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Design of shape memory alloy damper for reduction of vibration

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Abstract

Labor will be employed for performing loading operation in vehicles like trucks and lorries for transporting from place to place.. Labor will be forced to load the items beyond the capacity of vehicle for which they will climb on top of the vehicle in most unsafe way. This may further lead to accidental fall and get injured and sometimes it will still be worse. In order to avoid this unsafe freight loading mechanism in vehicles, design of an automated freight loading system is proposed in this project. The intended system will have a mobile basket which shuttles between ground and top of vehicle. This system enables labor to stand on the ground and just lift the freight and drop in the mobile basket when it is on the ground and then the basket will be energized to go to the top of vehicle and drop the freight there and return back for collecting next freight and this cycle continues till whole vehicle gets loaded. Hence this system will ensure safety of the labor. The necessary mechanism which makes the basket mobile will be designed with all mechanical elements which results into cost effective product. After identifying the configuration all subsystems will be designed and subsequently dimensional models will be framed. Then these dimensional models will be transformed to solid model of the assembled configuration using 3D CAD software. Then this system will be analyzed using Finite Element Method (FEM) in commercial FEA software i.e. ANSYS. Design will be fine tuned and finalized based on the outcome of analysis

Keywords: vehicles,Design, vibration, *ANSYS.*

1. Introduction

Available literature pertaining to the present topic is explored before evolving the idea for the proposed design. The objective of the literature survey is to understand the state of art of the technology and explore various other similar devices, which are in use while highlighting their relative merits and demerits. The outcome of the literature survey is an idea of the proposed design having the demerits of the surveyed systems as its features

To begin with the properties that are characteristic of shape memory alloys (SMAs) are understood and the same is discussed here. Two main characteristics identify shape memory alloys (SMAs), shape memory effect and pseudoelasticity. By training the SMAs at a given temperature, they can be made to memorize a specific configuration, which can be activated via temperature change or via externally applied load. They can sustain a large amount of strain, suffer no permanent plastic deformation, and recover their original length upon heating A reversible, solid phase transformation known as martensitic transformation is the driving force behind shape memory alloys. When nickel and titanium atoms are present in the alloy, in a given proportion, the material forms a crystal structure, which is capable of undergoing a change from one form of crystal structure to another. Temperature change or/and loading initiate this transformation. In ordinary metals, deformation occurs by dislocation motion and atomic planes sliding over one another, taking on a new crystal position. Increased tangles of dislocations will not allow the metals to reverse the deformation, thus resulting in permanent damage to the crystalline order. Unlike regular metals, SMAs deform by detwinning (changing the tilt of a twin orientation), which does not cause any dislocation. Det winning is a shearing motion that allows the martensite phase to absorb dislocation, to a given extent. For complete shape recovery to occur, the deformation process should not involve slip, because slip is an irreversible process.

When a SMA is in its austenite phase, it exhibits a highly elastic behavior. This allows the material to deform up to 7% and then fully recover the resulting strain by simply removing the load. This behavior is known as the pseudoelastic effect or pseudoelasticity; some people refer to pseudoelasticity as superelasticity. Deforming a pseudoelastic material results in the formation of a martensite crystal. The martensite formed in this forward transformation is called stress-induced martensite.

A damper device based on shape memory alloy (SMA) wires is developed for structural control implementation. The design procedures of the SMA damper are presented. As a case study, eight such SMA dampers are installed in a frame structure to verify the effectiveness of the damper devices. Experimental results show that vibration decay of the SMA damper controlled frame is much faster than that of the uncontrolled frame. The finite-element method is adopted to conduct the free and forced vibration analysis of the controlled and uncontrolled frame

2. Design of shape memory alloy damper

Based on the design philosophy a configuration is identified. All the subsystems of the configuration are to be designed taking functional loads into account. While designing the subsystems various mechanical design aspects are considered. The outcome of the structural design would be solid models of all subsystems of the intended system. The total design process is concluded with mention of details for the design, which will be ascertained further by finite element method details of which would be mentioned in later chapters. This chapter brings out the details of the design procedures adopted

When any automobile vehicle goes on normal road it experiences vibration. When same vehicle goes on rough road it experiences shock. To provide comfort for the passenger there is something called shock absorber mounted in a vehicle as shown in figure 1.

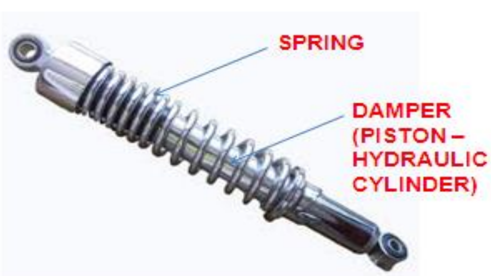

Figure 1 shock absorber mounted in a vehicle

Even with shock absorber very often passengers notice discomfort while traveling particularly in ordinary busses. To avoid this discomfort stiffness of spring in the shock absorber is supposed to be high for normal road . Whereas stiffness of spring in the shock absorber is supposed to be less for rough road. But same shock absorber can't provide different stiffness values for vehicle's travel over different roads which leads to discomfort.

To provide solution to this problem it is thought of designing a damper (Shock absorber) which can provide two different values of stiffness. Additional feature proposed is damping characteristics are embedded with spring material itself to make the design compact. This particular feature is proposed to be accomplished by choosing shape memory alloy (SMA) as material for spring reasons for which are further elaborated below.

As mentioned earlier for taking shock loads spring needs to have very low stiffness i.e. high elongation

Elongation of shape memory alloy (Nitinol-NiTi) is 10 times more than that of normal metals.

As it was mentioned in the outcome of literature survey most of the existing systems needs precise instrumentation for their operation and some of them deals with spring alone. Hence it is planned to design a system which will have provision for change over option between two springs with different stiffnesses.

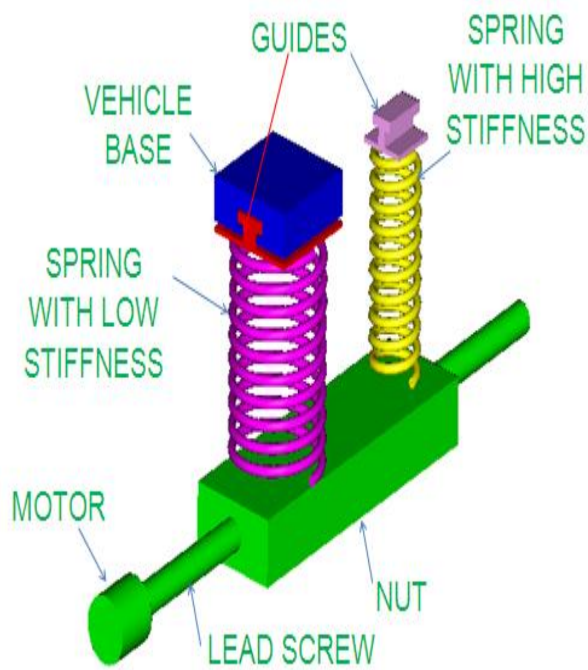

Figure 2 Proposed design

2.1 PRINCIPLE OF WORKING

- When vehicle has to pass rough road spring 1 will be engaged between vehicle base and nut
- Nut is attached to axle through guides (Not shown here)

- When vehicle has to pass normal road driver operates the motor which rotates lead screw with which nut moves towards motor with which spring 1 gets disengaged and spring 2 gets engaged with vehicle base

2.2 DESIGN OF COMPONENTS

From figure 3.3 the following components are identified for which detailed design is carried out.

- Lead screw
- Motor
- Spring for normal road
- Spring for rough road
- Guides
- Bearing

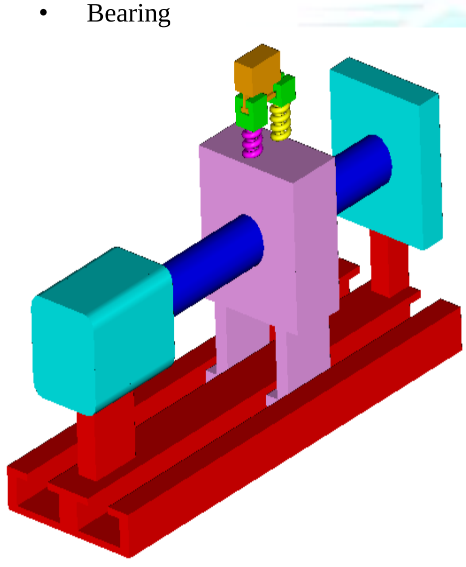

Figure 3. Solid model of the assembly

3.Finite Element Analysis

To begin with geometric model of the shape memory alloy damper is built in 3D CAD software from its dimensions evolved as an outcome in the previous chapter. However load bearing members are only considered for analysis.

Then geometric model is converted into FE model by discretizing with elements in commercial FEM software package ANSYS.

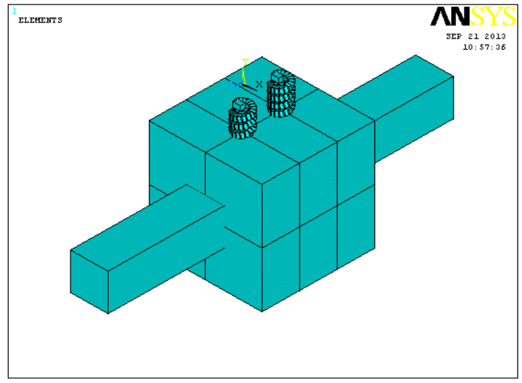

Figure 4. FE model

The FE model is then solved for Von Misses stress using ANSYS software. Maximum stress plot is shown in Figure 4.2 in which maximum stress location is visible in red color.

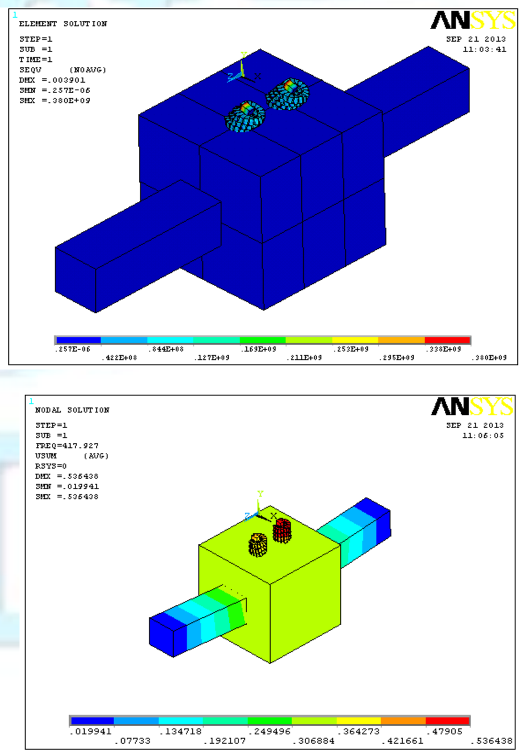

Fig 5 FEA structural and dynamic analysis

4.Conclusions

Design of a shape memory alloy damper is done which will have provision for change over option between two springs with different stiffnesses.

Static analysis – Functional load
Maximum Von Misses stress is observed to be 380 MPa.
Available factor of safety is observed to be (3.3) by comparing the maximum stress with that of allowable stress (Yield) of shape memory alloy material i.e. 1256 MPa.
As the available factor of safety (3.3) is more than minimum desired factor of safety (1.5) the design is safe.

Modal analysis
Frequency of the intended system corresponding to first bending mode is found to be 417 Hz.
System doesn't experience resonance.
It is recommended to incorporate the shape memory alloy damper proposed in this project for reduction of vibration and shock in automobiles effectively

5.References

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