



# **UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

## **DESIGN AND DEVELOPMENT OF HITTING SYSTEM FOR HEAD CONCUSSION TEST RIG**

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Maintenance) with Honours.

by

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# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

Tajuk: DESIGN AND DEVELOPMENT OF HITTING SYSTEM FOR HEAD CONCUSSION TEST RIG

Sesi Pengajian: 2018/2019

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## **DEDICATION**

To my respected supervisor,  
my beloved family,  
and all my friends,  
Thanks for your support.

## ABSTRACT

Regardless of rising attention to the issue of game related injury in rugby, great evolution of sport equipment went on, and this led to progressive development and improvement on the design of testing rig. This project will develop a hitting system thus, the study of a fluid power will be a part of this project. Pneumatic control circuit is a type of fluid control circuit where it will give the efficient force and acceleration compare to the previous hitting machine. In order to develop the project there is a few aims that need to be emphasis, where the first thing is to design the new concept for a hitting system for head concussion test rig, the second aim is to develop a prototype of hitting system for head concussion test rig. Last but not least, to conduct testing on the hitting system and validate the testing rig with head model. The methodology applied to conduct this project is generate trough research analysis, research design, component selection, design for manufacturing, and prototyping and testing. Where the development of the project is by using House of Quality, Morphological chart, Pugh selection method, conceptual design, product design specification, and prototyping and testing. Next the development of the project were assisted by engineering software in order to produce the best solution for the test rig with high efficiency that can stimulate the actual impact during the real game. The hitting system will generate the force that execute the vibration data for analysis. The performance standards has an impact ( $9.5 \text{ m / s}$ ,  $58 \text{ J}$ ) which is same with the collision experienced by the Rugby player ( $5 \pm 1 \text{ m / s}$ ,  $50\text{-}60 \text{ J}$ ). Thus the test rig accomplish all the standard stated where the speed of the actuator has been analyse where it can reach up to  $11 \text{ m/s}$ . Moreover the speed of the actuator can be set by follow the SMC standard which can be improvise by using flow control valve. Defining the standard needs, and infusing the standard from the IRB and NOCSAE into every aspect of the design process. The test rig needs were transcribed into engineering characteristics by the method of Morphological chart to organize the solutions for every sub problems. The design alternatives generated were undergone Pugh selection method, where every design alternatives were compared to each other and the best design was selected for further development. This whole process has certainly infused the product design specification into every aspect of the design process.

## ABSTRAK

Peningkatan perhatian terhadap masalah kecederaan berkaitan permainan dalam rugby, evolusi peralatan olahraga berjalan lancar, dan ini membawa kepada perkembangan progresif dan peningkatan pada rig pengujian. Projek ini akan membangun sistem memukul dengan demikian, kajian kuasa bendalir akan menjadi sebahagian daripada projek ini. Litar kawalan pneumatik adalah jenis litar kawalan bendalir di mana ia akan memberikan kekuatan yang cekap dan pecutan berbanding dengan mesin memukul terdahulu. Untuk membangunkan projek ini ada beberapa tujuan yang perlu ditekankan, di mana perkara pertama adalah untuk merekabentuk konsep baru untuk sistem memukul untuk rig ujian gegaran kepala, matlamat kedua adalah untuk membangunkan prototaip sistem memukul untuk kepala rig ujian gegaran. Untuk menjalankan ujian pada sistem memukul dan mengesahkan rig ujian dengan model kepala. Di mana pembangunan projek tersebut adalah dengan menggunakan House of Quality, carta Morfologi, kaedah pemilihan Pugh, reka bentuk konseptual, spesifikasi reka bentuk produk, dan prototaip dan ujian. Seterusnya pembangunan projek ini dibantu oleh perisian kejuruteraan untuk menghasilkan penyelesaian terbaik untuk rig ujian dengan kecekapan tinggi yang dapat merangsang kesan sebenar semasa permainan sebenar. Sistem memukul akan menghasilkan daya yang melaksanakan data getaran untuk analisis. Standard prestasi mempunyai kesan ( $9.5 \text{ m / s}$ ,  $58 \text{ J}$ ) yang sama dengan perlanggaran yang dialami oleh pemain Rugby ( $5 \pm 1 \text{ m / s}$ ,  $50\text{-}60 \text{ J}$ ). Oleh itu rig ujian mencapai semua standard yang dinyatakan di mana kelajuan penggerak telah menganalisis di mana ia boleh mencapai sehingga  $11 \text{ m / s}$ . Selain itu kelajuan penggerak boleh ditetapkan dengan mengikut piawaian SMC yang boleh dibuat dengan menggunakan injap kawalan aliran. Menetapkan keperluan standard, dan membuat standard dari IRB dan NOCSAE ke dalam setiap aspek proses reka bentuk. Keperluan ujian rig telah diterjemahkan ke dalam ciri-ciri kejuruteraan dengan kaedah carta Morfologi untuk mengatur penyelesaian untuk setiap masalah sub. Alternatif reka bentuk yang dihasilkan telah menjalani kaedah pemilihan Pugh, di mana setiap alternatif reka bentuk dibandingkan antara satu sama lain dan reka bentuk terbaik telah dipilih untuk pembangunan selanjutnya. Proses keseluruhan ini telah pasti memperkenalkan spesifikasi reka bentuk produk ke dalam setiap aspek proses reka bentuk.

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## LIST OF SYMBOLS

<b>RU</b>	-	Rugby Union
<b>RL</b>	-	Rugby League
<b>ARF</b>	-	Austrian Rules
<b>NOCSAE</b>	-	National Operation Committee in the Standard Athletic Equipment
<b>l</b>	-	Length
<b>m</b>	-	Mass
<b>v</b>	-	velocity
<b>P</b>	-	Pressure
<b>Q</b>	-	Volumetric flow-rate
<b>CTE</b>	-	Chronic traumatic encephalopathy
<b>PE</b>	-	Polyethylene
<b>EVA</b>	-	Ethyl Vinyl Acetate
<b>IRB</b>	-	International Rugby Board
<b>ASTM</b>	-	American Testing an Material Association
<b>HIC</b>	-	Head Injury Criteria
<b>TRIZ</b>	-	Teoriya Resheniya Izobretatelskikh Zadatch
<b>PDS</b>	-	Product Design Specification

# CHAPTER 1

## INTRODUCTION

### 1.1 BACKGROUND OF STUDY

Rugby became a popular and quick paced outdoor contact sport after South Africa hosted the rugby world cup in 1995 where rugby player became professional and made the game as career. Attracting various individual of all shapes and ages, there are presently around 2,000 players competing in the Rugby Union Premiership (otherwise acknowledged as the Guinness Premiership) in England alone[1]. There are also professional, semi-professional and phase time teams competing in National Division One. Rugby Union is a particularly aggressive recreation and one which relies upon fitness, dedication, and skill to succeed. It is governed via the International Rugby Board (IRB). Regardless of rising attention to the issue of game related injury in rugby many Sports Protective Equipment was invented for rugby such as headgear. The first scrum cap design consisted of a headband that turned into padded inside the ear regions attached to a chin strap prolonged over the top of the head. The scalp a part of the head changed into left open and uncovered. This design make the top of the head area quite like a hot-cross bun. Then the scrum cap develop also known as headgear that used by rugby players to shield the ears inside the scrum, that could otherwise suffer accidents leading to the circumstance normally referred to as cauliflower ears. Even though at first designed for forwards they're now worn by players of all positions, even individuals who don't play inside the scrum. The scrum cap changed into invented by Eurig Evans and was first worn through Christ's college Finchley's 1st XV. despite the fact that the game of rugby became invented in 1823 with the aid of



William Webb Ellis, it wasn't until the early 1900's earlier than scrum caps made their debut on the international stage [1].

Despite the growing awareness of sport-related issues with concussion, many issues surrounding contribute to the prevention and management to reduce the injury. Focusing on the rugby union, where the extent to which different participants (e.g., Players, coaches, parents, medics, and referees) understand how to avoid injury, and what role they need to do in preventing concussion. Based on the history from the rugby world cup 2003 there are few investigations of damage rates in elite or professional rugby. From the data recorded during world cup 2003, Bathgate recorded 142 injury in 91 games. Injury rate show that 36.2% for each 1000 player injuries that resulted in games reported during the three seasons of elite rugby surveillance in Australia. The result from that studies shows the most frequently injured body regions were the head, neck, and face 33.7% injuries per 1000 player game hours, followed by the ankle and foot 14% injuries then knee 12.7%, and the thigh 9.5% The rate of injury to the head, face, and neck was over twice the rate of the next most frequently injured body region, the foot and ankle [2]

The latest concussion prevention strategies in rugby union became one of the important view, ranging from the development of protective equipment, to govern special education program and sports rule [3]. In the previous study, there were minimal considerations for wider contextual factors affecting how rugby participants received guidelines for the prevention and management of the concussion, or its relevance factor and value. In most cases of injury it is accepted that player across the system of interest share responsibility for the cause of injury. However, before it became mutual responsibility and it can be enacted, it is worth clarifying how responsibilities across different participants where the tackle occasion accounted for most head collisions. Most gamers have been privy to the approaching contact. Higher damage threat ball-carriers in the front-on tackles scored exceptionally low in proficiency as compared to lower damage risk ball companies. Eighty-four percent of head collisions took place at some stage in the tackle, accompanied through aerial collisions (10%), and rucks (6%). eighty-percent of collisions befell with an opponent. higher hazard players were aware of the upcoming contact 70% of the time [39].

There is three variation of rugby game in Australia which is rugby union (RU), rugby league (RL) and, Australians rules (ARF). For the injury that statically recorded in the elite ARF, the concussion rate has increase gradually from 2.2% to 3.9% per one hundred player over the last five years. There is only restrained prospective statistics on the incidence and incidence of concussion in rugby union (RU) and rugby league (RL) however, it is an area of issue to administrators, players, and the scientific fraternity. Consequently, there is a need to watch the components of concussion in rugby and methods which may decrease its frequency and severity. The format system for protection systems requires information of the conditions under which the system is required to operate. With protective headgear, it is basic to characterize the idea of the influences that outcome in concussion, so that headgear can be developed or improvise that will prevent concussion below these conditions. The essential parameters to define are impact speed and energy, head have an impact on sites, the nature of the impacting object, and usual head acceleration. To choose the elements of head impacts bringing about concussion, it is basic to measure the kinematics or energy of the damage rate. The systems and instrumentation required to quantify this in the region renders it for all intents and purposes.

A range of parameters have been estimated. First, the influence closing speeds were calculated from the linear speeds. Next, with the aid of the usage of the conservation of momentum and power principles, a technique used to be developed to estimate the head impact energy. This technique involved the following steps and assumptions first is the momenta of the putting objects, The final velocity (vf) of the striking and struck object, The trade in speed of the head, The change in speed of the head, The change in momentum of the head and head have an impact on energy, and the closing one is The head impact power at some stage in the impact was once estimated the usage of a conservation of strength strategy [4].

In order to develop the project, the usage of fluid system will be used which show the capability in controlling the system to test the headgear. By using the pneumatic system it is economical and environmentally friendly, as air is inexpensive, plentiful and easily compressed with good stored in tank. The used of pneumatic concept yet has grown all over the world because it have better

operational advantage compare to hydraulic system. Next the hitting system need good accelerating and decelerating actuator to stimulate the rugby impact where the pneumatic system have a better control in compressor flow rates, air is very agile and can flow through pipes very quickly and easily with little resistance. A pneumatic system is use to achieve the desire implement to the required velocity by regulating the pressure. The resultant head acceleration is taken by the same method as the linear impact testing method. To ensure accurate test velocity, the projectile is exposed to two velocity traps at set distances from the cannon to capture a reliable measure of velocity. Where this method are more convenient and easy to control compare to drop test method and linear impact method.

The initial phase in outlining a bit of headgear is to comprehend the idea of the powers that follow up on it and the damage components of its specific application. In production helmets, impacts are typically on top from falling items, in which as a soccer helmet can assume influences at any location, frequently with multiple affects at a couple of places on the identical time. Bike helmets will experience crashes at excessive speeds while baseball helmets will experience impacts while the player is stationary or jogging at fairly slow speeds. This seems a challenging task, but there are suggestions that may help to categorize those standards in the form of trying out requirements. Consequently, the NOCSAE advanced a standard for projectile impact testing that once more incorporates the NOCSAE-specific headform set up to a linear bearing table.

## 1.2 PROBLEM STATEMENT

The typical rugby headgear that is in the market right now has some controversy about the protection against concussion where the survey shows that the padded headgear does not reduce the rate of head injury and concussion even after adjustment for level play[4]. The standard headgear has a limited potential to attenuate impacts to the head and reduce the head's acceleration to a tolerable limit. Although, by using the modified headgear, there are not sufficient enough to reduce game head injury [5].

Basically most commercially available soft helmet fail to meet impact testing criteria that would be typical of sport-related concussion [4]. From the previous study by McIntosh and McCrory, the result shows that the impact attenuation of rugby headgear decrease over time thus decreasing its effectiveness in protecting against head injury. However the study consist of only 5 drops, impact by using drop test at the parietal-lateral site where an extended period of time between impact is not constant and the speed of drop is between 7 m/s to 14 m/s which are difficult to control. By developing the pneumatic hitting system for head concussion test rig all the outcome can be controlled such as speed and the contact area where lead to better accuracy in the result.

This project will develop a hitting system thus, the study of a fluid power will be a part of this project. Pneumatic and hydraulic control circuit is a type of fluid control circuit and currently plays an important role in the automobile tool industry. Therefore, in this experiment, pneumatic circuits are represented by dynamic graphs together with a knowledge base in which a set of rules is used to represent the logic that controls the behaviour of the component type. The motion simulation is performed by the inference engine by searching the graphs based on the matching rules from the knowledge base in each simulation step. The system is implemented based on user-friendly users or machine interface provided to assist the construction of design circuit representation. Fluid power knowledge base available elements is built into the system. Engine inference is a search engine graph based on the basic rules of knowledge. The system has facilities that allow it to perform animation of the circuit action. The important modules that affect usability are the display

response from the men's interface or machine and animation. As this can be modularly programmed, the high capability for this system is expected to run [6].

### **1.3 OBJECTIVES**

1. To design the new concept for a hitting system for head concussion test rig
2. To develop a prototype of hitting system for head concussion test rig
3. To conduct testing on the hitting system and validate the testing rig with head model

### **1.4 SCOPE**

The scopes and limitations of this project are:

1. The use of AutoCAD and FluidSIM software to design the pneumatic hitting system for head concussion test rig
2. This project will study the performance of fluid power that can control the hitting system for head concussion test rig
3. This project needs to vary the momentum rate to forecast the sensitive area of at the rugby headgear during the impact

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

There are many injuries in the rugby where the most frequent report for rugby injury is the concussion. This study will conduct an experimental test that can precisely replicate the condition in the real head impact and develop a testing system to test the headgear in the field and in particular condition, to determine whether the test had underestimated the protective capacity of headgear. There will be using a fluid system for the impact test between the two surface and then develop the testing rig according to the engineering process. After that, this project will purpose the most suitable manufacturing process in order to construct the hitting system for head concussion test rig

#### **2.2 Head concussion**

In the professional rugby union a concussion is a regular reported injury that increasing by year especially in the England rugby union. It has been recorded that the increasing rate are 0.28% by year [3]. Worry about the long-term effect of various sport related concussion, an associated representative head trauma were growing in preventing the injury that cooperate with International Rugby Board (IRB). Acknowledge the effect from the concussion there are codes of rugby union and rugby league that has been participated by 199 countries that have resisted with International Rugby Board (IRB). For the last decade, an approach has been focus on the rule, policy, research, and public awareness to increase the prevention for

brain injury. It is because, the injury that related to brain including concussion increasing in sport related injuries. The large number of participants with various ages, coupled with the view that sports does not provide social and health benefits which concern the player [8]. Regarding the efficacy of currently the rate and the characteristic of the injury that has been studies by Bird et. Al. the research shows the number of injury in a game for rugby union in England where for 1000 player participated the data show the result detect 25% decreasing in injury rate in the group that wearing standard headgear. But in the no headgear group the injury rate increase drastically up to 40% especially for the minor injury during the game [10]. The rate injury mostly occur on the head followed by ankle and knee.

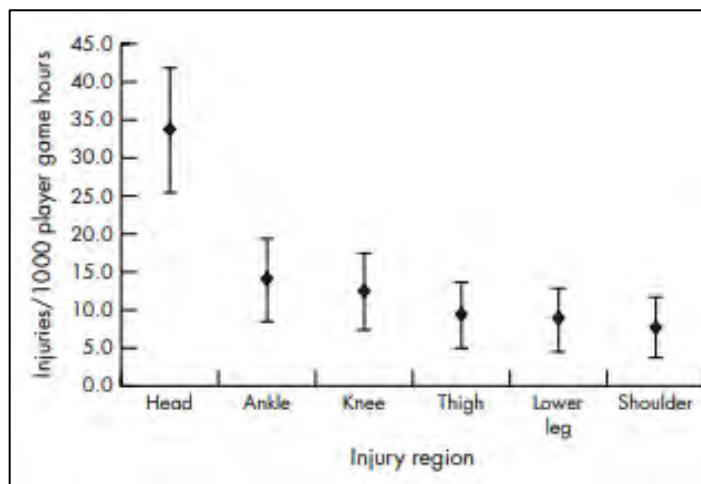


Figure 2.1: Rates of injury (all teams combined) and 95% confidence intervals for the most often injured body regions. Rates are expressed per 1000 player game hours

The capacity for injury to the head ensuing in concussion is pretty high. "A trauma-induced alteration in mental reputation which could or won't involve loss of attention"[40]. At the same time as some degree of amnesia or confusion is perpetually skilled, signs and symptoms including dizziness, headache, and nausea can also or might not be present. A concussion can simply have an impact on the wellbeing of a player or even briefly impair cognition. It has been recommended that repeated concussion can also irreversibly affect interest and memory. However, potential studies are lacking and this statement, consequently, stays debatable. No matter their capacity lengthy-time period outcomes, rugby related concussions are

a crucial health concern, and powerful strategies of prevention want to be advanced. Rugby headgear is currently not obligatory, and its use need to follow the standards set down via the international Rugby Board (IRB). In the long run, it is the referee who determines if a specific piece of headgear is acceptable or now not, based totally at the recommendations. The IRB has recently amended regulation for players dressed that consist of headgear. It states that headgear ought to be product of smooth and thin materials, without a part of the headgear thicker than 1 cm while uncompressed, no element to have a density less than 45 kg/m<sup>3</sup>, and head form acceleration have to be restricted to two hundred–550 g in a drop take a look at from zero. Three m.15 several groups, consisting of Rhino, Canterbury, Gilbert, Rugbytech, Mizuno, and Predator, now manufacture headgear that complies with IRB recommendations, which may be observed in specialized sports stores across Canada and around the world. Headgear use is quite variable, with a few groups—for example, the Shawnigan Lake high school groups in Victoria, BC and even one us of a (Japan) making it mandatory. More typically, the selection to apply headgear is living with the person participant. Even though it isn't presently known how many gamers global choose to wear headgear, Gerrard et al said headgear use via 20% of rugby gamers in New Zealand. At that time, it changed into mentioned to be frequently constrained to forwards and a few backline players who have been improving from an injury or who were concussed numerous instances in the beyond.

Rugby is a collision sport in which repetitive impacts among players and with the playing surface arise at some point of the sport. Rugby is physical in nature, and damage is an inevitable aspect of the game. Up to seventy two percent of rugby gamers enjoy at least 1 injury related to rugby during an aggressive season and 82% within a 1-yr duration [10]. Injury amount charges vary substantially from 114.37 to 490.29 per one thousand participant by position game hours, with an expanded rate of injury to forwards in comparison with backs. Concussions only account for up to twenty-five percent of all rugby injuries [11].due to the excessive incidence of collisions and resultant concussions suffered by way of rugby athletes, we need to decide ways to reduce the danger of head damage all through participation. In the past, rugby was commonly performed without using any protective equipment. However, improvements in protective padding, inclusive of headgear, have caused