UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND DEVELOPMENT FUNTIONAL PROTOTYPING FORMULA SAE KNUCKLE

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Electrical Engineering Technology (Bachelor's Degree in Manufacturing Engineering Technology Product Design) (Hons.)

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology (Bachelor's Degree in Manufacturing Engineering Technology Product Design) (Hons.). The member of the supervisory is as follow:

…….

(Engr. Hassan Bin Attan)

ABSTRACT

The goal of this project is to design and develop the functional prototyping of SAE steering knuckle. To achieve the goal, several approach must be followed in developing the knuckle. In this section, optimized and developed functional prototyping base from current knuckle using optimization tool that can generate idea to minimize the material consumption and maximized the stiffness of the knuckle. The measurement data is obtained via reverse engineering approach to generate conceptual design. The design is optimized with constraint on the structural integrity and compatibility with other components. Simulation was later done. To validate the design and further improvement. The new knuckle is produce via cadcam simulation and which was later transferred to actual CNC machining. Weight can be reduced through several types of technological improvements, such as advances in materials, design and analysis methods, fabrication processes and optimization techniques. After facing all the design implementations were achieves, the knuckle part can be fabricate according the design using CNC machine.

ABSTRAK

Matlamat projek ini adalah untuk merekabentuk dan membangunkan komponen “steering knuckle” untuk kereta formula SAE.Untuk memastikan projek ini tercapai, beberapa aspek pendekatan harus dikuti untuk membina komponen “knuckle” ini.Pada seksyen ini komponen yang terdahulu akan dioptimumkan menjadi lebih ringan dan kuat menggunakan perisian SolidThinking yang akan menjana idea dalam mengurangkan penggunaan bahan dalam masa yang sama dapat menjadikan komponen yang akan di buat ini lebih ringan dan lebih kuat.

DEDICATION

Dedicated to my father, MdSalleh B Sarbini and my mother, MarziahBtSazali. To my supervisor, Engr Hassan Bin Attan, co-supervisor, Mr. MohdQadafie Bin Ibrahim, lecturers that helping machining Mr. ShahrulAzwan Bin Sundi@Suandi, Mr. SyafikJumaliand friends for all of their help and friendship.

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INTRODUCTION

1.1 Background

The project focus on optimizing and fabricating the current knuckle design for formula SAE and also fulfill the requirements meet the specification needed for the knuckle. Thedesign is simplified in term of the weights and also eliminates time consumption when machining process. The knuckle are specified for formula SAE usage for maximum durability performance when cornering and braking. Theknuckle are made by aluminum that can reduce the weight and ease to machining. The knuckeis parts of SAE car that provide the interface connecting the upper and lower suspension arm that connect to the knuckles using ball joints with the spindle middle of the knuckle. The optimization approach is using solid thinking software that can generate idea to minimize the material to be used and maximized the load with using minimum thickness of knuckles.

1.2 Problem Statement

The current knuckle is made much heavier because the designs not use the optimization to minimize the weight accordance with the weight of the car. In industrial design, the optimization should be a must because it can reduce the amount of material usage and also reduce the costing to ensure no wastage happen. The improvise design should be done by optimizing from the current design to compare how does the upright can be perform maximum force with minimum thickness. The upright also should be ease to assemble to the formula SAE car.

1.3 Objective

- Tostudy existing design, conduct reverse engineering and create 3D modeling of of knuckle.

- To conduct design optimization to reduce the weight whilst maintaining structure integrating.

- To fabricate and test a functional prototype of SAE knuckle.

1.4 Scope and Limitation

The scope is to optimized and developed functional prototype base from current knuckle using design software that can generate optimization knuckle design,to minimize the material consumption and maximized the stiffness of the knuckle. The ideation to developed new knuckle design depends on the percentage of material to be reduced. The new shape of knuckle appear when the software generate and calculate base on how the constraint and the force to be placed. The new concept idea is exported to CAD data and the new solid part will be modeled using Solidworks software.The part will be fabricated using CNC machining and fitted to the actual SAE car for future testing.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter explains about the fundamentals and designs approach how the knuckle is made and also the suitable material and fabrication used in making this knuckle. Besides that, this chapter will discuss about the criteria to be needed for developing the knuckle.Knuckle is a component that connects to the control arm which is the knuckle is assembled with to the wheels allowing the car to move. The knuckle contains the brake disk, the caliper, the hub, bearing and spindle is attached to the knuckle part. This hub connect to the wheel allow the wheel is spinning in one direction. The bearing is the most important component that to be use in knuckle. The bearing is pressed into the center of knuckle for enable the shaft and spindle were assembled. The knuckles assembled with the suspension arm and securely mount and aligned with the chassis. The main function of the knuckle to give and interface connection to the upper and lower ball joints with the suspensions arm.

2.2 Steering knuckle for SAE

Steering knuckle was used as component for study. Main design and functionalityof steering knuckle depends on type of suspension implemented. Additional factors like brake caliper used, mounting of tie rod of steering sub-system also effects knuckle design. Suspension system in any vehicle uses different types of links, arms, and joints to let the wheels move freely; front suspensions also have to allow the front wheels to turn. Steering knuckle/spindle assembly, which might be two separate parts attached together or one complete part, is one of these links. (Sharma, Mevawala, Joshi, & Patel, 2014)

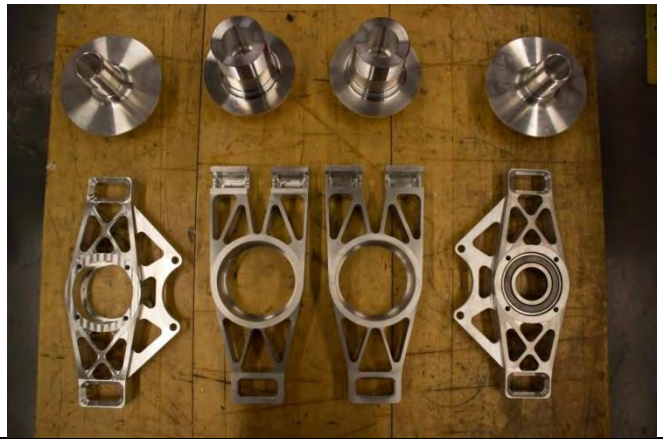

Figure 2.1 : SAE steering knuckle design (fsae.cooper.edu)

2.3 Steering knuckle design

The knuckle design must be reduce weight and maximized the stiffness. And also the design must be ease to machining. Several criteria must be considered in order for fabrication purpose. The parameter and constraint is important to create the suitable design to ensure the knuckle can be use and fitted to the SAE car. The design shape of knuckle depends on the weight, torque and speed of car. The material selection used to fabricate this part has to be strong, stiffness and have tensile strength. In order to get the great design of knuckle, the optimization and simulation analysis has to be done. The knuckle design should be withstand maximum braking force and cornering force.

To observe maximum stresses and deformation of steering knuckle when different forces such asbraking force, load transfer during acceleration and braking etc. are applied on it static analysis is performed(Sharma et al., 2014).

The lighter steering knuckle may produce greater power and less vibration, results from the less inertia. Besides need to be as light weight as possible, the component also must be very strong and rigid, due to harsh and high time varying loads for the race car driving conditions(Razak, Yusop, Yusop, & Hashim, 2014).

2.4 Design Approach.

To make the knuckle design can withstand maximum load, the optimization of weight and thickness need to change regularly by using previous simulation data. The optimization need to be focused on the limitation and the constraint. It is defined as the component that would be assembling to the knuckle such as the arm suspension, ball joint and brake caliper. The thing need to be considered for designing the knuckle is the weight distribution of forces and the braking force. In the meantime, the manufacturing process to fabricate this part need to take place because the design shape can effects the material consumption.

The design of the upright was a simple task once all of the data involved was collected. By using a sketch with all of the important points a bearing cup for the bearing to be press fit into was designed and used as the center for the upright. As all of the forces are centered on the bearing this was the most important part of the upright to keep strong.(Davis, Carney, Leith, & Kirschner, 2011).

The optimized design was then remodeled in the Solidworks to get the accurate shape and dimension.the new design was checked parallel with a series of analysis simulation to improve the handle ability, response and stability for the new design. The new design need to be fabricated as easy as possible without secondary machining process that could affect the strength of the new design.(Lumpur et al., 2014).

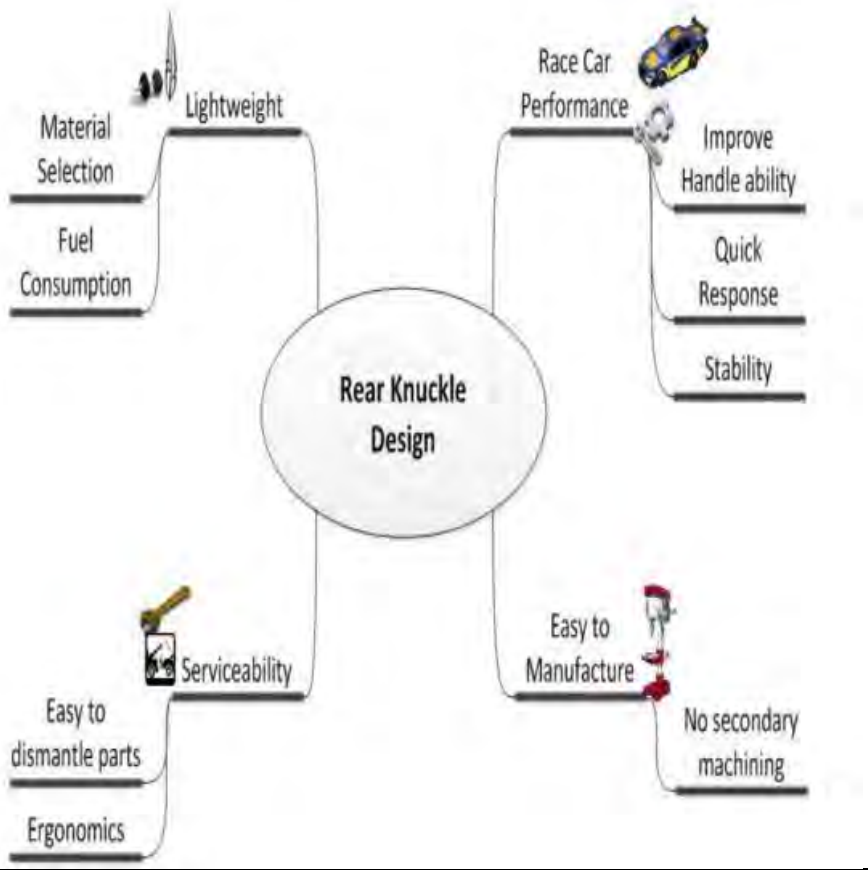

Figure 2.2 : Rear Knuckle Design Mind Map

2.4.1 Design Parameters Optimization

The steering knuckle assume a vital part they are the basic and supporting piece's of the suspension framework, they shape an association between the wheel like tire, edge, brake, plate, center on one side of the suspension framework like lower and upper wishbones, push bar arms controlling arm or toe-in arm. The brake caliper is likewise associated with it.The criticality of the knuckle part is considered as an un-suspended body, but it is subjected to very high stresses. Due to the various movement of the vehicle from different road conditions, braking and also moving of suspensions, which create continuous stresses on the knuckle.The upright outline depends intensely on the decision of bearing and axle assembly. There are a wide range of approaches to design the half-shaft/axle interface, for the most part because of the live axle, which is needed

of a back upright. Some upright outlines fuse a bigger bore in the inside to include an all together concentric ball joint and spindle bearing.

The suspension components covered in this paper include control arms, steering knuckles, spindles, hubs, pullrods, and rockers. Key parameters in the design of these suspension components are safety, durability and weight. (Jawad & Polega, 2002)

Shape optimization is technique to modify the structural shape based on predefined shape variables toobtain optimal shape. Size optimization defines ideal component parameters, such as material values, cross- section dimensions and thicknesses. Shape optimization is different from topology optimization in that it is used once the component's topology has already been defined(Sharma et al., 2014).

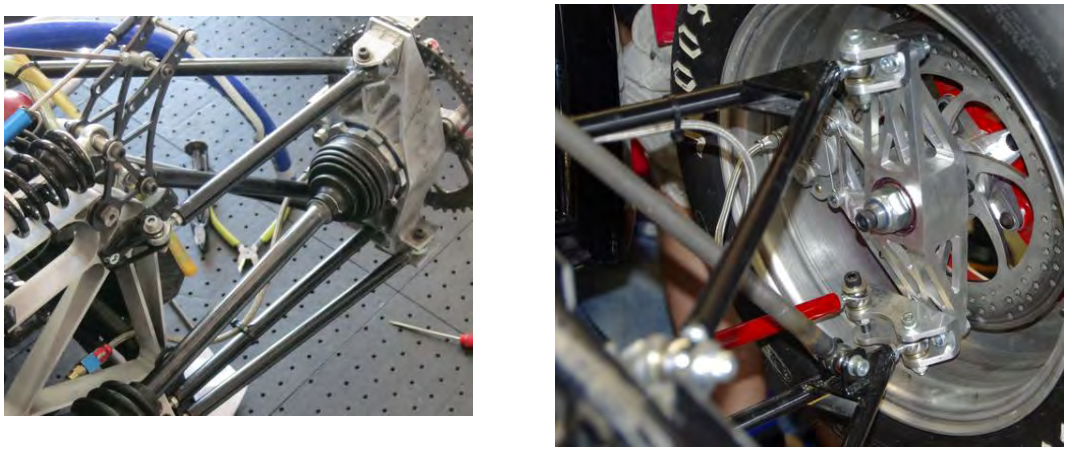

Figure 2.3 :SAE Design Parameters (https://www.formulastudent.de)

For the purpose of the application on a high performance, racing vehicle, it has to meet the following criteria:

• Lightweight to maintain good performance to weight ratio of the race car

• Optimum stiffness to ensure low system compliance and maintaining designed geometries.

• Ease of maintenance for enhancing serviceability and setup repeatability

• And for the purpose of this team, ability to manufactured the components in-house to reduce turnaround time and outside dependability.

(Garde, Shinde, & Jirage, 2014)