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Static Structural Analysis of A Skateboard Wheel With Different Materials

Aytek Kerem Küçük[1], Okan Gül[*2]

[1]Mechanical Engineering Department, Kocaeli University, Türkiye
[2]Mechanical Engineering Department, Kocaeli University, Türkiye

*(okan.gul@kocaeli.edu.tr)

Abstract – Skateboarding starts shrouded in mystery. We do know that it first started in the1950s, when all across California surfers got the idea of trying to surf the streets. No one really knows who made the first board. This sport, which is practiced by young people all over the world, is very common with the effect of being a place of origin especially in the USA, and it is assumed that it is practiced by approximately 7 million people. Due to this intense interest, there are thousands of stores and skate parks besides hundreds of related brands. In this study skateboard wheel with different materials were compared according to static structural analysis results. Firstly, a skateboard wheel design was made and this skateboard wheel design was analyzed using the ansys finite element method. ABS (high impact plastic) and Carbon Fiber was used as skateboard wheel materials. ABS is cheap material that allows mass produced wheels. Which makes skateboards way cheaper. On the other hand, Carbon Fiber is very expensive and needs more time to produce. Carbon fiber is way more durable than ABS plastic. But its riding quality and the cost is lagging behind ABS plastic.

Keywords – Skateboard, Wheels, ABS, Carbon fiber, Static Structural Analysis

I. INTRODUCTION

A skateboard is a kind of toy/equipment used for a recreational /sports activity called skateboarding. It basically is a piece of board with wheels attached beneath it. Skateboards consist of: The Deck (usually made with maplewood board), The Truck (usually made up of metal) and is used to connect the wheels and bearings to the deck. A skateboard is pushed by one leg while another leg remains on the board. If the rider uses his/her right foot as leading foot then he is said to be riding 'Goofy, ' or if their leading foot is left foot then he/she is supposed to ride 'Regular' and if a rider is usually 'goofy.'but rides in 'regular' stance and vice versa then they are meant to riding in 'switch' [1]. The real image of the skateboard is seen in Fig. 1.

Skateboarding starts shrouded in mystery. We do know that it first started in the1950s, when all across California surfers got the idea of trying to surf the streets.

Fig. 1 The real image of the skateboard

No one really knows who made the first board instead, it seems that several people came up with similar ideas at the same time. Several people have claimed to have invented the skateboard first, but nothing can be proved, and skateboarding remains a strange spontaneous creation. These first skateboarders started with wooden boxes or boards with roller skate wheels slapped on the bottom [2].

Like you might imagine, a lot of people got hurt in skateboarding's early years. It was a sport just being born and discovered, so anything went. The boxes turned into planks, and eventually companies were producing decks of pressed layers of wood similar to the skateboard decks of today. During this time, skateboarding was seen as something to do for fun after surfing. This sport, which is practiced by young people all over the world, is very common with the effect of being a place of origin especially in the USA, and it is assumed that it is practiced by approximately 7 million people. Due to this intense interest, there are thousands of stores and skate parks besides hundreds of related brands. Apart from this, although this sport has become more widespread in European countries, especially with the effect of the economic conditions of the countries, there is interest in this sport in almost every country of the world [1].

The love for the sport of skateboarding in Brazil, on the other hand, has led the youth, who somehow overcome the economic difficulties, to adopt skateboarding as the most common sport after football. In Japan, which is one of the countries where skateboarding is most common in the Far East, skateboarders complain about the rude behavior of the police and the breaking of their skateboards without explanation, the non-skid plates that they encounter frequently, and the fact that skateboard parks are only in big cities. Japan also has its own skateboard brands in the U.S. It is one of the rare countries outside of Canada, such as Germany [2].

II. Materials and Method

Wheels are usually made of polyurethane and come in different shapes and sizes depending on belt styles. Wider gauges, such as 65–90 mm, turn faster and move more easily over obstacles such as small stones in the route. Smaller gauges, such as 48–54 mm, keep the board closer to the ground, require less energy to accelerate, and create a lower center of gravity, but not as fast as larger ones.

Wheels also have varying degrees of hardness, which can be measured with a measuring instrument called a durometer. The wheels range from very soft (about 75A) to very hard (about 99A). The endpoint on this scale is 100A; however, there are also wheels labeled 101A or more. Today, some manufacturers have put forward a more useful system instead of this scale and classify the wheels according to their hardness according to 'A' or 'D' scale [3].

Modern streetstyle skaters prefer smaller wheels (usually 48–55 mm) as they make it easier to perform kickflip and ollie moves. The choice of streetstyle sliders should also be quite hard models; Because soft and small models absorb a lot of energy, they cause the skateboarder to spend a lot of effort. In the vert style, it is more beneficial to use wider wheels (usually 55–65 mm). This style requires high speed, and small wheels both make it difficult to reach high speeds and cause easier balance loss on the ramp. Vert wheels are usually very stiff so they can spin faster. In the rare slalom style, even wider (60–75 mm) wheels are used, thus achieving the highest possible speeds. However, they must be soft and rough to facilitate sharp and over-turning. Even wider wheels are used in Longboarding and Downhill skateboarding. Dimensions range from 65 mm to 100 mm. Almost all of these wheels have a hard plastic hub, resulting in a thinner and lighter structure than a rigid polyurethane wheel. Skateboard filmmakers and videographers mostly use these wheels so that they can move easily and without shake on almost any surface with wide and soft wheels [4].

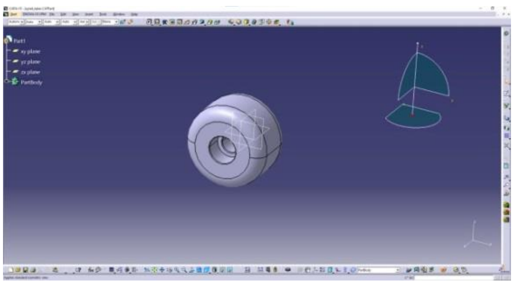

Fig. 2 Design of the skateboard wheel

Frequent shock impacts with ground during lifting and landing of the skateboard make the wheelers unguarded to sparking. To prevent this type of shock sparking and to ensure maximum safety – ABS plastic (Acrylonitrile Butadiene Styrene) is considered as the wheel materials due to its high flexural modulus, break strength, yield strength, toughness and specifically resistance to sudden impact [5]. A wheel design with dimensions of 54 mm diameter and 35 mm width was used in this study. Two different materials ABS (high impact plastic) and Carbon Fiber were used for skateboard wheel static structural analysis. The skateboard wheel design was designed by using the

Catia software program. The designed skateboard wheel is shown in the Fig. 2.

ABS is an engineering plastic that has butadiene part uniformly distributed over the acrylonitrile-styrene matrix. It possesses excellent toughness, good dimensional stability, easy processing ability, chemical resistance, and cheapness. However, it suffers from inherent shortcomings in terms of mechanical strength and vulnerability to environmental conditions. Furthermore, it is non-conducting and easily fretted. Plating on ABS can serve to enhance the strength and structural integrity as well as to improve durability and thermal resistance resulting in metallic properties on the ABS material. ABS is described as the most suitable candidate for plating because it is possible to deposit an adherent metal coating on it by only the use of chemical pretreatment process and without the use of any mechanical abrasion [3].

Carbon fiber composites are prohibitively expensive for a wide array of applications that would greatly benefit from their superior specific strength and specific stiffness. Replacing the market-dominant carbon fiber precursor material, polyacrylonitrile, with a low-cost alternative would significantly reduce the cost of carbon fiber production. Commodity polymers may provide such an alternative thanks to their abundance and ease of production into fibers. This review presents state-of-the-art carbon fiber production from polyacrylonitrile, an overview of melt-spinnable alternative precursors broadly, and an in-depth review of the latest advances in the synthesis of carbon fibers from low-cost, commodity thermoplastics such as polyethylene, polyamide, polystyrene, polyester, and poly(vinyl chloride). Carbon fibers are thin filaments containing at least 92 wt% carbon atoms arranged in planar hexagonal networks. Consequently, they possess high elastic modulus (up to 940 GPa for pitch-derived carbon fibers) and strength (up to 5.7 GPa for polyacrylonitrile-derived carbon fibers) as well as low density due to their atomic composition. Combining these fibers with a polymer resin matrix forms a composite material, called carbon fiber reinforced polymer (CFRP) composites, that can be formed into rigid components with tailored directional properties for great weight savings compared to conventional engineering metals. These properties have been leveraged in cost insensitive applications, such as motorsports, aerospace, and high-end sporting equipment. For decades, broader adoption has been limited by the high cost of carbon fiber production. CFRP composites have the potential to greatly improve the energy efficiency of human mobility, the productivity of renewable power generation, and resilience of domestic infrastructure if they were less costly. Accordingly, research and development has been focused on reducing the cost of CFRP composites by reducing the cost of producing carbon fibers. This would allow for broader application to address the most pressing socio-economic and environmental challenges worldwide [6].

III. Results and Discussion

The average weight of the skateboard rider was assumed to be 80 kg. The force acting on the skateboard was calculated as approximately 800 N. The force falling on a wheel was applied as an average of 200 N. Accordingly, the following tests were carried out. Total deformation, directional deformation and equivalent stress strain were calculated with these tests. A force of 200 N was applied from the middle of the wheel, keeping the bottom part of the wheel fixed. The purpose of this study is to compare wheel materials. It is aimed to determine the material with high efficiency. Fixed support area and force applied surfaces is seen in Fig. 3.

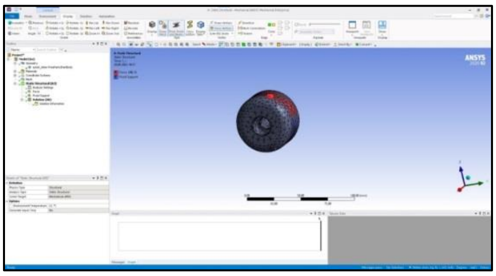

Fig. 3 Fixed support area and force applied surfaces

Static structure analysis was applied to the skateboard wheel with Ansys. As a result of the static structure analysis made on the wheel designed from ABS material, it was determined that the maximum equivalent elastic strain value was 0.00027425 mm/mm. The result of the analysis is shown in the Fig. 4.

Another result of the analysis for ABS wheel, the maximum total deformation value was obtained as 0.0019466 mm. The result expressing the total deformation is shown in the Fig. 5.

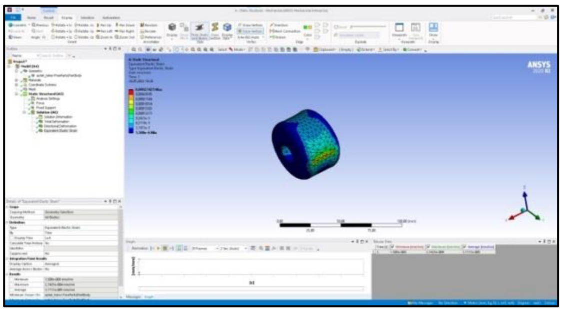

Fig. 4 Equivalent elastic strain on ABS wheel

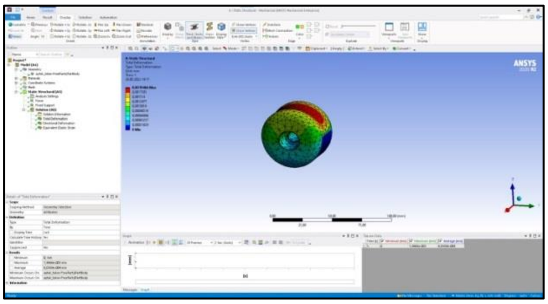

Fig. 5 Total deformation on ABS wheel

A result of the static structure analysis made on the wheel designed from Carbon Fiber material, it was determined that the maximum equivalent elastic strain value was 0.000039146 mm/mm. The result of the analysis is shown in the Fig. 6.

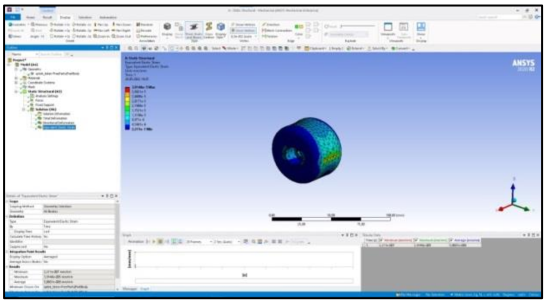

Fig. 6 Equivalent elastic strain on Carbon Fiber wheel

Another result of the analysis for Carbon Fiber wheel, the maximum total deformation value was obtained as 0.0019806 mm. The result expressing the total deformation is shown in the Fig. 7.

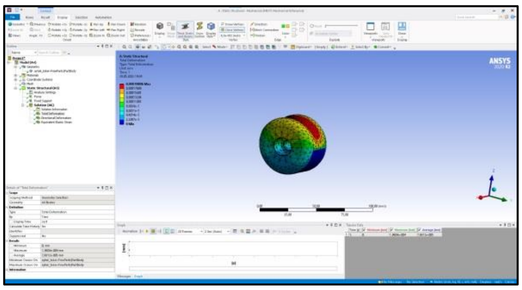

Fig.8 Total deformation on the Carbon Fiber Wheel

IV. CONCLUSION

In this study carbon fiber and ABS compared for skateboard wheel. Carbon fiber is a very durable and light material. These are the most prominent features. ABS has slightly less durability, but is also ahead of carbon fiber in terms of affordability and ease of manufacture. All things considered, ABS is more suitable for a skateboard wheel than carbon fiber. Because abs plastic is a composite material and it is really cheap compared to carbon fiber. Easier and faster to produce with cheapness. Rider can control the skateboard if wheel material chosen as ABS plastic. In summary, ABS makes more sense in certain aspects than other options for skateboard wheel material.

If the results are summarized;

- The maximum equivalent elastic strain value was 0.00027425 mm/mm for ABS wheel.
- The maximum total deformation value was obtained as 0.0019466 mm for ABS wheel.
- The maximum equivalent elastic strain value was 0.000039146 mm/mm for Carbon Fiber wheel.
- The maximum total deformation value was obtained as 0.0019806 mm for Carbon Fiber wheel.

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