UNIVERSITI TEKNIKAL MALAYSIA MELAKA

THE USE OF SNAKEHEAD FISH BEHAVIOR IN ROUND NOSE BULLET DESIGN

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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DECLARATION

I hereby, declared this report entitled "A Study of Bullet's Profile Design using Snakehead Fish's Aerodynamic Concept" is the results of my own research except as cited in references.

Signature : ……

Author's Name : ……

Date : ……

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Design) (Hons.). The members of the supervisory committee are as follow:

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(Supervisor)

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(Co-Supervisor)

ABSTRACT

In this modern era, the conflicts and violence acts are increasing which give an impact to the manufacturing of bullet due to the demand is high. Thus, the manufacturing industry has to improve the performance and design efficiency of the bullet in order to fulfil the market requirement. One of the issues that the manufacturer has to face is the aerodynamic effects on the bullet. The shape of the bullet will determine the impact and aerodynamic features of the bullet and the effectiveness of bullet can be maximized by improving the shape of the bullet. The concept of nature design of snakehead fish (BID) is then proposed to overcome this effectiveness issue. Round Nose Bullet is chosen as an existing design due to have the similar profile when compared to the snakehead fish. SolidWorks SimulationXpress and ANSYS Fluid Flow (FLUENT) are the software utilized in this research study. The results obtained in Linear Static Analysis depict that the improvement design tends to be mushroom shape due to the greater deformation while the Von Mises Stress is then small. Based on the computation of Newton interpolation polynomial, the prediction of fatigue can be obtained. From the computation, the existing design will experience the failure mode when the initial pressure applied, $x \geq 300.921526\times10^{6}$ while for improvement design is $x \geq 472.250888\times10^{6}$. Besides that, consistency of bullet design is also measured by employing Coefficient of Variation (CV). Based on the calculation of CV, improvement design has the lowest percentage when compared to existing design. Due to that percentage, this bullet design has increased in the number of the spin of the bullet which makes the bullet more stable during trajectory. Therefore, the snakehead fish profile design applied in improvement design is better than an existing design due to the structural and dynamic analyses that are shown.

ABSTRAK

Pada zaman ini, konflik dan keganasan sering berlaku sehingga memberi kesan kepada pembuatan peluru kerana permintaan yang tinggi. Oleh itu, industri pembuatan peluru perlu mempertingkatkan prestasi and kecekapan rekabentuk untuk memenuhi keperluan pasaran. Salah satu isu yang dihadapi oleh pengeluar adalah kesan aerodinamik terhadap peluru. Rekabentuk peluru akan menentukan kesan dan ciri-ciri aerodinamik peluru itu dan keberkesanan peluru boleh ditingkatkan sehingga maksimum dengan cara mempertingkatkan rekabentuk peluru. Konsep rekabentuk semulajadi ikan haruan telah dicadangkan untuk menangani isu keberkesanan ini. Round Nose Bullet telah dipilih sebagai rekabentuk sedia ada kerana profil peluru ini serupa dengan profil ikan haruan. Perisian SolidWorks SimulationXpress dan ANSYS Fluid Flow (FLUENT) akan digunakan dalam kajian ini. Hasil kajian yang akan dapat dari analisis Statik linear adalah rekabentuk penambahbaikan cenderung menjadi bentuk cendawan kerana perubahan yang ketara manakala Von Mises Stress adalah kecil. Berdasarkan interpolasi polinomial Newton pengiraan, ramalan 'fatigue' boleh didapati. Pengiraan tersebut menunjukkan rekabentuk sedia ada akan berada dalam keadaan gagal apabila nilai tekanan awal yang telah diaplikasikan, $x \geq 300.921526\times10^6$ manakala untuk rekabentuk penambahbaikan nilai $x \geq 472.250888\times10^6$. Selain itu, rekabentuk peluru yang konsisten diukur dengan menggunakan pekali variasi (CV). Berdasarkan hasil keputusan CV, rekabentuk penambahbaikan mempunyai peratus yang terendah berbanding dengan rekabentuk sedia. Oleh kerana peratus tersebut, rekabentuk peluru ini telah meningkatkan jumlah putaran peluru yang menyebabkan peluru lebih stabil semasa trajektori. Oleh itu, profil ikan haruan yang telah diaplikasikan sebagai rekabentuk penambahbaikan adalah lebih baik daripada rekabentuk sedia ada kerana disebabkan oleh struktur dan analisis dinamik yang telah ditunjukkan.

DEDICATION

Specially dedicated to my father, Mr. Mohd Azam Bin Hj. Muzakir and my mother, Mrs. Siti Rabunah Binti Talip who are very understanding, caring, patient and supporting for help me mentally. Thanks a million to my lovely siblings, honorable lecturers and dearest friends for the guidance, patient and encouraging in my final year project. My prayers upon you will be embedded in my lips whenever I go and whenever I think of you.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

3D	–	Three Dimensional
BID	–	Biolgically-Inspired Design
CAD	–	Computer-Aided Design
CFD	–	Computational Fluid Dynamics
CV	–	Coefficient of Variation
d	–	Displacement
DE	–	Design efficiency
FDM	–	Finite Different Method
FEA	–	Finite Element Analysis
FEM	–	Finite Element Method
FVM	–	Finite Volume Method
P	–	Pressure
PDF	–	Partial Differential Equation
$\boldsymbol{S_f}$	–	Safety factor
TET10	–	Tetrahedral Elements
v_i	–	Input velocity
v_o	–	Velocity
σ_o	–	Von Mises Stress

CHAPTER 1
INTRODUCTION

This chapter contains the general ideas of the research study which provided four main sections such as the project background and problem statement. Besides, the research objective of this study is stated in this chapter. This chapter 1 ends with the description of the research scope.

1.1 Background of The Research

In this era of globalization, designers and engineers have to solve problems by searching for inspiration. In general, inspiration is defined as a force or influence that inspires human by nature, person, place and many more. One of the alternatives of inspiration that help designers and engineers are about the nature (Volstad and Boks, 2012). This inspiration by nature is an excellent source for designers and engineers who want to inspire processes, functions, ideas, behaviours and structures to convert from biological knowledge to engineering knowledge (Konez, 2011). It is because the nature provides an important model to solve designer's problem and engineer's problem (Denis and Carlos, 2014). For example, by using the nature as an inspiration, the ship is innovating with the nose of the dolphin as the model (Anonymous, 2005). As the result, the nose of the dolphin creates a pear-shaped of bow protuberance that enables the ship to have less resistance of water while sailing and give a lower of fuel consumption. Figure 1.1 and Figure 1.2 show the picture of Dolphin's nose and the picture of the pear-shaped on the ship.

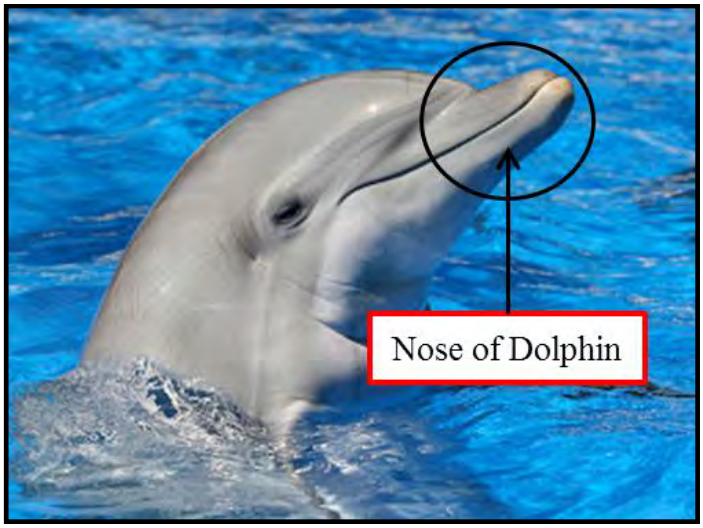

Figure 1.1: The Dolphin (Anonymous, 2010)

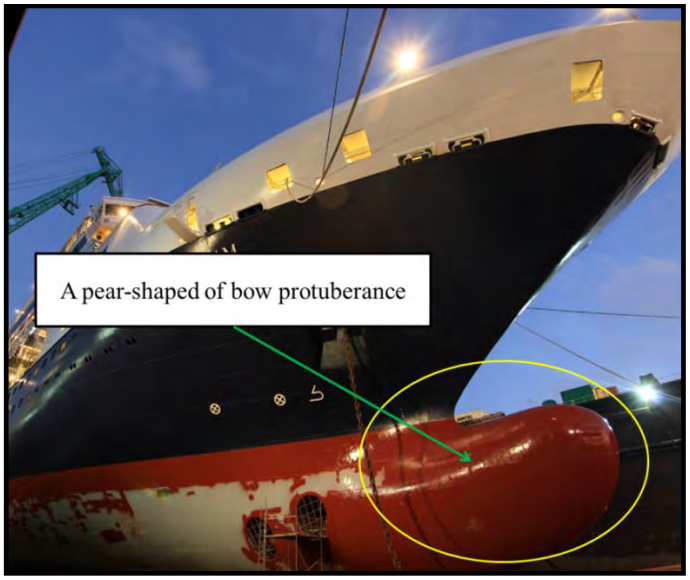

Figure 1.2: The ship that have a pear-shaped of bow protuberance (Anonymous, 2009)

Besides, the rough skin of the shark give the engineer an inspiration to develop a striped foil coating for the wings of aircraft. This innovation give benefit to aircraft which are the friction is low until six percents (Anonymous, 2005) and saving on fuel consumption. Figure 1.3 and Figure 1.4 show the rough skin of the shark and the picture of aircraft's wing.

Figure 1.3: The Shark (Anonymous, 2008)

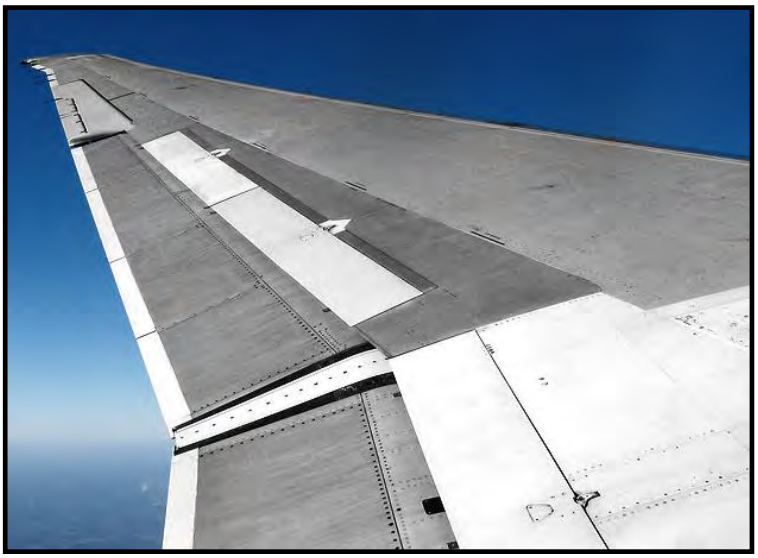

Figure 1.4: The wing of aircraft (Kuki, 2014)

Thus, the example stated on previous is known as biomimicry. At the 21st century, this biomimicry method becomes more interest and challenging amongst the engineer. It is challenging because it requires a breadth of knowledge in biology as well as engineering to fit the biological to the engineering (Weissburg, 2014). Moreover, Avinash (2014) said that biomimicry also recognized as Biologically-Inspired Design (BID).

Chakrabarti (2014) noted that BID is the design with inspiration from nature and developing a creative design to solve engineering problems. It is defined as a practice of taking ideas and concepts from the nature and implementing them into various fields such as design, engineering and architecture (Elmahdi, 2008). Since 1960s, the

BID has become important in improving the design and generating innovative ideas (Freitas, 2013). Benyus (1997) claimed that the objectives of BID are looking to the nature as a model, nature as a measure and nature as a mentor. Figure 1.5 depicts the viewing nature as a design model, measure and mentor.

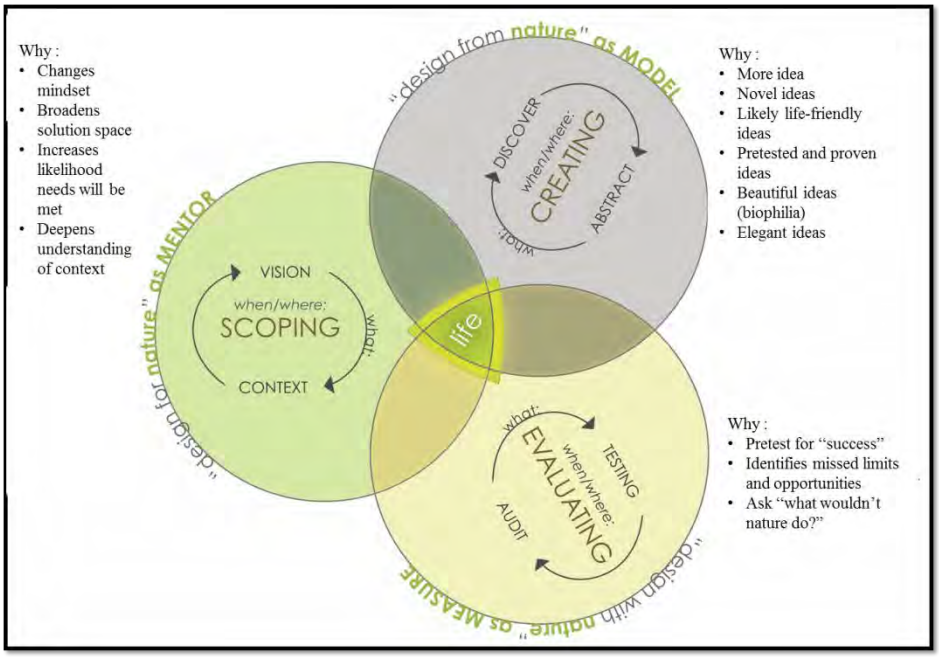

Figure 1.5: The viewing nature as a design model, measure and mentor (Curricula, 2009)

The nature as a model is referred to as the inspiration solution to solve such as the human problem in the field of science and technology (Chang, 2012). While, nature as a measure means to find out the accuracy of innovation in ecological and the nature as a mentor is used as a source where the characteristic and behaviour of the nature is imitated for science and technology purpose (Chang, 2012).

Moreover, the behaviour of BID can be employed in order to develop the related solution, especially in engineering problem. For instance, the wind turbine is redesigned by using whale fins as an inspiration. The researcher want lessen the noise generated by wind turbine and to improve the reliability of the wind turbine (Andy, 2009). Thus, this inspiration helps the wind turbine decreased the drag force, doubled the performance at speeds of 17 miles per hour, reduce turbulence over the surface and create more efficient of wind turbines (Anonymous, 2010). Benyus (1997) said that BID is a vital and well-known application in design method that fulfilled the environmental and sustainable development.

In general, this BID has two approaches of processes which are problem-to-solution and solution-to-problem. The problem-to-solution recognized as the problem-driven BID process needs to identify a problem, biologize the problem and the problem is solved biological (Vattam et al., 2007). Specifically, problem-driven BID process involves problem definition that need to define a specific or detectable problem of human life and for problem decomposition, it require understanding properly the meaning of the problem. While, biologize the problem means to innovate the problem in biological terms. In biological search, it needs to develop a solution that relate with the biological system. Continuously, understand the principles and techniques that used by the biologist to solve the problem via observation and experimentation. In principle extraction step, necessitates knowing the constraints of the solution that acquire. Lastly, the possible principles such as Hooke's Law will be discovered and apply the principle in project research. Figure 1.6 shows the procedures of the problem-driven BID process.

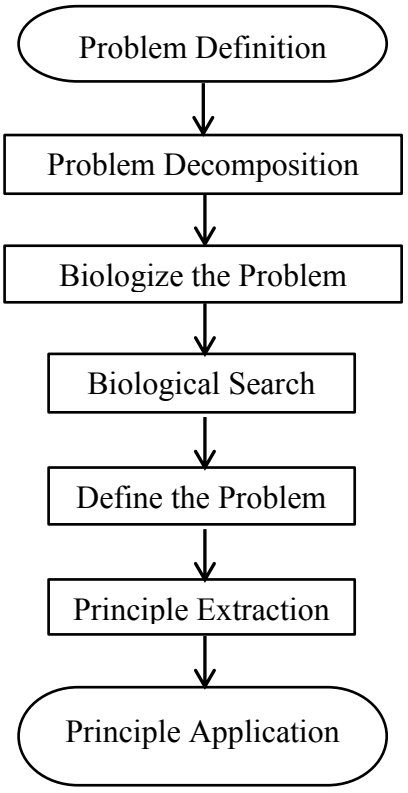

Figure 1.6: The process flow diagram of the problem-driven BID processes

On the other hand, the solution-to-problem or also known as solution-driven BID process includes the application biologically inspired solution, principle extraction

and principle application (Vattam et al., 2009). The process begins with the biological solution identification which is observing the biological solution with the casual study. In define the problem, it needs to understand the problem properly and the principles that used to solve the problem. Then, implement the applicable principles that must be suited to the engineering field.

In the problem search, it requires to know the constraint of the solution and define a new problem or stay in the previous problem. The last procedure is principle application which leads to apply the possible solution principle in the problem which then solved smoothly. Figure 1.7 shows the procedures of the solution-driven BID process. The next section will be explained about some of example that using BID concept.

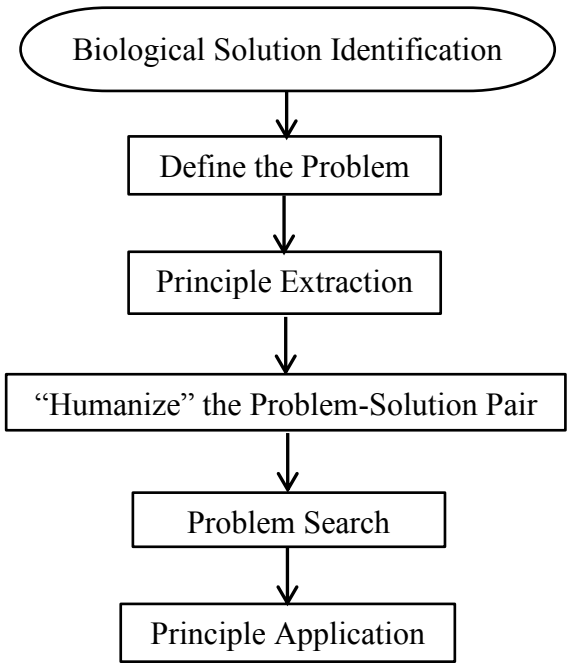

Figure 1.7: The process flow diagram of the solution-driven BID processes

1.2 The Application of BID's Concept

This section will be described the design project that successfully used Biologically-Inspired Design (BID) method. Abalone Armor is one of the examples of the Biologically-inspired design project. Abalone Armor is a bullet-proof vest which used material that combines the qualities of strength, toughness, and self-healing

properties. This project had used solution-driven BID approach and problem-driven BID approach to solve the problem. Firstly, the team for this project is determined to use abalone shell or also known as nacre as their inspiration. Then, prepared and organized the problem that could be solved by the impact-resistant nacre. The team uses the abalone nacre to settle the problem of conceptualizing a bullet-proof vest. By using the problem-driven approach, several characteristics in combination the quality of material which are the strength, toughness and self-healing is chosen. For the step of biologize the problem, search the organism that had the same characteristic as mentioned above and investigated six alternative biological sources of inspiration. Based on Table 1.1, there are six biological models that had been considered in this project. This table shows the reason for considering and the reason for rejecting. The first biological model is spider silk. The spider silk is considered due to its strength per weight ratio and it is rejecting due to possible to manufacture and not strength enough to avoid from knife wounds.

Then, the lobster exoskeleton is considered because it ability to blunt cracks by using overlapping plates but the process requires water in order to be effective and would not scale-up to level required by body Armor. Next, the reason for considering the sea star is its ability to generate entire structure from a small fraction of its original mass. While, the reason for rejecting is the process of regeneration is only available to bring organism and cannot be replicated in inorganic materials. The rhino horn is considered because the strength and it is able to regrow, but it had been rejecting due to unknown rejecting. Besides, human bone is being considered because the strength, ability to regrow and modestly flexible. It has been rejected due to healing properties of bone are not viable under normal circumstances and requiring a suspension in a solution of calcium.

The Abalone shell has been chosen as a source of inspiration due to the toughness, strength, and ability to reform itself. Then, focused on how abalone nacre reacted when it was applied on the forces at variety of time scales including the fracture characteristic on the bullet impact like fracture stress, minimum of initial crack size, strength intensity and surface energy. Table 1.1 depicts the biological models that considered in Body Armor design.

Table 1.1: Several of biological models applied for Abalone Armor (Vattam et al., 2007)

BIOLOGICAL MODEL	REASONS FOR CONSIDERING	REASONS FOR REJECTING
Spider Silk	Strength to weight ratio.	Manufacturing on the industrial scale is not currently possible and not resistant to knife wounds.
Lobster Exoskeleton	Ability to blunt cracks (dampen fractures as occur) using overlapping plates.	This process requires water in order to be effective and would not scale-up to level required by body armor.
Sea Star	Ability to generate entire structure from a small fraction of its original mass.	The regeneration process (through cell division) is only available to living organism and cannot be replicated in inorganic materials.
Rhino Horn	Strength and its ability to re-grow (the same way that finger nails re-grow).	Unknown.
Human Bone	Strength and its ability to re-grow. Also, it is modestly flexible.	Healing properties of bone are not viable under normal circumstances, requiring a suspension in a solution of calcium.
Abalone Shell	Toughness, strength, and ability to reform itself.	Accepted

The analysis (as shown in Table 1.2) showed that body armor made from abalone shell would be one hundred times powerful to stop a bullet. The characteristic of self-healing mechanism was excluded from the criteria due to the mechanism was not well understood. In addition, Abalone Body Armor would ten times heavier than Kevlar Body Armor. Despite there is a light-weight characteristic, the problem definition does not state about the weight characteristic. Thus, the team had chosen Abalone Body Armor as their biological inspiration for bullet-proof vest problem. Table 1.2 depicts the different between Kevlar and Abalone Vest. Figure 1.8 and 1.9 shows the picture of Abalone shell and Kevlar Body Armor.

Table 1.2: Kevlar and Abalone types of vest (Vattam et al., 2007)

CRITERIA	KEVLAR	ABALONE
Thickness	0.6 cm	0.9 cm
Weight	2.3 kg	20.5 kg
Stress	2.6×10^7 GPa	2.5×10^5 GPa