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Chapter 1

Project Definition, Goals, Vehicle and Component

Project 1

Fatigue Analysis of Wheel Lug Stud/Wheel Lug Bolt

Vehicle:

Toyota RAV4 2015

Wheel Lug Stud

AME 3353

Design of Mechanical Components

Professor H. L. Stalfor

1.1 Project Definition and Goals

In this project, we are going to analyse the use of a lug stud and a lug nut in the wheels of the car. The analysis is based on Toyota RAV 4 2015 model. We will perform the stress analysis under numerous environments. The materials these studs and nuts are made from is crucial to the safety of the car and this topic will be explored. Different diagrams will be constructed and every theory – basic or complicated will be mentioned. We will also explore the different design scenarios. We will also explore the response of these studs and nuts due to a long-term fatigue. Based on this, we will also learn the life expectancy and how frequently we should get these parts changed.

1.2 Vehicle Information

The car that I am interested in is Toyota RAV4 2015, which a 5 seater SUV having a unique sporty look and is black in colour. It has a superb mileage of 24 miles per gallon and is an automatic shift. Its curb weight is 3445 lbs. The full capacity weight with passenger is not available, so we will have to approximate this information.

The average weight of a person is 137 lbs¹ and the average baggage that a person carries is 48 lbs².

$$\text{Total weight} = 3445 + 137*5 + 48*5 = 4370\text{lbs} \quad (1.2-1)$$

The full capacity weight of the car is 4370 lbs. Its height is 65.4 in, length is 179.9 in and width is 72.6 in without the mirrors³. The exact weight distribution is not known; however, it is mentioned that they have built the car with quite low centre of gravity for extra stability⁴.



Figure 1.2-1: Picture of the car



Figure 1.2-2: Front-right wheel



Figure 2: Stud on the wheel

Stud on the wheel is the mechanical components we are studying.

1.3 Mechanical Component

The lug stud is shown in the figure below.



Figure 1.3-1: Wheel lug stud

The following figure shows the stud in place in Toyota RAV4 2015.



Figure 1.3-2: Stud on the wheel

This is a 20 thread stud with .625 in of diameter and 1.78 in of length⁵.

1.4 Table of Data

Parameter	Description	Value in English Units	Value in Metric units
<i>W curb</i>	vehicle curb weight	3445 lbs	1562 kg
<i>W-full</i>	vehicle full capacity weight	4370 lbs	1982 kg
<i>Length</i>	Length of the car	179.9 in	4.57 m
<i>Width</i>	Width of the car without the mirror	72.6 in	1.84 m
<i>Height</i>	Height of the car	65.4 in	1.66 m
<i>CG</i>	Location of center of gravity of the car	Low cg	N/A
<i>Stud diameter</i>	Diameter of the stud	.625 in	.0156m
<i>Stud length</i>	Length of the stud	1.78 in	.045 m
<i>Stud thread</i>	Total threads in the stud	20 beads	20 beads

1.5 References

1 Quilty-Harper, Conrad. "The World's Fattest Countries: How Do You Compare?" *The Telegraph*, Telegraph Media Group, 21 June 2012, www.telegraph.co.uk/news/earth/earthnews/9345086/The-worlds-fattest-countries-how-do-you-compare.html.

2 "Wheel Stud 1/2 Ton, Each." *Wheel Stud 1/2 Ton, Each-Broncograveyard.com*. N.p., n.d. Web. 21 Jan. 2018.

3 "2015 Toyota RAV4 FWD 4-Door LE Specs." *The Car Connection*, www.thecarconnection.com/specifications/toyota_rav4_2015_fwd-4dr-le-se.

4 Allen, Author Markus. "29 Tips, Secrets and Surprises about the New Toyota RAV4." *TruthIn7Minutes.com*. N.p., n.d. Web. 21 Jan. 2018.

5 "Wheel Stud 1/2 Ton, Each." *Wheel Stud 1/2 Ton, Each-Broncograveyard.com*. N.p., n.d. Web. 21 Jan. 2018.

1.6 Level of Effort

I spent about 4 hours in this project. This was especially hard because I had to first find a car I could use for the project. I also took time out to visit AutoZone and have a look at the lug stud and get a feel for it. Since I don't have a car, I had to cycle there.