UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ROUND NOSE BULLET DESIGN USING HIGH-PROFILE CURVE DEFINITION

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

by

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ABSTRACT

Nowadays, the rapid improvement in technologies causes the conflicts and violence acts all over the world rises day by day and it gives a significant impact to the bullet manufacturing as the demand of military production is high. Hence, the manufacturing industry need to improve the performance and design efficiency of the existing bullet that meet the customer requirement. One of the main problem in military industries is the aerodynamic on a bullet. The study of aerodynamics is vital to improve the design efficiencies and the performance of a bullet. Besides, the improvement of the bullet shape will influence the impact, aerodynamic features and maximize the effectiveness of bullet, and therefore, the concept of C-shaped transition curve is proposed to analyzed the effectiveness of the improvement bullet design due to its shape. Round Nose Bullet is selected as an existing design due to its high aerodynamic and better penetration. Solidworks SimulationXpress and ANSYS Fluid Flow (FLUENT) packages are the software that have been utilized in this research study. The results attained in Linear Static Analysis illustrated that the increment in the deformation and decrement in Von Mises Stress will contribute the improvement design to slowly undergo the failure and the projectile provides better penetration. The prediction of fatigue can be obtained by applying the computation of Newton interpolation polynomial, which indicates that the improvement design will experience the slower failure condition as the value of initial applied pressure, x in improvement designs is higher when compared with existing design. Furthermore, the consistency of bullet design is also validated by computing Coefficient of Variation (CV). According to the CV calculation, improvement design has a lowest percentage rather than existing design so that the concept of Bernoulli principle can be applied in this research study. An increase of velocity in bullet movement occurs simultaneously with a decrease in pressure in the improvement design. Hence, this research shows that the implementation of C-shaped transition curve in improvement design has increased the stability of the bullet and explicit a low resistance during the projectile motion along trajectory.

ABSTRAK

Pada masa kini, peningkatan pesat dalam teknologi telah menyebabkan tindakan konflik dan keganasan di seluruh dunia bertambah setiap hari dan ia memberi kesan yang besar kepada pembuatan peluru kerana permintaan keluarannya yang tinggi. Oleh itu, industri pembuatan perlu meningkatkan prestasi dan kecekapan rekabentuk peluru yang sedia ada untuk memenuhi keperluan pelanggan. Salah satu masalah utama dalam industri ketenteraan adalah aerodinamik terhadap peluru. Kajian aerodinamik adalah penting untuk meningkatkan kecekapan reka bentuk dan prestasi peluru. Selain itu, peningkatan bentuk peluru juga akan mempengaruhi kesan, ciri-ciri aerodinamik dan memaksimumkan keberkesanan peluru, dan disebabkan itu, konsep lengkung peralihan berbentuk C telah dipilih untuk menangani masalah ini. 'Round Nose Bullet' telah dipilih sebagai bentuk yang sedia ada kerana ia mempunyai aerodinamik yang tinggi dan kadar penembusan yang lebih baik. Solidworks SimulationXpress dan ANSYS Fluid Flow (FLUENT) adalah perisian yang akan digunakan dalam kajian ini. Hasil kajian yang didapati dari analisis Statik linear menerangkan bahawa kenaikan dalam rekabentuk dan susutan dalan tekanan Von Mises menjadikan peluru itu lambat untuk musnah dan penembusannya lebih baik. Ramalan 'fatigue' dapat diperolehi dengan menggunakan pengiraan Newton interpolasi polinomial, yang menunjukkan bahawa penambahbaikan reka bentuk akan mengalami kemusnahan yang lebih perlahan kerana nilai tekanan awal yang diaplikasikan, *x* dalam peningkatan rekabentuk adalah lebih tinggi berbanding rekabentuk yang sedia ada. Tambahan pula, kesahihan rekabentuk peluru juga disahkan dengan pengiraan pekali variasi (CV). Mengikut pengiraan CV, penambahbaikan rekabentuk mempunyai peratusan CV yang lebih rendah berbanding rekabentuk yang sedia ada dan disebabkan itu, prinsip Bernoulli boleh digunakan dalam kajian ini. Peningkatan halaju peluru juga berlaku secara serentak dengan penurunan tekanan semasa peningkatan ini berlaku. Justeru itu, pelaksanaan lengkung peralihan berbentuk C dalam reka bentuk penambahbaikan dapat meningkatkan kestabilan peluru dan mempunyai rintangan yang rendah semasa gerakan peluru di sepanjang trajektori. .

DEDICATION

Special dedicated to my beloved parents, Mr. Abul Jalil bin Hashim and Mrs. Rosmaina binti Saripp who are caring, understanding, supportive and patience in helping me physically and mentally. Thanks a million to my lovely siblings, honourable lecturers and fellow friends for all the encouragements, guidance and patience in completing my final year project. My prayers upon all of you will be embedded in my heart whenever I go and whenever I think about you.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

2D	-	Two Dimensional
3D	-	Three Dimensional
CAD	-	Computer-Aided Design
CAGD	-	Computer-Aided Geometric Design
CFD	-	Computational Fluid Dynamics
CV	-	Coefficient of Variation
DE	-	Design Efficiency
F	-	Force
FEA	-	Finite Element Analysis
FEM	-	Finite Element Method
FVM	-	Finite Volume Method
P	-	Pressure
PH	-	Pythagorean Hodograph
S_f	-	Factor of Safety
TET10	-	Tetrahedral Element
t	-	Time
v_i	-	Input velocity
v_0	-	Output velocity
$\geq$	-	Greater than or Equal to
$>$	-	More than
$<$	-	Less than
$=$	-	Equal to
φ	-	Phi

CHAPTER 1

INTRODUCTION

This chapter provides the general ideas of the research study, which provides five main sections, started with the background of research study and continued with the problem statement. Besides, the significance of this research study will be briefly explained through this chapter. Furthermore, the objectives of this research study are also stated in this chapter. This chapter will end with the explanation of the report organization.

1.1 Background of the Study

Engineers and designers have interacted over long distances for thousands of years to have a good environment in terms of work. They have to find a good workspace in order to gain inspiration. The term inspiration is defined as a power or influence that makes somebody want to do or produce something by person, place, nature, curve, abstract, and others as a role of solving a problem. One source of alternatives inspiration that help engineers and designers is curve. The curve should be monotonically varying in such curves, since it dominates the changes of reflected images on curved surfaces (Yoshida et al., 2009).

One of the examples of curvature is a transition curve. Transition curve defines as radius of a curve where a complete gradual transition from the straight to circular curve with the curvature changes from zero to a finite value (Yahaya et al., 2008). This curve is important in manufacturing industries because it has been used in the cutting paths for numerically controlled cutting machinery, non-holonomic robot path planning, highway or railway designing and spur gear designing (Habib and Sakai, 2013).

Curve design is essential for utilization in Computer Aided Geometric Design (CAGD). It is applied to create the suitable curve, which meets the satisfaction with all the properties of designing a curve. The process will be continued to develop this curve in manufacturing practices such as in self-defense application. In this research study, the design of C-shaped transition curve will be applied to round nose bullet. Baass (1982) proposed five design templates to be applied in designing a C-shaped curve. Thus, one of the chosen templates that is applied in this research study is C-shaped transition curve (Baass, 1982)

The round nose bullet is chosen as the bullet's profile because of its high aerodynamic and better penetration (Russ, 2014). The round nose bullet is defined as the bullet that can penetrate hard regions. According to Charles (1990), round nose bullet is good for penetration rather than deflection because it has high velocity, sharp edges of leading and low resistance of the initial target. This kind of bullet is mainly utilized in revolvers as the accuracy of the bullet is high and it is suitable for practice (Partizan, 2013). The selection of round nose bullet is also due to its shape which is identical with the mathematical concepts. Hammond (2013) stated that the shape of the round nose bullet torso is cylindrical and the tip is round. This will explicit the good ballistic properties in round nose bullet.

1.2 Problem Statement

In the manufacturing industry, the study of aerodynamics is vital to improve the design efficiencies and performance. Aerodynamic shape optimization has risen in popularity ever since, even among researchers from industry (Gagnon, 2015). The impact and the aerodynamic features are determined by the shape of a bullet (Jeffry, 2014). The accuracy of the bullet whether it hit the target is depended on high aerodynamic. Besides, Nygaard (2013) defined that the tip of the bullet is usually pointed which is called an ogive (curve). Leghorn (2013) also stated that the tip of the bullet is circled in the spherical shape and not particularly aerodynamic.

Furthermore, the drag force is considered as the most important type in aerodynamic force. This drag force is essential in spin-stabilized for the bullet. The purpose of the spin is to stabilize the trajectory of the bullet (Vincent, 1998). The trajectory is defined as the path of the motion of a bullet via air. Therefore, this drag force can decrease the velocity of the bullet. It is because the direction of a drag force is different than the direction of a bullet while trajectory via air. Figure 1.1 shows the direction of aerodynamic force.

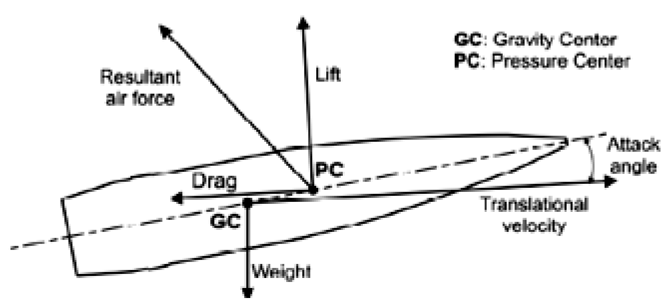

Figure 1.1: The direction of aerodynamic force (Garibaldi et al., 2008)

According to Jeffry (2014), manufacturers tend to improve the shape of bullet continuously. To get the perfect bullet, the manufacturers try to get the appropriate combination of materials and shape (Jeffry, 2014). The effectiveness of the bullet can be increased by improving the shape of the bullet (Andrew, 2011). Aerodynamic features are vital in the shape of the bullet because the force of rotation can stabilize the motion of the bullet (Jeffry, 2014). Meanwhile, the selection of material is also important to attain the objectives of bullet impact (Jeffry, 2014). Regularly, lead is chosen as the material of the bullet (Billsbury et al., 1997). Furthermore, Billsbury et al. (1997) stated that lead provide a low toxicity, low cost, and high density material which is usually used in ammunition practice. Thus, the best combination of shape and materials will produce a perfect bullet for penetration. The performance of the bullet is will also increase as it is easy to manufacture with the combination of materials and shape.

In this research study, C-shaped transition curve is chosen as the line of curvature due to its high-profile design. Walton and Meek (1999) highlighted that the specialty of C-shaped transition curve is, it has its own curvature compared to the other curve design. The bullet with high aerodynamic force enables to overcome the resistance of wind and impact in the improvement of the bullet performance. To produce high aerodynamic bullet, C-shaped transition curve is suitable because it can withstand the undesirable curvature extreme and exhibit the smooth variation of curvature.

By using the design of C-shaped transition curve, the purpose of high-profile curve definition can be achieved. Moreover, this research study is focused on the aerodynamics of the round nose bullet's profile design. Hence, the round nose bullet's profile design using the concept of C-shaped transition curve will be supported by the simulations.

1.3 Significance of the Study

This section will describe the product designs that successfully used transition curve in their application. Manufacturers had found ways to overcome the problems confronted in the industries. Generally, the industries that involve are civil engineering, mechanical engineering, and also manufacturing engineering. There are several improvements made by these industries such as highway and railway design, vase design and spur gear tooth design. Hence, the next paragraphs will explain about these three applications using transition curve design.

In civil engineering, the design of highway and railway has been improved to meet the satisfaction and safety of the users. Normally, drivers tend to make their own transition curves by moving indirectly within their lane and sometimes exceeding their own lane when transition curves are not provided. This will dangerously impact them and also the other users. Thus, designers and manufacturers had found a solution to solve this problem by designing transition curve in highway and railway. Figure 1.2 depicts the example of highway design.

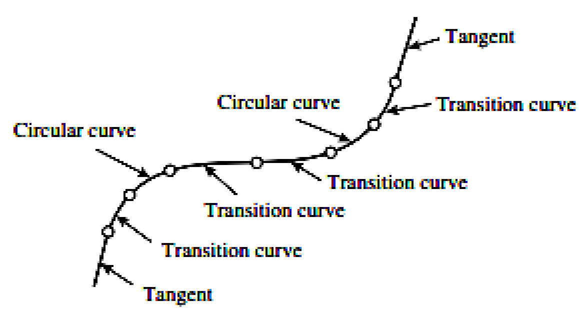

Figure 1.2: Example of Highway Design (Argyroudis et al., 2014)

Next, vase design is one of the product designs that using a C-shaped and S-shaped transition curves in its application. According to Yahaya et al. (2008), three forms or shapes to design a vase is proposed based on three division's profile. The first and second division is known as S-shaped, while the third division is a C-shaped (Yahaya, 2008). Figures below illustrate the vase design using C and S-shaped transition curves.

Figure 1.3: Vase design using C and S-shaped transition curve (Yahaya, 2008)

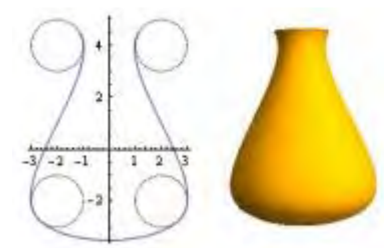

Figure 1.4: Modification of vase design (Yahaya, 2008)

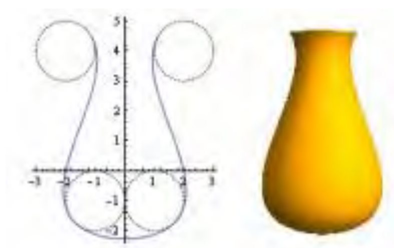

Figure 1.5: Center point modification of vase design (Yahaya, 2008)

Subsequently, Figure 1.3 explains about the method used in designing a vase.C and S-shaped transition curves are chosen to design the curvature of vase according to its shape parameter. Figure 1.4 shows the modification of vase design when the radius has been reduced from 1 to 0. The modification proceeds in Figure 1.5 with the transformation of the center points, but the value of shape parameter used is similar as before.

Meanwhile, an involute curve is utilized by designers to design a spur gear tooth. To create involute curve, it is generated by tracing point method. The application of S-shaped transition curve is used in this product design because it can produce a direct curve without using the method of tracing point (Yahaya et al., 2008). Figure 1.6 demonstrates the S-shaped transition curve in spur gear tooth design.

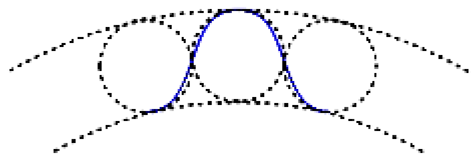

Figure 1.6: S-shaped transition curve in spur gear tooth design (Yahaya, 2008)

1.4 Research Objectives

The objectives of this research study entitled bullet's profile design by using a high profile curve definition are listed as follows:

i. To study the concept of C-shaped transition curve

ii. To apply a C-shaped transition curve in round nose bullet design

iii. To redesign the existing model (round nose bullet) using Solidworks Software

iv. To analyze both existing and improvement designs using the methods of analyses

v. To validate between the existing and improvement designs using Design Efficiency (DE) and Coefficient of Variation (CV)

1.5 Report Organization

This report begins by discussing the background of the research, problem statement, significant of the study, research objectives and report organization. Initially, research background will explain about the transition curve and the reason of using a C-shaped transition curve as a method for an improvement design in round nose bullet design. Furthermore, the discussion about the problem related to the existing or current round nose bullet design profile will be clearly stated. The significance of this study continues in this chapter which will highlight about the contribution to the engineering and manufacturing industries. Chapter 1 also focuses on the explanations on the research objectives and report organization.

Chapter 2 reviews the history of the bullet, bullet terminology, general types of the bullet, the ballistics of the bullet and the method in designing a bullet nose. This chapter will begin with the definition of ammunition and its component, followed by the definition of the projectile and its features in bullet terminology. The explanation about the bullet design and its feeding reliability will discuss through this chapter. The general types of the bullet such as round nose bullet, hollow-point bullet, wad-cutter bullet and semi-wadcutter bullet will also be described. Chapter 2 also reviews the ballistics of the bullet for example, the internal, external and terminal ballistics. Method of designing a bullet nose, such as conical, elliptical, tangent ogive, secant ogive and power series is also covered in this chapter. Templates of curve design will also highlight in this chapter namely, an S-shaped, C-shaped, J-shaped, straight line to the straight line and circle to circle where one circle lies inside the other with a C transition.

Chapter 3 describes the process flow and the methodology of this research study. This chapter explains an introduction to bullet's profile design and the high profile curve definition using C-shaped transition curve. Furthermore, the process flow diagrams of designing the round nose bullet profile design models for existing and improvement designs will be depicted in this chapter. The 2D and 3D design models will be