

# Investigation on the Effects of Different Coil Spring Materials on Vehicle Ride Comfort and Handling

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## Abstract

This research investigates the effects of different coil spring materials on vehicle ride comfort and handling. Utilizing ANSYS simulation software, we analyzed the performance and fatigue behavior of automotive springs made from Monel 400, MP35N, and A286. The study aims to understand how these materials impact the operational efficacy and durability of suspension systems. The results indicate significant variations in performance metrics, with Monel 400 showing potential for superior ride comfort due to its high strength and corrosion resistance, MP35N demonstrating excellent fatigue resistance and strength-to-weight ratio, and A286 providing high-temperature stability. These findings contribute valuable insights for optimizing material selection in automotive spring design, enhancing both vehicle performance and ride quality.

## 1. Introduction

The automotive industry has seen significant advancements focused on enhancing vehicle performance and ride comfort. Central to these improvements is the suspension system, with coil springs being vital for supporting the vehicle's weight and absorbing road imperfections [1]. This project investigates the effects of different coil spring materials on vehicle ride comfort and handling, providing insights valuable to manufacturers, engineers, and automotive enthusiasts.

The choice of coil spring material, whether steel, composite materials, or various alloys, significantly impacts the suspension system's behavior, affecting ride quality and handling across diverse driving conditions. The steel coil springs have long been synonymous with durability and high yield strength [2]. By conducting comprehensive tests and evaluations, this study compares the performance of different materials, analyzing parameters such as vibration damping, cornering stability, and steering responsiveness. Load-related parameter, including load capacity and preload, offer insights into the spring's ability to support weight and initial compression force, respectively [3]. In the context of automotive suspension systems, machinery, and other mechanical systems, understanding the implications of coil diameter is crucial for tailoring the spring's response to external forces [4,5]. Adaptive suspension offers drivers a more personalized and responsive driving experience[6].

The influence of coil spring design and manufacturing leads to advancements in vehicle suspension systems. Ultimately, this research aims to enhance the driving experience by optimizing the ride comfort and handling of vehicles, thereby contributing to a safer and more enjoyable journey for all road users. The choice of coil spring material presents an intricate engineering decision. However, there is a limited body of

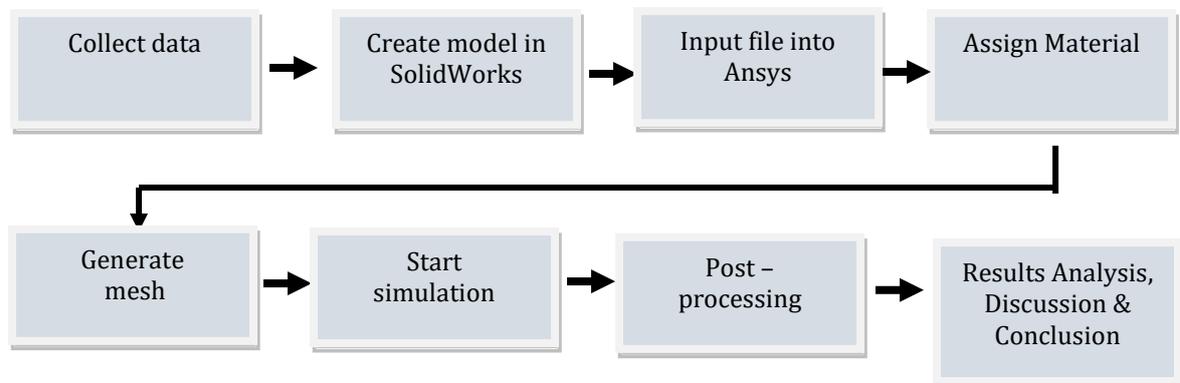
comprehensive research that quantitatively and qualitatively evaluating the effects of different coil spring materials on vehicle ride comfort and handling performance. Therefore, a study on the effects of different coil spring materials on vehicle ride comfort and handling is carried out in order to evaluate the static and dynamics response of coil springs.

## 2. Method

In this research, we employed a detailed methodology to investigate the effects of different coil spring materials on vehicle ride comfort and handling. Geometric characteristics encompass wire diameter, coil diameter, free length, and solid height, which shape the physical structure and dimensions of the spring [7]. The process began with creating a precise 3D model of the coil spring using SolidWorks, which was then exported as an IGES file and imported into ANSYS, a powerful engineering simulation software.

Within ANSYS, we assigned material properties to the coil spring model, focusing on Monel 400, MP35N, and A286. Next, we generated a high-quality mesh, crucial for accurate simulations, by carefully selecting appropriate element types and sizes. After meshing, we defined the boundary conditions and loading scenarios to replicate real-world conditions.

The simulations in ANSYS provided key performance metrics, including total deformation, equivalent stress, and frequency response, offering valuable insights into how different materials impact the behavior of coil springs. These findings help guide material selection and design optimization for automotive suspension systems.



**Fig 1** Flowchart of research methodology



**Fig 2** Coil Spring ,(a) Model (b) Meshing

### 3. Material

In this research, we explored four distinct materials for coil springs: traditional steel, Monel 400, MP35N, and A286. Each material was selected for its unique properties and potential advantages in automotive applications. Steel has been the conventional choice for coil springs due to its durability, cost-effectiveness, and reliable performance. Monel 400 is known for its exceptional corrosion resistance and high strength, making it suitable for harsh environments. MP35N is a high-performance alloy with an excellent strength-to-weight ratio and fatigue resistance, ideal for enhancing suspension performance. A286, renowned for its high-temperature strength and oxidation resistance, offers reliability in demanding conditions. By analyzing these materials, we aimed to understand their impact on vehicle ride comfort and handling, providing insights for optimizing suspension systems.

**Table 1** *Materials properties*

Material	Density (gcm <sup>3</sup> )	Young Modulus (MPa)	Poisson Ratio	Bulk Modulus (Pa)	Shear Modulus (MPa)
Monel 400	8.83	1.79 e <sup>5</sup>	0.35	2.015e <sup>11</sup>	66200
MP35N	8.43	2.34e <sup>5</sup>	0.44	7.77e <sup>11</sup>	80700
NiCr A286	8.03	2e <sup>5</sup>	0.39	3.165e <sup>11</sup>	71700
Steel	7.85	2 e <sup>5</sup>	0.3	1.667e <sup>11</sup>	76923

### 4. Results

In this study, we conducted a comprehensive investigation into the effects of different coil spring materials on vehicle ride comfort and handling. The materials analyzed were traditional steel, Monel 400, MP35N, and A286. Utilizing ANSYS software, we performed simulations to evaluate the performance of coil springs made from these materials, focusing on parameters such as total deformation, equivalent stress, and frequency response under harmonic loading conditions. This analysis provided a detailed understanding of how each material influences the dynamic behavior and fatigue characteristics of the springs. Our results aim to guide material selection for optimizing the performance and durability of automotive suspension systems.

**Table 2** *Result of total deformation and equivalent stress*

Materials	Total deformation (m)		Equivalent Stress (Hz)	
	Minimum	Maximum	Minimum	Maximum
Monel 400	0	0.17567	0	2.3316e <sup>9</sup>
MP35N	0	0.14255	8.2242e <sup>21</sup>	1.9624e <sup>9</sup>
NiCr A286	0	0.16152	0	2.1797e <sup>9</sup>
Steel	0	0.15192	0	2.4808e <sup>9</sup>

#### 4.1. Analysis of Total Deformation and Equivalent Stress

In the ANSYS analysis of the steel spring, the total deformation results indicate the extent to which the spring undergoes displacement or deformation under the applied loads. The minimum total deformation observed in the steel spring is 0 m, indicating regions where the spring experiences minimal or negligible displacement. This suggests that certain parts of the spring remain relatively unchanged in shape or position, possibly due to constraints or load distribution within the system. On the other hand, the maximum total deformation recorded in the steel spring is 0.15193 m while the maximum total deformation recorded in Monel 400 is 0.17587 m. This value represents the point of maximum displacement or deformation within the material under the applied loads. It highlights areas where the material experiences significant distortion or deflection, possibly due to high stress concentrations or loading conditions.

The maximum equivalent stress recorded in Monel 400 is  $2.3316 \times 10^9$  Hz (or 2.3316 GPa). This value represents the point of maximum stress concentration within the material under the applied loads. It highlights areas where the material experiences significant stress levels, potentially leading to deformation or failure.

Material	Total Deformation	Equivalent Stress
Monel 400		
MP35N		
NiCr A286		
Steel		

Fig 3 Equivalent stress and total deformation

## 4.2. Analysis of frequency Response

Frequency response analysis is a critical aspect of evaluating the dynamic behavior of mechanical systems, particularly in automotive applications. This analysis assesses how a system responds to various frequencies of harmonic loading, which is essential for understanding its vibrational characteristics and resonance tendencies. By examining the frequency response, engineers can predict how different materials and designs will perform under dynamic conditions, ensuring stability and optimal performance. In our study, frequency response analysis was conducted to evaluate the impact of different coil spring materials, such as steel, Monel 400, MP35N, and NiCr A286, on vehicle ride comfort and handling. This involved examining key parameters like amplitude, phase angle, and stress distribution at specific frequencies. The results provided insights into the maximum amplitude, phase relationships, and real and imaginary stress components for each material, guiding material selection for optimal suspension performance.

**Table.3** Result of frequency response

Material	Maximum Amplitude (Pa)	Frequency (Hz)	Phase Angle (°)	Real (Pa)	Imaginary (Pa)
Monel 400	5.0358 $e^{005}$	1	180	-5.0358 $e^{005}$	0
MP35N	5.0672 $e^{005}$	1	180	-5.0672 $e^{005}$	0
NiCr A286	5.0308 $e^{005}$	1	180	-5.0308 $e^{005}$	0
Steel	5.0347 $e^{005}$	1	180	-5.0347 $e^{005}$	0

## 5. Conclusion

In conclusion, this research delved into the impact of various coil spring materials on vehicle ride comfort and handling, focusing on Monel 400, MP35N, NiCr A286, and steel. Using SolidWorks to create accurate spring models and ANSYS for detailed simulations, we analyzed crucial parameters such as total deformation, equivalent stress, and frequency response. The results highlighted significant differences among the materials. Monel 400 demonstrated exceptional performance across several metrics, making it a standout material for automotive suspension systems. It exhibited balanced characteristics with optimal deformation and stress responses, along with a stable dynamic behavior under harmonic loading conditions. This makes Monel 400 particularly advantageous for applications requiring both durability and high performance. MP35N and NiCr A286 also showed promising results, especially in terms of strength and resistance to fatigue, but they did not consistently outperform Monel 400 in all evaluated parameters. Steel, the traditional material for coil springs, performed adequately but was surpassed by the advanced alloys in several key aspects, particularly in managing stress and deformation under dynamic conditions. The findings suggest that transitioning to Monel 400 for coil springs could lead to significant improvements in ride comfort and handling, providing a smoother and more stable driving experience. This research underscores the importance of material selection in the design and optimization of suspension systems, offering valuable insights that can drive innovation in the automotive industry. By adopting advanced materials like Monel 400, manufacturers can enhance vehicle performance, safety, and passenger comfort, meeting the evolving demands of modern automotive engineering.

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## Conflict of Interest

The authors declare that there are no conflicts of interest concerning the publication of this paper.

## References

- [1] Chin, C. H., Rahim, A. A. A., Abdullah, S., Singh, S. S. K., & Md Nor, N. (2021). Acceptability of the effective strain damage model for fatigue life assessment considering the load sequence effect for automotive coil spring. *Engineering Failure Analysis*, 126. <https://doi.org/10.1016/j.engfailanal.2021.105462>
- [2] Abidin, M. I. Z., Mahmud, J., Latif, M. J. A., & Jumahat, A. (2013). Experimental and numerical investigation of SUP12 steel coil spring. *Procedia Engineering*, 68, 251–257. <https://doi.org/10.1016/j.proeng.2013.12.176>
- [3] Arslan, E., & Genel, K. (2023). Failure analysis of automotive helical spring. *Engineering Failure Analysis*, 153. <https://doi.org/10.1016/j.engfailanal.2023.107569>
- [4] Bergh, F., Silva, G. C., Silva, C., & Paiva, P. (2021). Analysis of an automotive coil spring fracture. *Engineering Failure Analysis*, 129. <https://doi.org/10.1016/j.engfailanal.2021.105679>
- [5] Chen, L., Xing, W., Wu, L., Chong, J., Lei, T., Jiang, Q., & Tang, Y. (2022). Understanding multiple parameters affecting static and dynamic performances of composite helical springs. In *Journal of Materials Research and Technology* (Vol. 20, pp. 532–550). Elsevier Editora Ltda. <https://doi.org/10.1016/j.jmrt.2022.07.120>
- [6] Hasan, M. J., Ahmed, S. F., & Bhuiyan, A. A. (2022). Geometrical and coil revolution effects on the performance enhancement of a helical heat exchanger using nanofluids. *Case Studies in Thermal Engineering*, 35. <https://doi.org/10.1016/j.csite.2022.102106>
- [7] Divani, A., & Mohammadi, J. (2022). Further development in modeling fatigue failure in metals with a multi-spring non-linear mechanical system. *Engineering Structures*, 257. <https://doi.org/10.1016/j.engstruct.2022.114044>