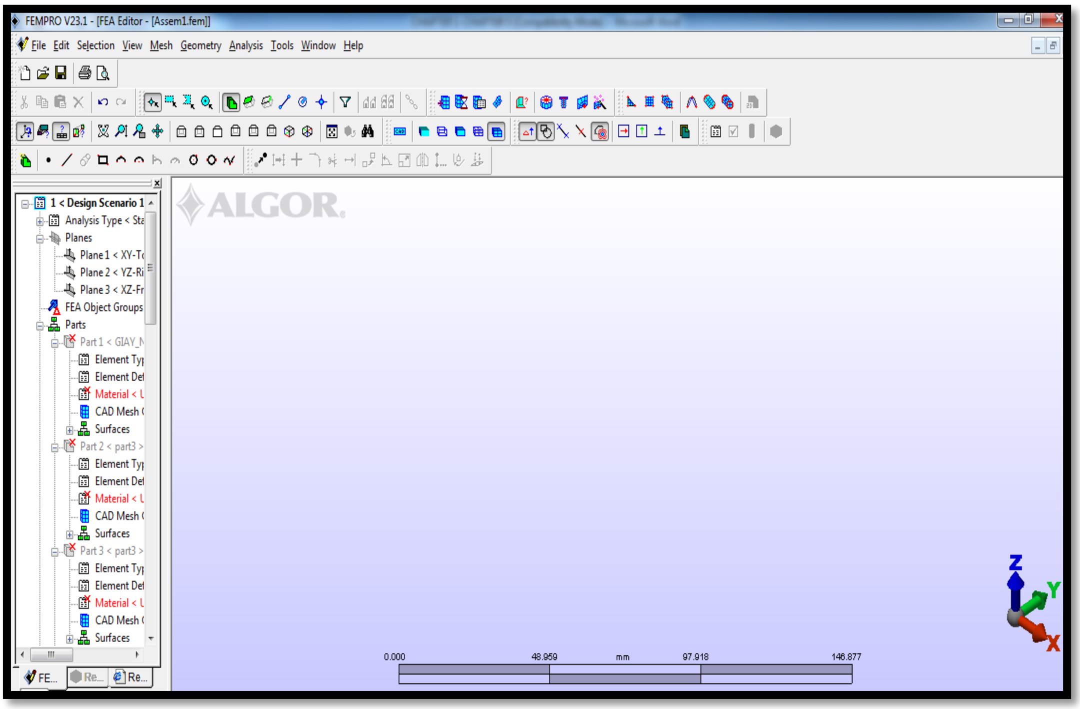

Figure 3.17: ALGOR command window

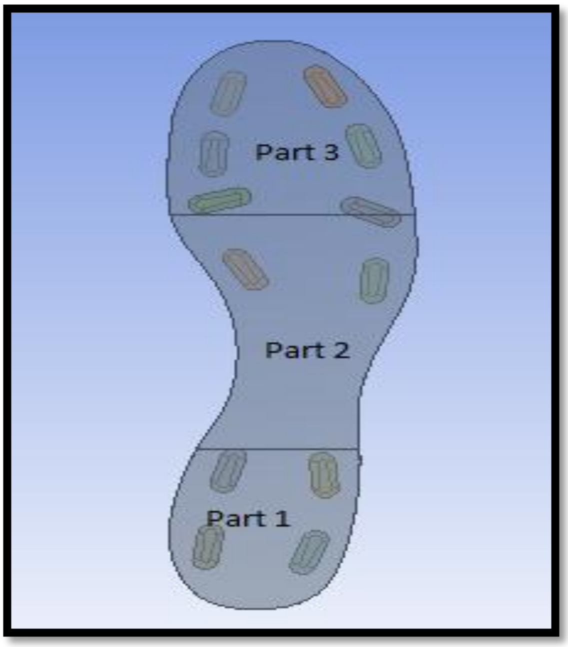

Figure 3.18: Divide into three parts

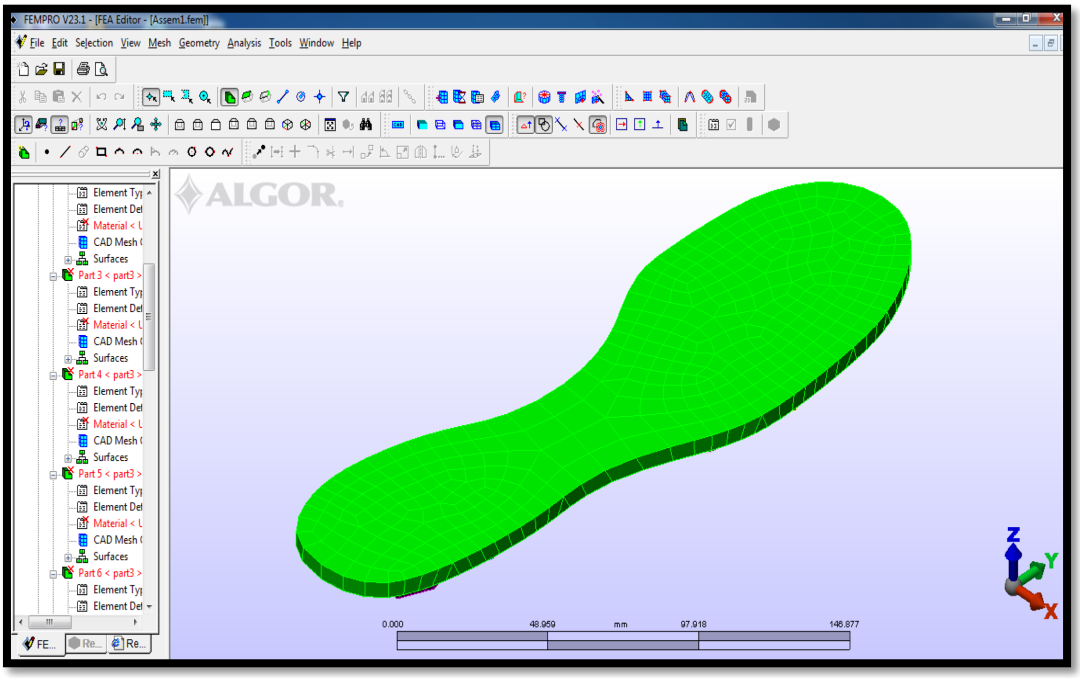

Figure 3.19: Meshing

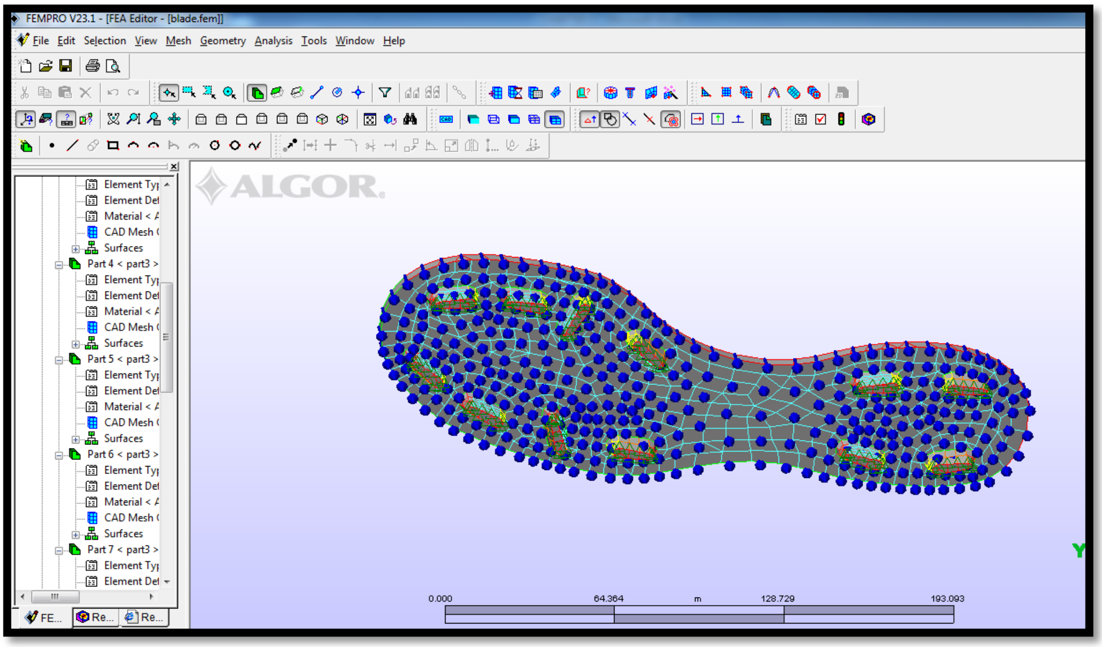

Figure 3.20: Nodal force

3.7 MATERIAL SELECTION PROPERTIES

The material selection is based on the original soccer boot. The main material of the outsole and the stud are thermo polyurethane. The other design of stud material is aluminum. Each design has its own function on the players depends on the surface condition. The chosen material based on characteristic of material has been discussed in literature study. The material properties used in simulation when the material doesn't list in a table.

Table 3.1: Material properties

Material Properties	**Thermo polyurethane**	**Aluminium Alloy**
Density (kg/m^^{3})	1080	2714.5
Modulus Elasticity (MPa)	60	69637
Poison Ratio	0.39	0.36

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

The previous chapter described the methodology used in this study which consist the design, experiment on force plate and simulation. This chapter mainly discusses about the results obtained during the experiment conducted and simulation also the possible causes.

4.2 EXPERIMENT RESULT ON FORCE PLATE

From the experiment, the data of the ten football player is done. The result is shown in the graph. The procedure of the experiment already discuss in chapter 3. The result of without shoes on a force plate uses to run simulations with Algor software. The graph shows the time (ms) versus force (N).

The result reaction force was described in three orthogonal axes during two sequential footfalls on force platform. The vertical ground reaction force is depicted as Fz, anterior-posterior ground reaction force as Fy and mediolateral ground reaction force as Fx. The data were collected with no specific velocity but times five steps before force platform. From the result, analysis of the force plate to find the value of the resultant force is done.

Figure 4.1 depicts a representative result on a force plate without shoes to use the value to run the simulation. From graph just take three points that already show in the graph.

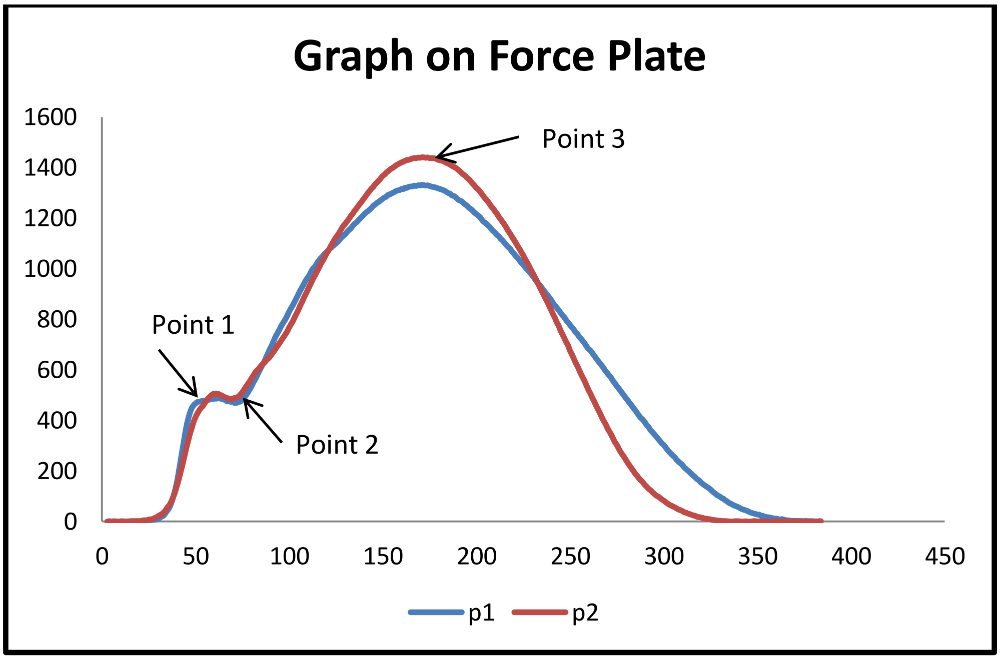

Figure 4.1: Result without shoes

4.2.1 Experiment result on force plate

The result showed in figure 4.2 that end their experiment on a force plate. The five subjects was finish to run this experiment using three different design of soccer boot that are blade, rounded and combination. All players has different weight and size. The positions for everyone are totally different. Table 4.1 showed the value of weight and position of the players.

Table 4.1: Data subject experiment on force plate

Subject	Weight (kg)	Position
Subject 1	61.5	Defend
Subject 2	59	Striker
Subject 3	64.7	Goal keeper
Subject 4	63	Defend
Subject 5	58	Striker

The graph showed in Figure 4.2 is example of graph when combine the plotting graph with three different design of boot and without shoes. The value of resultant force for every data represent in graph. The graph just to shows the different value of peak point for every boot. From the result, the rounded design give higher peak followed by combination design and last the blade design.

The graph design all subject on force plate are same pattern but different value of force based on the characteristic of the player. The weight also influence of the boot traction on force plate (Table 4.2). From the result on table 4.2 that showed when the weight higher, the peak value of force also increase.

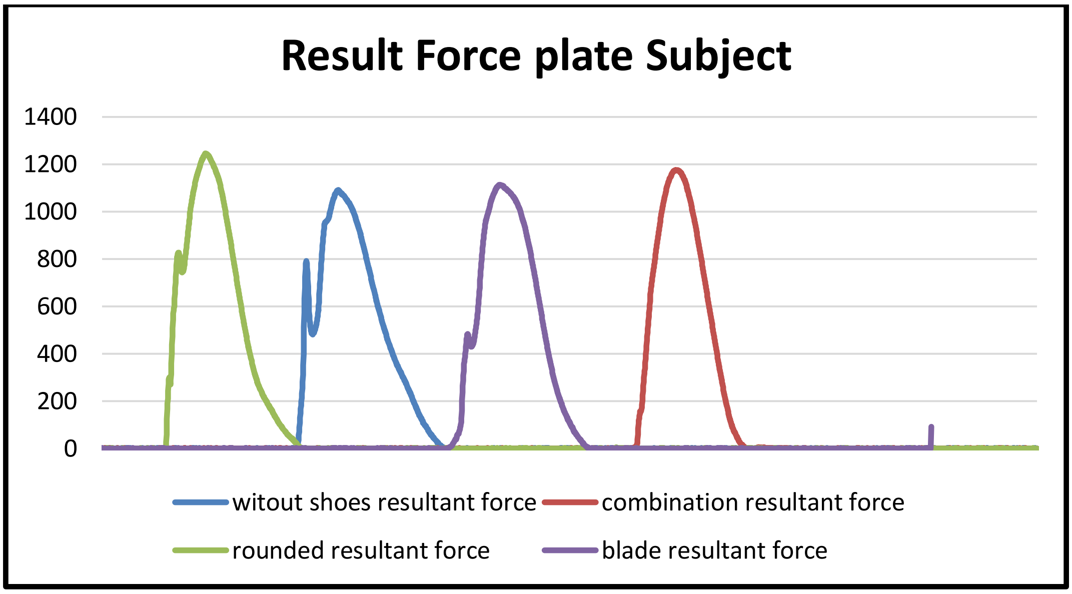

Figure 4.2: Result force plate subject

From the result showed in figure 4.2, the four lines achieved with three different boots and one line with without shoes. The higher force can see on rounded design followed by combination and the lower force on blade design.

From the experiment, many factors can influence such as the speed of the subject when running on a force plate. The speed can affect the plantar pressure when higher speed the force also increasing (Bently,2011). The effects of the speed can function on some technical elements like dribbling, slalom and agility in soccer, and also to determine the effect ratio of these elements on one another.

The result showed at the force plate also affect by weight of the subject. When running or walking, the stability of players also difference between players. This meet when a player changes their direction or suddenly braking that related to injury when stability under control. Often, taking a long time to recover the injured of football players (Gabriel et 1998).

The highest and lowest of resultant force are different between three subjects. All three subjects have same pattern graph and showed the same result. Every subject has a different running pattern or movement that showed their performance in the game (Bently et 2011).

Table 4.2: Data of peak value, Force (N)

Subject	Peak value, Force (N)			
	Without shoes	Blade	Rounded	Combination
Subject 1	1090	1114	1245	1175
Subject 2	976	1040	1116	1042
Subject 3	1300	1312	1544	1519
Subject 4	1201	1357	1447	1215
Subject 5	990	1021	1211	1019

4.3 SIMULATION USING ALGOR

For this part, the results that are obtain from the simulation by using Algor software. The simulation was developed based on the parameter that defines from the stud design in chapter 3. This part can preview the resulting simulation of the stud configuration design with different number of stud and design. The simulation of the stud with the static stress analysis was conducted to obtain the result.

4.3.1 Number of Studs is 12

The simulation of the number of stud configuration is 12 are shown as in the figure below. The result shows the higher stress on blade design (Figure 4.4). The cross sectional area of the blade design is bigger than other two design. The highest stress can see because the force applied in front of the boot (Part 3) is bigger value than other two part when running condition.

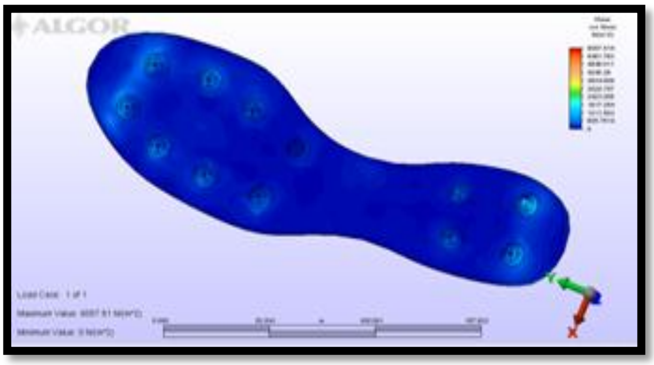

Figure 4.3: Aluminium alloy (rounded)

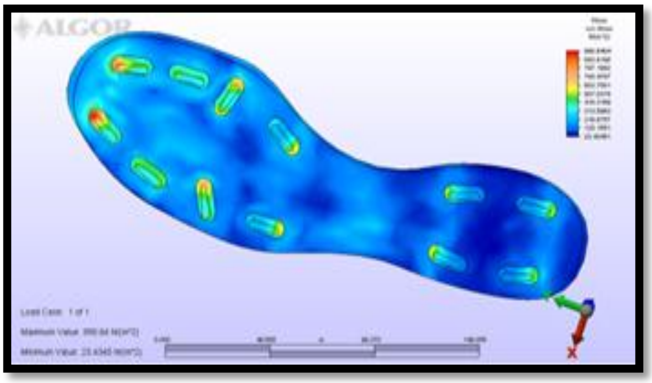

Figure 4.4: Alluminium Alloy (Blade)

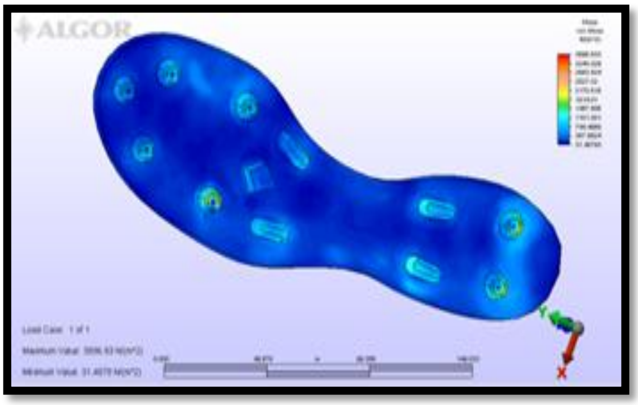

Figure 4.5: Aluminum alloy (Combination)

From the figure 4.7 observations, the results from simulation of implementation show that Aluminium alloy produces the higher stress with rounded design. The value of maximum stress is 6057. The lower maximum stress is 990 by blade design. The result maximum stress produces by Thermo polyurethane also rounded design is 5767.65. The lower maximum stress 977.68 also by blade design. This cause of cross sectional area of the rounded design is less than other designs.

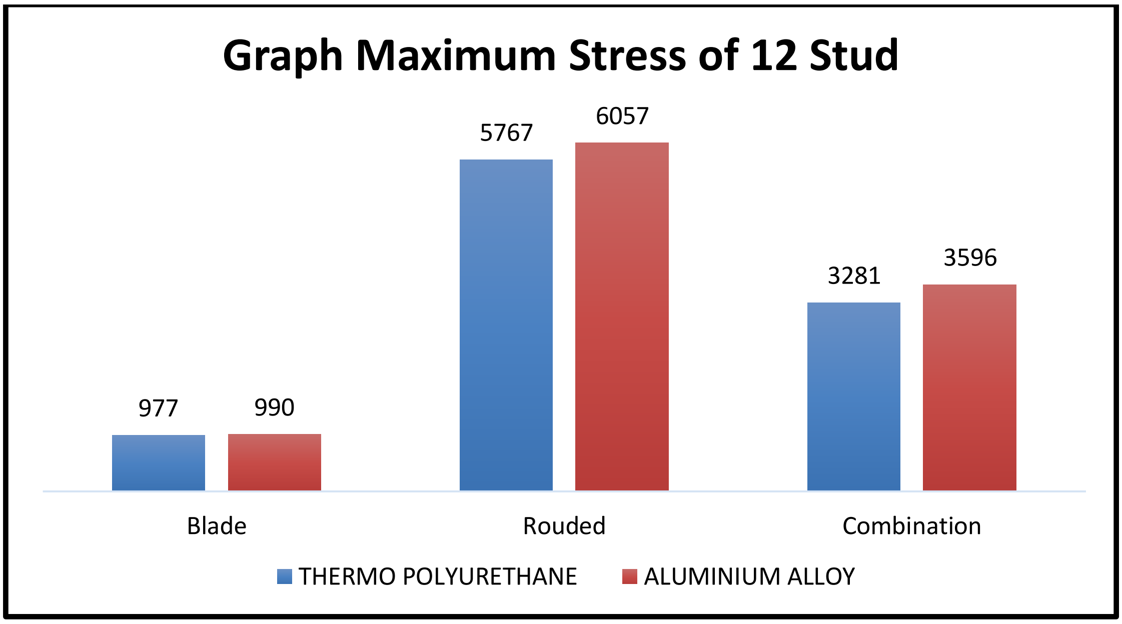

Figure 4.6: Graph maximum stress of 12 studs

4.3.2 Number of Stud is 13

The simulation of the number of stud configuration is 13 are shown as in the figure below. From the result represent the stress formed on the middle of boot. The number of stud in front and back can give unbalance on the middle. The higher stress at the middle actually less probability to take the injuries when performance.

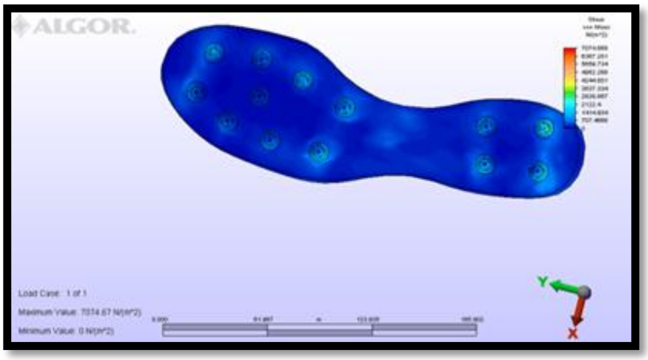

Figure 4.7: Thermo polyurethane (Rounded)

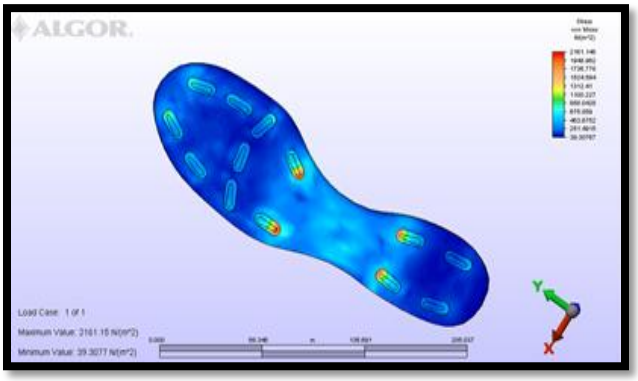

Figure 4.8: Thermo polyurethane (Blade)

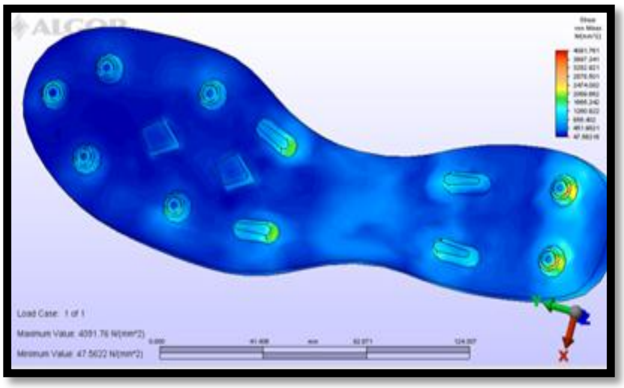

Figure 4.9: Thermo polyurethane (Combination)

From the figure 4.14 observations, the results from simulation of implementation show that Aluminum alloy has produced the highest stress with rounded design. The value of maximum stress is 7420. The lower maximum stress of aluminum alloy is 3380 by blade design. The result maximum stress produces by Thermo polyurethane also rounded design is 7074. The lower maximum stress 2161 also by blade design. This cause of cross sectional area of the rounded design is less than other designs.

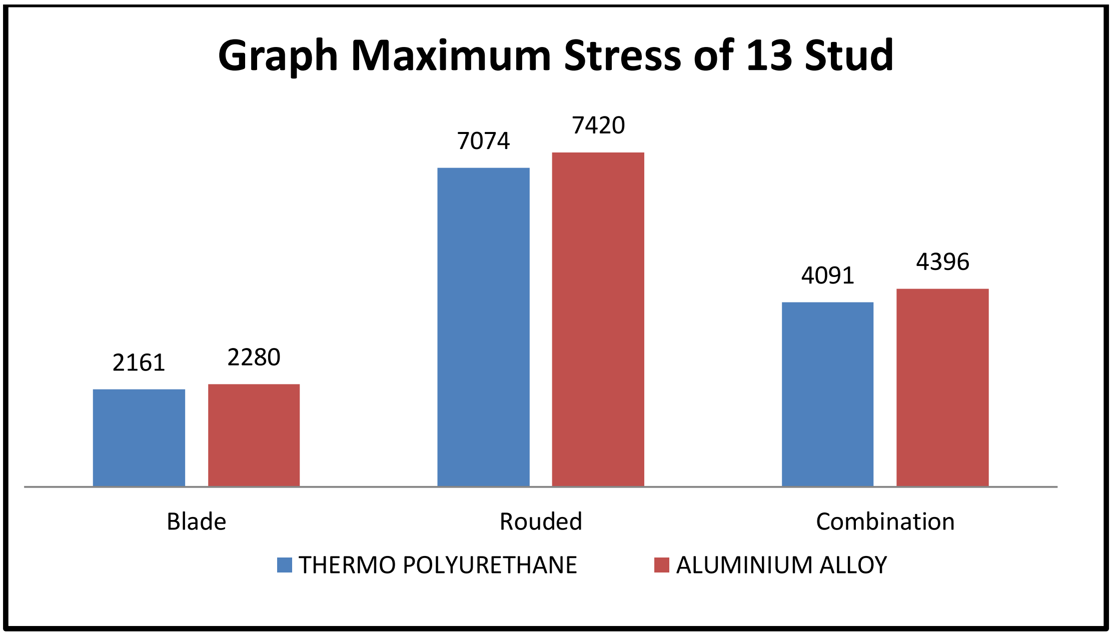

Figure 4.10: Graph maximum stress

4.3.3 Number of Stud is 14

The simulation of the number of stud configuration is 14 are shown as in the figure below. From the result showed in the figure that can see the different part have value of stress. From the figure 4.18, the stress form on the back of the boot. It is because the numbers of stud in front of boot more than back part. The unbalance load distribution can see when applied the value of force based on the experiment.

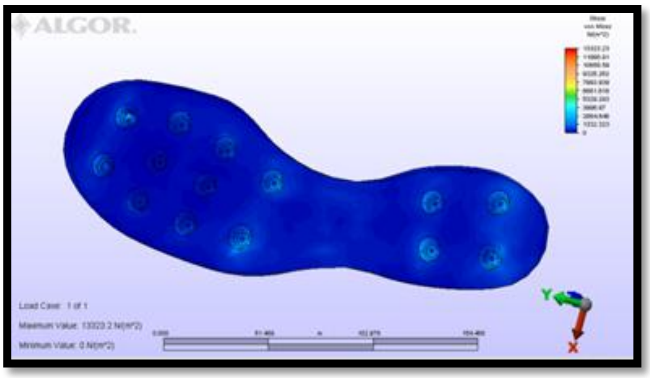

Figure 4.11: Aluminium alloy (Rounded)

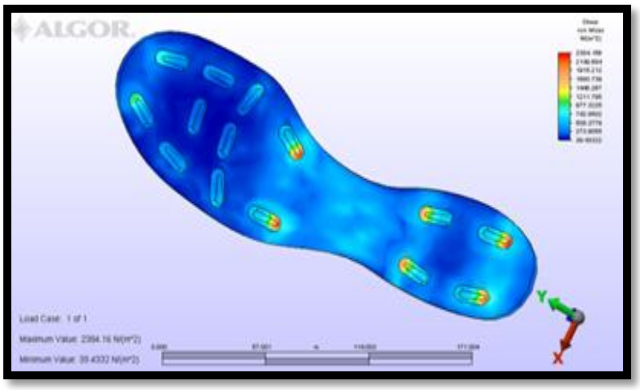

Figure 4.12: Aluminium alloy (Blade)

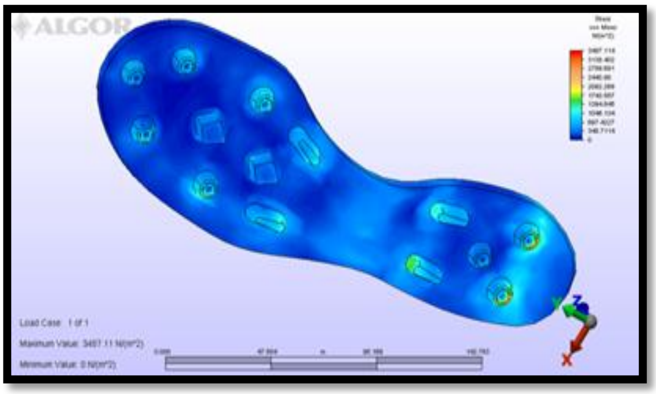

Figure 4.13: Aluminum alloy (Combination)

From the figure 4.21 observations, the results from simulation of implementation show that Aluminum alloy produces the higher stress with rounded design. The value of maximum stress is 13323. The lower maximum stress of aluminum alloy is 2359 by blade design. The result maximum stress produces by Thermo polyurethane also rounded design is 111924. The lower maximum stress 2359 also by blade design. This cause of cross sectional area of the rounded design is less than other designs.

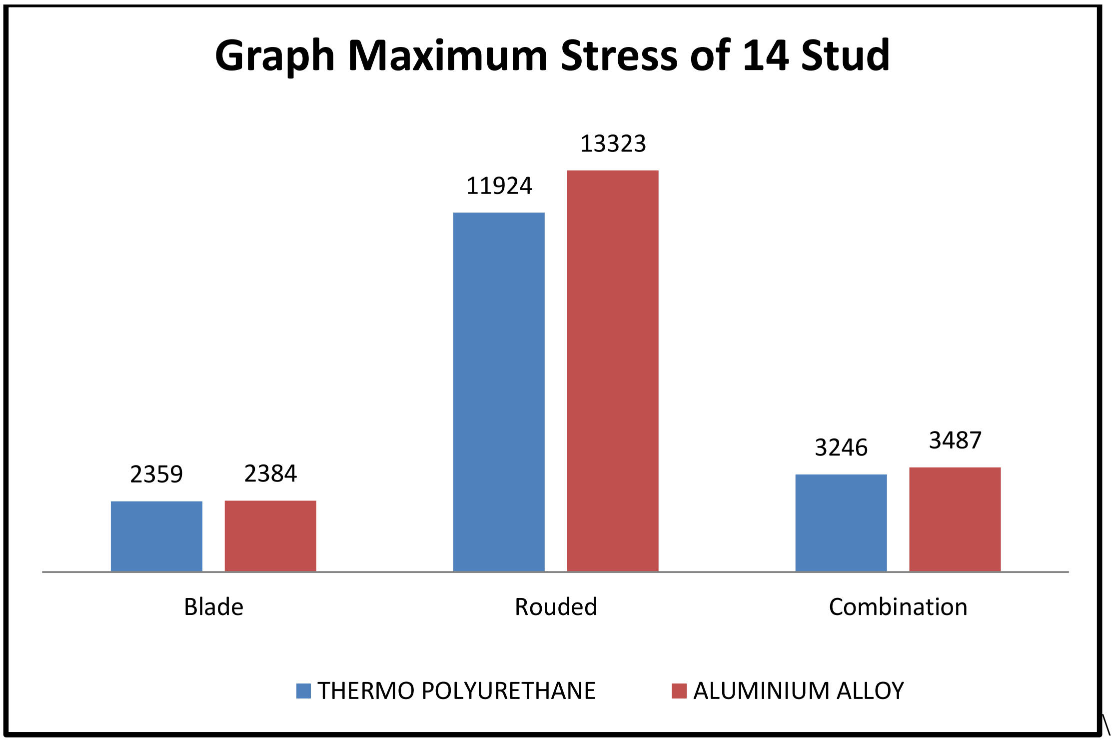

Figure 4.14: Graph of maximum stress

The result of traction stud configuration is valid between experiments on force plate and simulation. Main idea to design the soccer boot is considered about the traction of the stud. So, the idea to make the powerful soccer boot is depend on the design of the stud and configuration of stud itself. The ability of stud to tract on the surface of field for example, will show us and will give us the first observation of the boot performance.

Based on simulation, blade design is the higher stud traction due to the lower stress result. This one will contribute the player performs. The blade stud design will contribute the lower stress and more traction especially in this surface simulation. The lower stress gives more traction and also make the football player feel comfort when he wearing the boot. Compare to the other two designs of stud, rounded and combination of blade and rounded, blade showed the result is better in term of traction and stress. The result showed blade design has lower stress than other two designs.

Besides that, expertise in football game also said that, the stud configuration and stud design is very important for the player performance. It's affected to the player skills also. Even the surface of field is in very good condition, still cannot to guarantee the best performance of the football player if the design and configuration of stud are bad. The professional in soccer also needs assisted from the other aspect to give their performance and skills in perfect condition. The phrase from journal, "Harmful cleat of football boots" also mention that, the design and configuration of soccer boot stud is very important. It also said that rounded design is better than other design in spec of traction on turf surface (Bently et al 2011).

Others aspect that is needed to consider in the soccer boot design is the number of studs. The result showed that more numbers of boot stud is better. But, this is depending on size of boot sole. In this experiment, 13 pieces of boot stud is a very good quantity for boot that are in size 7 to 9 (UK Spec Measurement of boot size). This is suitable for Malaysian normal boot size. Also consider about the slippery cause, 13 numbers of studs is very compatible with size of boot sole especially to Malaysian use.

The injury in football game always related to the design of stud configuration and number of studs. Poor boot selection cause a player to long term injury. Boot selection must properly fit performance enhancement and injury prevention. The material plays an important thing and being the last thing to be considered in boot stud fabrication. Aluminum alloy is the material that is very suitable for boot stud fabrication. This material will contribute to higher stress than TPU, it is because the one of the characteristic of aluminum alloy is lightweight because more traction happen when the players running (Kirk, Noble et al 2007

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5. 1 INTRODUCTION

In this chapter, a conclusion is made up for summarizes whole part of this paper. The improvement and recommendation suggestion of knowledge will be included for future works. By referring the conclusions made in this study, it is related to the objectives targeted initially. Besides that, by referring to the recommendation to this study, scope and limitation can be improved and enriched in the future.

5.2 CONCLUSION

The aim of this study is to optimize the stud configuration on soccer boot. The method used in this study is collecting data from experiment and simulation. The result from the experiment is utilized by the different designs of boot with different sole configuration affecting the ground reaction force and make difference in performance. Overall results in experiment indicated that the rounded design give higher force than other design followed combination and blade.

After running the simulation using Algor software, the highest stress value is on rounded design. It required three different number of stud configuration that are 12, 13, and 14 and also using the different material that are Thermo polyurethane and aluminum alloy. The parameter which is different in material shows the result that aluminum alloy produced greater stress than Thermo polyurethane.

This study on natural turf are suitable with the weather in Asia that Equator not having a summertime. When increasing the number of stud (to 13 or 14), it also can decrease performance as a number increase. However, differences in performance were also found with the same number of studs depending on their distribution. These study also finding the implications for impact that related injuries for harder turf especially in other situation like raining to avoid slippery.

5.2 RECOMMENDATION

Recently, the engineering field is growing parallel with sport field to develop the new era in football game. In this thesis also provide the method to optimizing the stud configuration on soccer boot using experiment on force plate and running the simulation using the Algor software to validate the result experiment. Therefore, the Biomechanics groups still new in UMP, many limitations and not enough equipment in lab to plan or running this project with success.

For the future development in other research to build a testing device that can measure the velocity in force plate. In this case when running the experiment, the velocity can totally same between subject. The biomechanics lab very limited space also affects the movement of the subject. The future recommendation is to build new laboratory that enough space with new equipment for future research.

Besides, the simulation still can be improved by using other software. When running or walking that include in gait analysis the time also can measure. The new simulation tries to get the result with dynamic structure because the latest study just using the static stress analysis.

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APPENDIX A

RESULT EXPERIMENT ON FORCE PLATE

Figure A-1: Result force plate subject 1

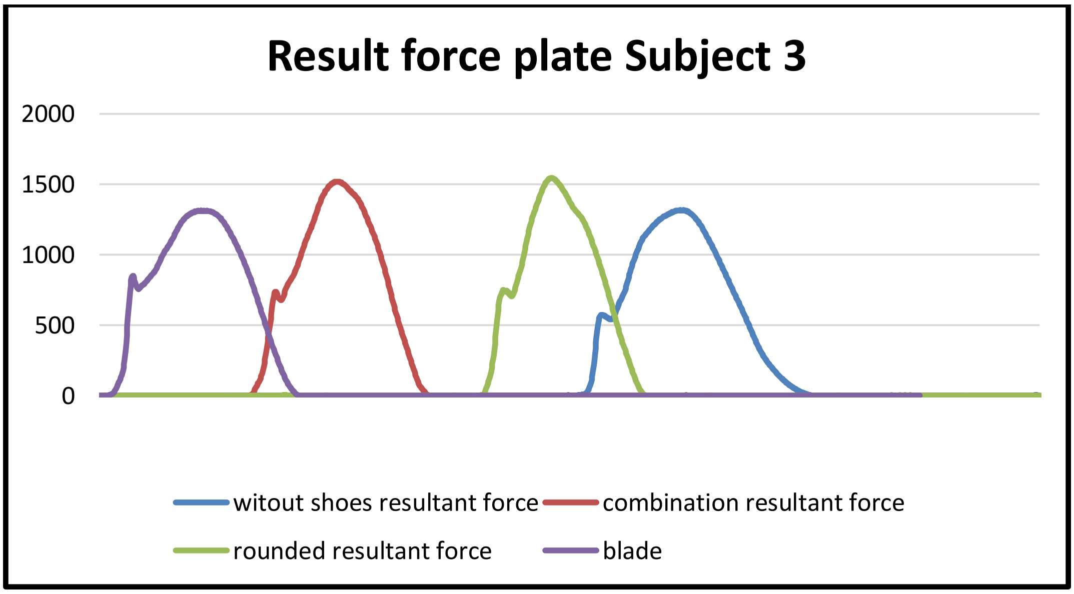

Figure A-2: Result force plate subject 3

APPENDIX B

ALGOR SOFTWARE

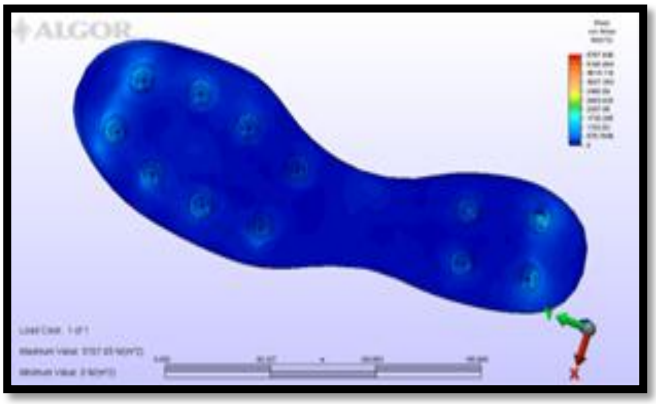

Figure B-1: Thermo polyurethane (Rounded)

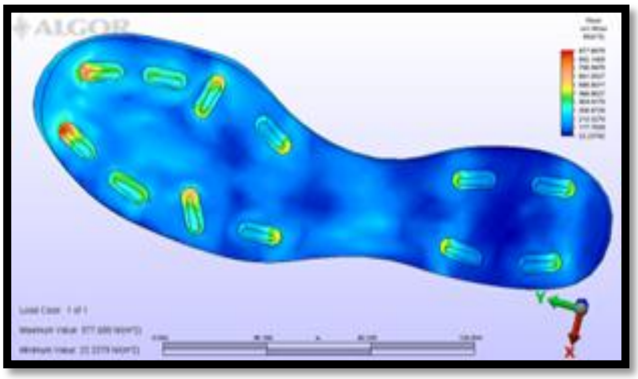

Figure B-2: Thermo polyurethane (Blade)

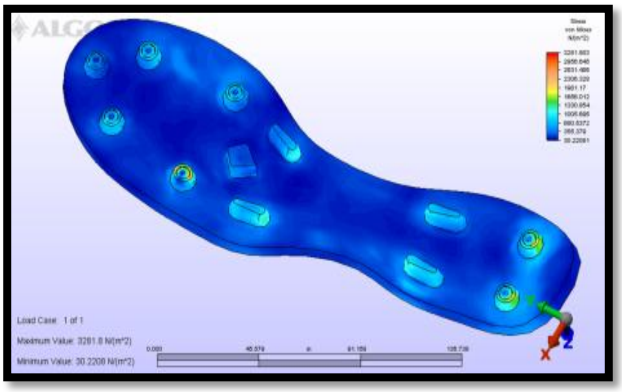

Figure B-3: Thermo polyurethane (Combination)

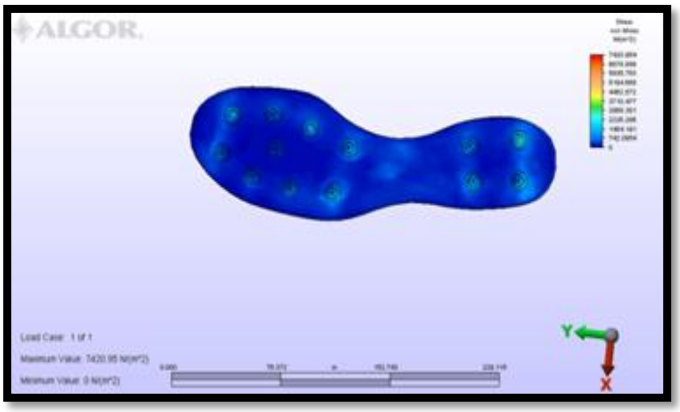

Figure B-4: Aluminium alloy (Rounded)

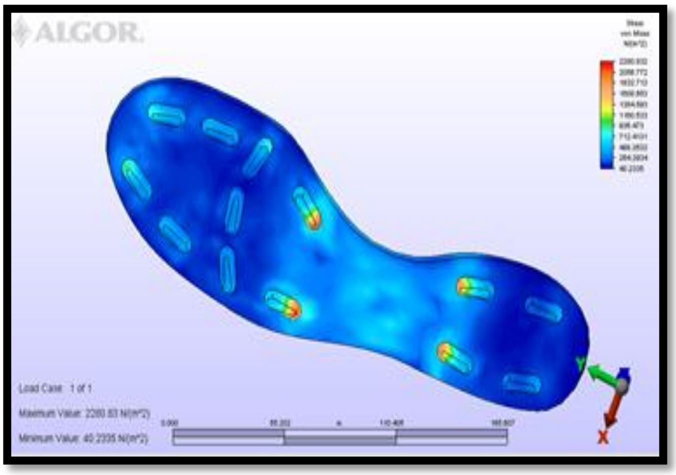

Figure B-5: Aluminium alloy (Blade)

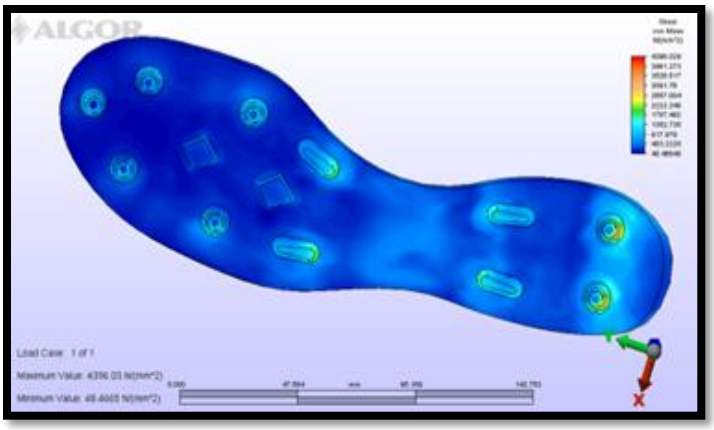

Figure B-6: Aluminium alloy (Combination)

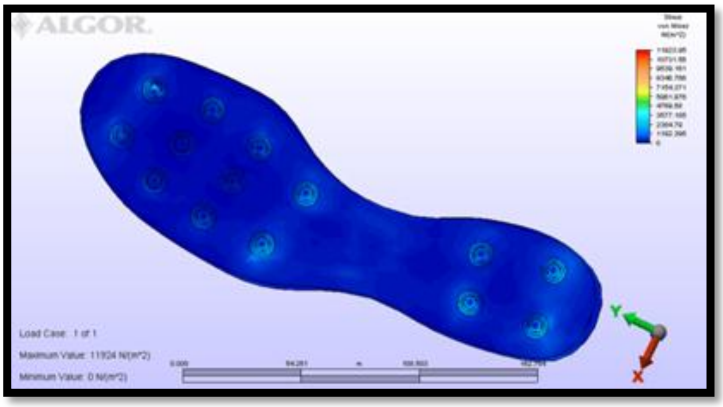

Figure B-7: Thermo polyurethane (Rounded)

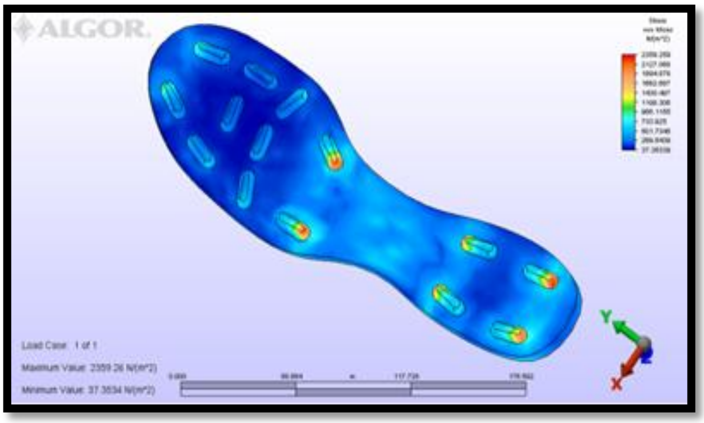

Figure B-8: Thermo polyurethane (Blade)

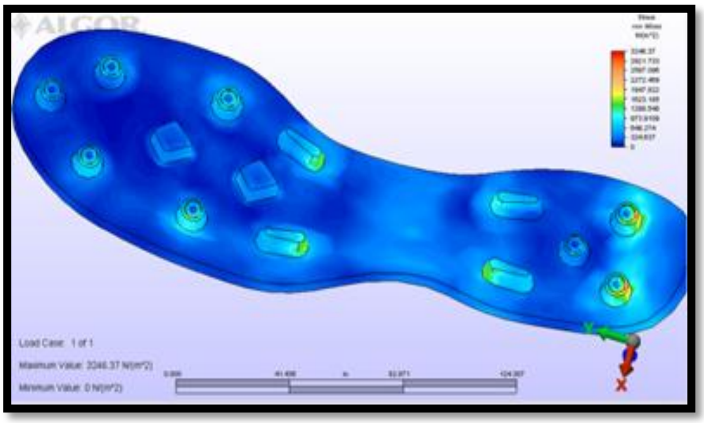

Figure B-9: Thermo polyurethane (Combination)

APPENDIX C

GANTT CHART FOR FINAL YEAR PROJECT 1

PROJECT TASK	SEPTEMBER			OCTOBER				NOVEMBER				DECEMBER			
	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9	WK10	WK11	WK12	WK13	WK14	WK15
Meet supervisor															
discuss title															
Overview overall															
title															
Literature review															
(find journal)															
Literature review															
(do summary)															
Prepare for project															
proposal															
Submit proposal															
and slide presentation															
Seminar															
Presentation PSM 1															
Methodology															
(structural)															
Methodology															
(experiment setup)															
Prepare for 2nd															
Progress presentation															
Methodology															
(simulation)															
Report for															
PSM 1 and log book															

Planning

Actual

APPENDIX D

GANTT CHART FOR FINAL YEAR PROJECT 2

PROJECT TASK	FEBRUARY			MARCH			APRIL			MEI			JUNE		
	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9	WK10	WK11	WK12	WK13	WK14	WK15
Meet supervisor discuss progress															
Briefing of experiment															
Preparation of experiment															
Running experiment On force plate															
Simulation using Algor															
Analysis result															
Paper writing															
Prepare for 1st Progress presentation															
Prepare result And discussion															
Report for PSM 2 and log book															
Writing thesis															

Planning

Actual