Design and Analysis of Two Wheeler Leg Guardfor Material and Shape Optimization

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Abstract. The growing demand for high performance engine technology in the two-wheeler market segment has pushed the average speed of the motorcycle to a higher limit, which has already raised the danger of motorcycle accidents leading to serious knee and lower tibia injuries. Vehicle designers, testers, and validators undergo rigorous design, testing, and validation processes based on the highest criteria for strength, weight reduction, enhanced fuel efficiency, etc., but with the fewest requirements for a vehicle's safety in an accident. The design of a leg guard for the popular Indian Pulsar 150 motorcycle. By changing the shape and material, a thorough investigation of strength is performed. We select three different materials, such as SS202, SS347, and SS440C. The leg guard for the pulsar was built, and its stress and deformation were assessed. The optimal configuration is selected from a total of six variants using the least weight and stress deformation.

Keywords: Leg guard, Stainless steel, Analysis, Impact loading, Compressive loading, Bending Loading

1. Introduction

In comparison to other countries, India has exceptionally high accident expenses, life injuries, and compensations as a result of accidents. By looking at the factors that lead to collisions, we can see that motorcyclists are the most vulnerable group and that they are far more likely to perish in a collision. Also taking into account the low cost of motorcycles, there are more motor vehicles in India, particularly in the capital city (approximately one million motorcycles, or 25% of all motor vehicles nationwide). Therefore, further research should be done to lessen the harm that accidents do to motorcycle riders. When motorcycle accidents are taken into account, it becomes clear that the legs are the most exposed part of the body. Front leg protectors for motorcycles are one of the most efficient ways to lessen the risk of harm.

The front guards of the motorcycle reduce the likelihood of significant injury when it collides with another vehicle or the ground. The leg is the most crucial portion of the body in motorcycle accidents. Therefore, a proper study of the leg protection is necessary to minimize this damage. Here we use two different shapes and three different materials in this instance, the performance of which may be anticipated after using varied stress situations.

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1.1. Leg Guard

Airbags and leg protectors are increasingly recognized as the two primary secondary safety equipment in several researches. About 60% of motorcycle riders suffer major leg injuries, most of which cause permanent disability. It has been argued that leg guards could help prevent similar accidents. Studies have revealed conflicting results about the effectiveness of leg protectors, with some studies claiming they would minimize leg injuries while others claimed they would even increase the risk of other types of injuries. To decrease this type of injuries, the shape and material of the leg guard need to be modified. The Material that is used in existing leg guard of pulsar is Stainless Steel of grade 202(SS202). Two more materials are taken into consideration for testing along with the existing material. And the best material is chosen for modification.

Materials used for testing and modification are:

- Stainless Steel Grade 202
- Stainless Steel Grade 347
- Stainless Steel Grade 440C

2. Literature review

The material of the leg guard needs to be upgraded to improve the strength with minimal weight, the model is tested under Bending, Compressive and Impact loads in ANSYS. When compared to the distance between the leg guard and the actual leg, the deflection under bending is also very low. There will be no failure in this situation because of the extremely low stresses under compressive force. With a yield strength of 500 kg, which is substantially more than the vehicle's actual weight of only 100 kg (Hero passion), stress under bending load is a cause for concern. If material c650 is switched out for the current material, the leg guard's weight bearing capacity will rise to 700 kg [1,11]. The chassis frame was subjected to various loading conditions, and the structural integrity of the chassis frame was examined by using other materials and alternatives geometries while preserving strength. The current chassis frame design's geometry is modified by altering the thickness of the hollow tubes Stresses for modified designs 1 and 2 are 74.24 MPa and 80.84 MPa, respectively, For the modified versions of design 1 and design 2, weight reductions of 16.05% and 26.15% are achieved [2,3,12]. The BAJA vehicle's frame is created in accordance with the requirements of the BAJA SAE India rulebook. Due to its superior power to weight ratio and excellent yield strength as compared to other materials, AISI 1020 was chosen. The choice of a circular cross section improved the chassis' strength by distributing forces more evenly [4]. A safety measure in front of the scooter bike is the front guard. To identify the impact energy absorbing component and research the impact of stiffness on crash behavior. A safety guard S-shaped longitudinal component is designed in this project. When compared to the current guard, these S-shaped longitudinal members exhibit good crash behavior and energy absorption characteristics. One may determine how much impact energy should be absorbed. The new design was improved by comparing the current Impact Analysis results for Stress, Strain, and Displacement for the same speed [5,6]. To accurately calculate bending stresses, finite element models and solution techniques must first be established. Then, bending stress findings from ANSYS calculations were compared to those from other methods. This work develops a 3D deformable-body (model). With data from theoretical calculations, the outcome is verified. The deformable-body (model) must be accurate because the simulation findings and theoretical results agree well [7-10].

3. Modelling and Analysis of Leg guard

3.1 Materials Properties

A240/SUS 302 stainless steel and grade 202 stainless steel are both types of Cr-Ni-Mn stainless. At low temperatures, stainless steel of grade 202 has very good toughness. It is one of the precipitation hardening grades that is most frequently used and has excellent corrosion resistance, toughness, high harness, and strength.

High carbon martensitic stainless steel is known as grade 440C. It possesses good hardness and wear resistance, high strength, moderate corrosion resistance, and moderate corrosion.

In this design and analysis three stainless materials SS202, SS440 and SS347 are considered. Their chemical properties are shown in table 1. And Mechanical properties have shown in table 2.

Table 1. Chemical Properties of three Materials

Element	**SS202 (%)**	**SS440C (%)**	**SS347 (%)**
Iron, Fe	68	79.15	62.83-73.64
Chromium, Cr	17-19	17	17-20
Manganese, Mn	7.5-10	1	2
Nickel, Ni	4-6		9-13
Silicon, Si	≤ 1	1	1
Nitrogen, N	≤ 0.25		
Carbon, C	≤ 0.15	1.1	0.04-0.10
Phosphorous, P	≤ 0.060		0.040
Sulphur, S	≤ 0.030		0.030
Molybdenum		0.75	
Niobium, Nb			0.320-1

Table 2. Mechanical Properties of three materials

Strength	Metric	Metric	Metric
Tensile strength	515Mpa	762-1970Mpa	480Mpa
Yield strength	275Mpa	450-1900Mpa	205Mpa
Elastic modulus	207Mpa	200Gpa	190-210Mpa
Poisson’s ratio	0.27-0.30	0.27-0.30	0.27-0.30

3.2 Modelling of Leg guard

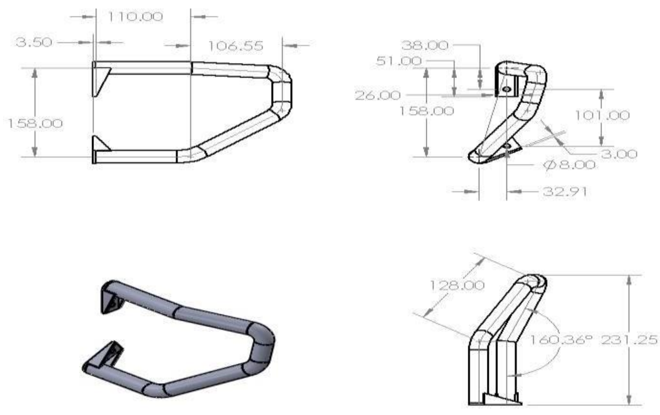

Fig. 1. Modelling of new leg guard

The CAD models are developed using the existing and new dimensions which is shown in figure 1.

3.3 Analysis of leg guard

Analysis on both the leg guards is carried out by applying bending, compression and impact loads in ANSYS software. Analysis is carried out with 2 different materials along with the existing material to know the deformations. Materials used are SS202, SS347, SS440C.

3.3.1 Loading conditions

For existing and new design the loading conditions are given below (table 3):
The approximation of vehicle weight at 4G's on the leg guard has been taken as load.

Load on the leg guard (W) = 4 x Vehicle mass x acceleration due to gravity (g)
W = 4mg, Vehicle mass (m) = 150kg

In Impact loading, the force on leg guard is taken as the vehicle (M=150) impacting a wall at 100kmph with a duration of 100 milliseconds.

$$F = \frac{M \times V}{2t}$$

F=Impact force in Newtons=21000, M=Mass of vehicle in impact in kgs, V=Velocity of impact, t=duration of impact in seconds.

Table 3. Loading on the leg guard

Load type	Magnitude
Compressive	6000N
Bending	6000N
Impact	21000N

3.3.2 Results of Analysis with SS440C for New design

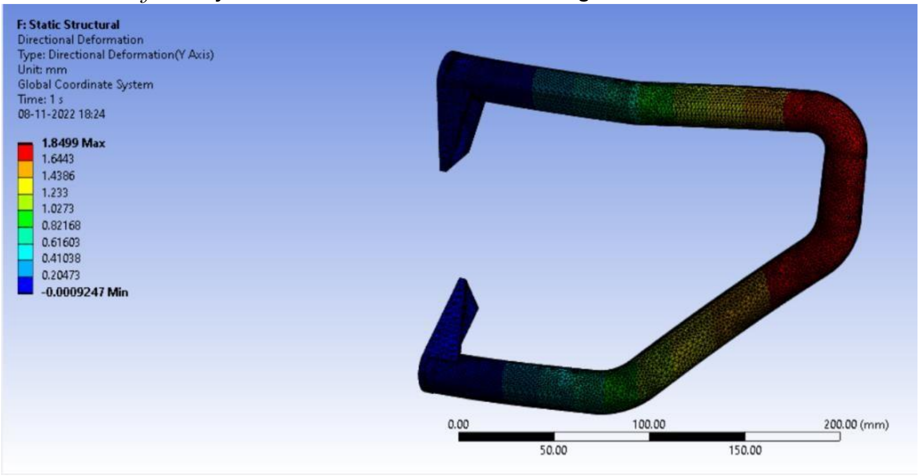

Fig. 2. Analysis with SS440C for New design subjected to bending load

Figure 2 shows the results of analysis i.e. deflection for SS440C material with bending load. Similarly compression and impact loading was applied on the same material SS440C and cooresponding deflections were found. Likewise analysis is carried out for all the three different materials for both existing design and new designed leg guard. Results shown in figure table 4 and 5.

Table 4. Results of Analysis of existing design with three materials

S. No	Material	Young's Modulus(GPa)	Deflection due to Bending (mm)	Deflection due to Compression (mm)	Deflection due to Impact (mm)
1	SS202 (existing)	200	0.787	0.49	1.66
2	SS347	193	0.816	0.51	1.72
3	SS440C	210	0.750	0.46	1.58

Table 5. Analysis of New design with three materials

S. No	Material	Young's Modulus (GPa)	Deflection due to Bending(mm)	Deflection due to Compression (mm)	Deflection due to Impact (mm)
1	SS202 (existing)	200	0.971	0.215	0.79
2	SS347	193	1.006	0.223	0.78
3	SS440C	210	0.924	0.204	0.75

3.3.3 Results and Discussions

Based on the values in the table 4, 5, it appears that SS440C has the highest Young's Modulus and is the stiffest material in the list. It also has the lowest deflections due to bending and compression, indicating it is better at resisting these types of loads. However, SS347 has the lowest Young's Modulus and is the least stiff material in the list. It has the highest deflections due to bending and compression, indicating it is more flexible and able to deform more easily. When it comes to impact, SS347 has the highest deflection, indicating it may be less able to withstand sudden shocks compared to the other two materials.

In summary(table 5), the revised table shows that SS440C is still the stiffest material with the highest Young's Modulus, and it is also the least deformable under bending and impact. However, the order of materials has changed for the deflection due to compression. It's also important to note that the values of the deflections due to different loads are still relatively small, indicating that all three materials may be suitable for certain applications where moderate loads are expected.

4. Conclusion

The article describes the creation of a finite element model for a motorcycle leg guard. The simulation of the model was tested under different loads such as compression, bending, and impact. The new design of the leg guard is more effective in protecting the rider during a crash. The length of the leg guard has been increased, and the bend reduced, which has led to a 50% reduction in compression deformation compared to the previous design made of SS202 material. The deformation during impact has also been reduced, while the deformation during bending has increased, providing better protection during a crash, especially at high speeds. The cost of the materials used in the new design is comparable to the previous one, with SS440C providing better structural performance even though it may be slightly more expensive.

References

1. J. P. Badgujar, Design of a Leg Guard at Different Loading Conditions, International Journal of Latest Trends in Engineering and Technology, Vol. 3 Issue 4, ISSN: 2278-621X, (2014)
2. K. Sivaramakrishnan, S. Poovarasan, S. Sakthivel ,K. Ranjith Kumar, Design and Analysis of Two Wheeler(Bike Chassis),Volume 6, Issue, ISSN: 2320-2882(2018)
3. Mr. Inzamam Mulla, Prof. A. M. Qureshi, Design Analysis and Optimization of Two-Wheeler Chassis for Weight Reduction, Volume: 06 Issue, (2019)
4. DivyanshUikey, Prof. Vedansh Chaturvedi, Design and Analysis of SAE BAJA Car Frame using ANSYS, Volume: 08 Issue, (2021)
5. R. Balamurugan, S. Mohamed Abdul Sukkoor, S. Madhankumar, A. Tamilselvan, Design and Crash Analysis of Scooter Front Guard, Volume 5, Issue 3 January 2018
6. Leela Krishna Vegi ,Venu Gopal Vegi, Design And Analysis of Connecting Rod Using Forged steel, Volume 4, Issue 6, (2013)
7. Dr. P. Ravikanth Raju, Somagani Upendar, Design and Analysis of a Crane Hook,Volume-5, Issue-4, (2018)
8. Mrs. Shinde S.P, Mr. Nikam A.A, Mr. Mulla T.S, Static Analysis of Spur Gear Using Finite Element Analysis, ISSN: 2278-1684, PP: 26-31(2018)
9. Muhammad HasifAnuar, Rahim Jamian, Design and Development of Bikes-Spoke Guard (BSG), Vol. 2 No. 1,pp. 711–718(2021)

10. K. Dinesh Babu, M. Siva Nagendra, Ch. Phanideep, J. Sai Trinadh, Design and Analysis of Differential Gear Box in Automobiles ,Volume 8, Issue 5,pp. 175–185 (2017)
11. Arun Ravi, Design, Comparison and Analysis of a Composite Drive Shaft for an Automobile, Volume 4, Number 1 pp. 21-28(2014),
12. G. Manusha, G. Kavya, K. S. J. Sadhana, Naseer Ahmed, Sd. Inthiyaz, T. Harish Babu, Design and Analysis of IC Engine Piston, Piston Rings and Connecting Rod, Vol.10,Issue.04, (2018)