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Research paper

Effects by Various Cross Sections on Monoshocks Helical Spring Using Static Stress Analysis and Sustainable Analysis

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Abstract

Mono suspension system installed in two-wheeler vehicles is to absorb impulsive shock loads caused often by irregular jumpy road surfaces. The shock impulsive force by the jumps is absorbed by the mono-suspension system through wheel. To provide comfort ride over rough surface, the suspension system should be equipped in. The core objective of the suspension system is to provide good comfort and better ride control to the riders. The perspective of this research is to conduct von mises stress analysis and displacement analysis on mono shocks helical spring to optimize the weight of the helical spring without affecting its functional requirements. To optimize the weight of the mono-suspension helical spring, various cross sections for helical spring design is used and von mises stress analysis and displacement analysis on each cross section has to be done to compare the weight, stress capability and maximum displacement. These two analyses are carried out by solid works simulation Xpress module. Theses analyses helps to recommend better cross section should be used to make helical spring mono-shocks with optimized weight and without affecting its functional requirements and environmental impact.

Keywords: *Shock impulsive force; von mises stress; mono shocks; solid works simulation Xpress module.*

1. Introduction

Two wheelers manufacturers are focusing on weight optimization of their products and aiming the result of better performance and increase the fuel economy. A two wheeler has a number of essential parts like engine, wheels, steering, suspension spring etc. nowadays two wheeler manufacturers are manufacturing their products with the mono suspension system. Mono suspension system is a single helical spring design attached at the middle of the vehicle to absorb the vehicle vibration [1]. All manufacturers use a helical spring which has solid circular cross section with variable pitch. To optimize the weight instead of using solid circular cross section bar to manufacture a helical spring hollow circular, square, hollow square and I section bars might be a choice to manufacture the variable pitch helical spring. To recommend the best cross section for making the helical spring by optimizing the weight has been more important for obtaining better performance and fuel economy [2]. More certainly the selection of cross sections depends the functional requirements and also should be lesser in weight than conventional cross section (solid circular). To identify, the various cross sections are need to be designed to make static stress analysis by applying an equal amount of load on each type of spring [4]. This research work uses SOLID-WORKS simulation `and displacement of each type of spring. The sustainability analysis also were made on each type of spring to measure the amount of environmental impact by the springs. This type of springs are normally manufactured in cellular manufacturing system [5].

2. Methodology

Base model selection:
To design a typical bike suspension system HONDA HORNET bike suspension system is chosen for study.
Measurements:
The selected bike suspension system parts were measured using metrological equipment's.
Modelling:
The measured dimensions of all parts were used to do computer modelling. SOLIDWORKS software [3] is used to draft the components of suspension system. The cross sections of helical springs are changed into four types and four different suspension systems were designed.
Analysis:
SOLIDWORKS simulation Xpress module for static stress analysis. SOLIDWORKS sustainability for sustainable analysis.
Result comparison discussion
Stress analysis results and sustainability results for four types of suspension systems to be compared.

3. Base model selection

A Honda hornet bike suspension system dimensions were taken for reference with the help of metrological equipment's. The dimensions are

- Wire diameter (d) = 7.35mm
- Mean diameter (D) = 48mm
- Outer diameter (D out) = 51.75mm
- Inner diameter (D in) = 45.12mm
- Variable pitch (P) = 10.2mm
- No of coils (n) = 10
- Maximum load (W) = 4000N

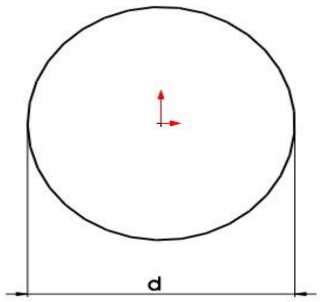


Fig. 1: Cross section of helical spring (solid circular)

4. SOLIDWORKS drafting

Table 1: Cross section data

S no	Type of cross section	Dimension measure	Value	value
1	Solid circular	D	7.35mm	-
2	Hollow circular	D&d	7.35mm	5.35mm
3	Solid square	A	7.35mm	
4	Hollow square	a&t	7.35mm	2mm

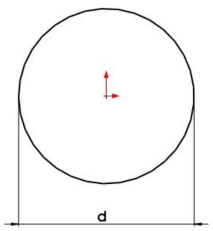


Fig. 2: Solid circular

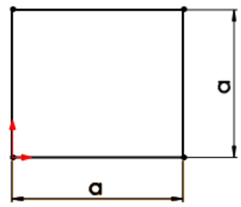


Fig. 3: Solid Square

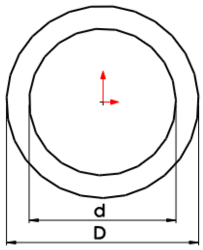


Fig. 4: Hollow circular

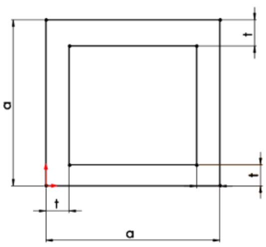


Fig. 5: Hollow Square

The cross sections are taken for helical spring design. The hollow sectioned helical springs are lesser in weight than solid cross sections. The stiffness is high in hollow cross sections than solid one. The one end of helical spring is attached with main rod and another one is with spindle to absorb vibration from wheel. The spring is initially maintained with a pre-load of the vehicle by a stop gear attached in the spindle.

4.1. Parts of mono suspension system

Mono socks has variable pitch helical spring, main rod with eye, spindle with eye and stop gear. The main rod has thread in its outer circumference and sleeve hole in its inner peripheral. The sleeve hole not a through hole and it end up with 76 mm. It means the spring does not deflect when the sleeve touches the end. When heavy vibration occurs the sleeve will move inside the main rod hole and hits the whole bottom. The spring resist the motion of the sleeve inside the main rod hole to safe the vehicle vibration during riding on the jumpy road surface. All the parts are made by alloy steel namely chrome vanadium which is harder than plain carbon steel.

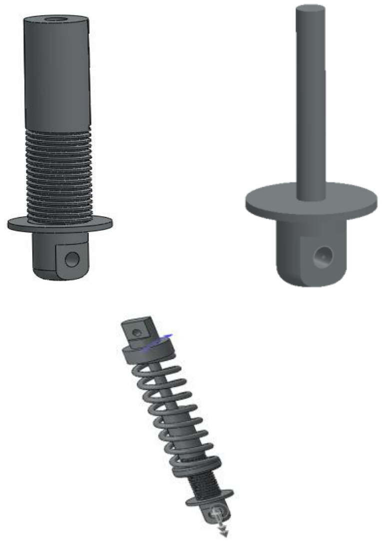


Fig. 6: Parts of mono-shock helical suspension spring

5. Static stress analysis

The static stress analysis is conducted on mono shocks with different cross sectioned helical springs by using solid works simulation Xpress module and the stress results are tabled. Eye end of the suspension system (main rod end) is fixed. The eye end has zero degree of freedom. The static load is applied on the frame end (sleeve end). The load is applied on the spring through spring sleeve. The spring can compress and expand depends on the load applied in it. The maximum load is taken as 4000 N which is average weight of a commercial vehicle with 2 persons.

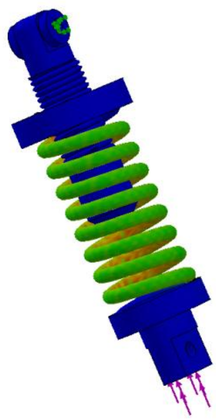


Fig. 7: stress output of solid circular cross section helical spring

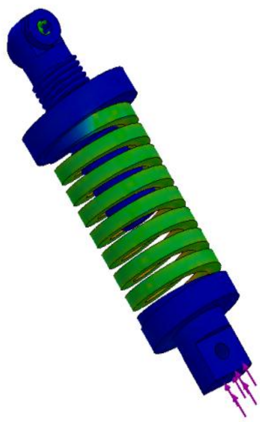


Fig. 8: stress output of solid square cross section helical spring.

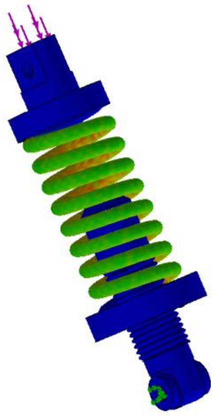


Fig. 9: tress output of hollow circular cross section helical spring

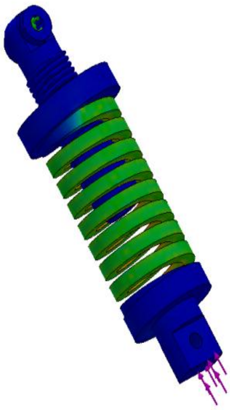


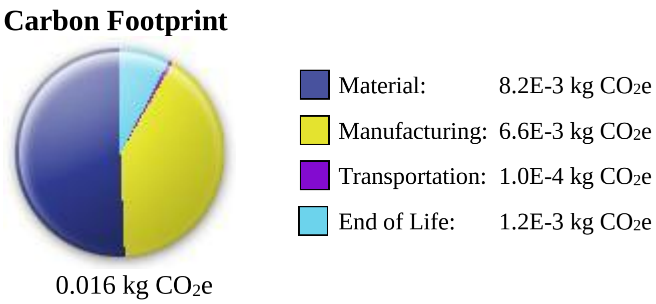
Fig. 10: Stress output of hollow square cross section helical spring

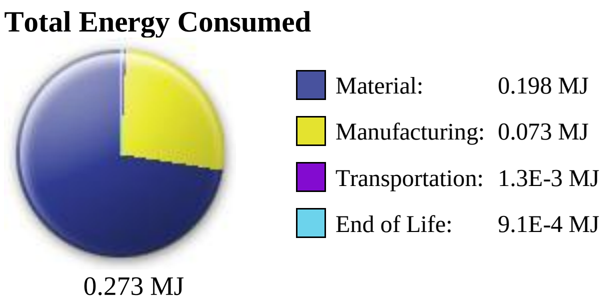
Value displacement output for different cross section helical springs is taken from solid works simulation Xpress module are tabled.

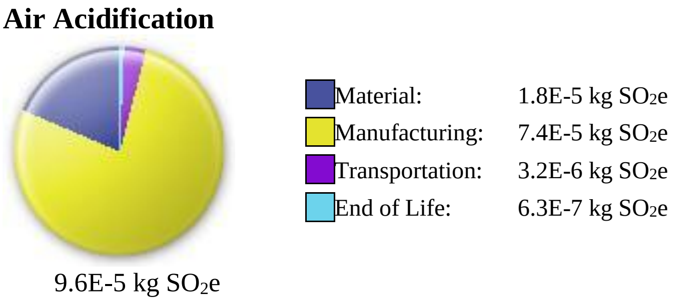
6. Sustainability analysis

The results from static analysis shows that helical spring which is made by hollow circular cross section has better static strength than other three types. The sustainability analysis were made on the particular spring type suspension system are listed as follows.

Carbon footprint, total energy consumed, acid rain formation and water eutrophication are the sustainable parameters which affect the environment can be calculated using solid works sustainability module available in the software.







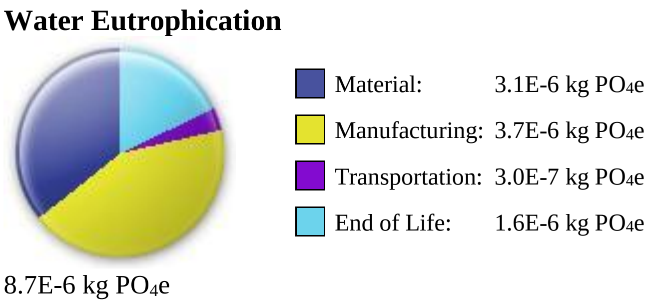


Fig. 11: Sustainable results of the helical spring

These are the sustainable results of helical spring made with hollow circular cross section.

7. Result comparison

From the comparison table it is clear that the weight of hollow square type mono suspension system is slightly lesser than other three types. But the Stress and displacement values are greater than other three types which should not recommended for making the mono shocks. While looking on the hollow circular type it is lesser in weight than both solid cross sections and also lesser in stress. Both solid section has higher in weight and also equal in stress and displacement. The weight of Solid Circular is in lesser than Solid Square. The sustainability analysis were made and the results are showing that the environmental impact is lesser than the conventional helical spring suspension system due to its material reduction.

Table 2: Comparison Table of different sections

S no	Comparison	Weight (Kg)	Stress (MPa)	Displacement (mm)
1	Solid square	6.45	961.43	66.731
2	Solid circular	6.476	1002.87	58..824
3	Hollow circular	5.11	956.11	60.237
4	Hollow square	5.392	991.71	59.217

8. Conclusion

The hollow circular cross sectioned mono shocks has higher stiffness (low displacement under same load). The making of hollow circular helical spring is same as solid one and the sustainability analysis gave detailed data like amount of carbon footprints, acid rain formation, water eutrophication, and total energy consumed are positive. This research is concentrated on weight optimization, performance enhancement and sustainable product, the two wheeler mono shocks helical spring is recommended to manufacture with hollow circular raw material replacing the solid one.

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