Vibration control of cantilever beam using SMA Springs in Series

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Abstract - *Shape memory alloys (SMAs) are one of the most widely used smart materials in many applications because of their shape memory effect property and pseudo elastic behavior. In this work, shape memory alloy (SMA) spring based dynamic vibration absorber is developed for extinction of vibration in cantilever beam. The system consists of cantilever beam fixed with C Clamp. The shaker is used to generate real time vibration with the help of function generator. The SMA springs with mass is attached at the free end. The experiments were carried out by using SMA and conventional spring. The variable DC power supply was used to supply optimum current to the SMA springs. The FFT, accelerometer and non contact type displacement sensor were interfaced with PAK software to note the results. The result demonstrates that the SMA springs has great potential and are more effective in reducing the amplitude of vibration for wider frequency range.*

Key Words: Shape Memory alloy (SMA) Springs, dynamic vibration absorber (DVA), PAK Software, FFT.

1. INTRODUCTION

Nowadays, vibration is one of the major issues in the environment, which may cause some serious injuries to the human health. Vibration may occur due to mechanical oscillation from industrial machines, railway track nearby human reside, and many more reasons. There are two types of vibration: Free Vibration and Forced Vibration. Due to the interaction between humans and machines, vibration cause serious damage to the human health. Hence, it needs to be eradicated with proper controlling techniques. Using the magnificent properties of shape memory effect, the vibrations can be controlled. In the proposed technique, the vibrations in the machineries as well as the place where the vibration may occur are reduced to safeguard the humans form the effect of vibration.

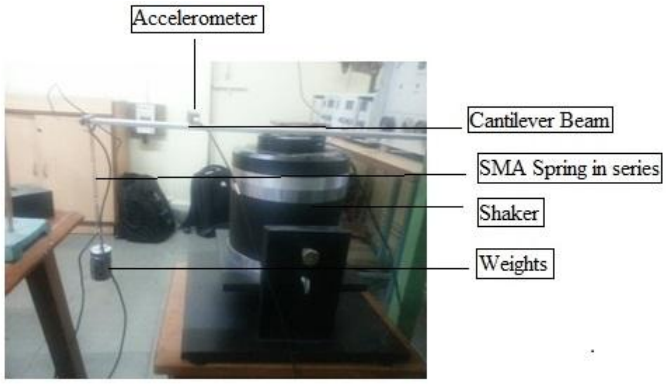
Recently, several studies have highlighted the significance of resistive exercise to uphold a healthy human body, particularly in prevention of weakening of physical potency [1]. Most of the recent mechatronic systems necessitate numerous feasible devices namely, reaction or momentum wheels, revolving devices, and electric motors for its operation and performance. However, these devices can also be the sources of harmful vibrations that may greatly affect the mission performance, efficiency, and accuracy of operation. Hence, there is a need for vibration control [2]. Vibration problems can arise at anytime in the installation or operation of a motor. When they happen it is normally risky and one should react speedily to solve the problem. If the problem is not solved hurriedly means, one can either expect long term injure to the motor or instant failure [3]. A vibration sensor is a very high sensitivity accelerometer without DC output requirement. Without drift or bias stability specifications, the design can be optimized to provide the lowest noise floor [4].

Vibration control systems are divided into two types: active control system and passive control system. The combination of both active and passive systems is called hybrid control system. Active control of vibrations relieves a designer from strengthening the structure from dynamic forces and the structure itself from additional weight and cost [5]. Passive control systems add damping to the structure, naturally, when a tremor occurred. These systems have been used extensively because of their simplicity and low-priced [6]. Passive control devices represent diverse types of base isolators and seismic dampers. Base isolators control the penetration of potentially detrimental seismic waves into a building structure, whereas the dampers reduce the destructive effect of those waves. An active vibration control system comprises an actuator, controller, sensor and the system / plant (beam), which is to be controlled. Fully active actuators such as Piezoelectric, Magneto Rheological (MR) fluids, Piezoceramics, Electro-Rheological (ER) fluids, Shape Memory Alloys (SMA), Polyvinylidene Fluoride (PVDF) are employed to create a secondary vibration response in a linear mechanical system [5].

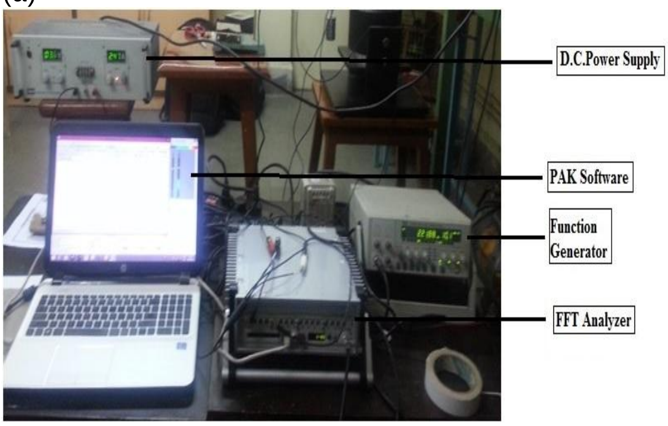
SMAs are smart materials, and their physical properties vary as a function of temperature. The stiffness of the SMA spring can be controlled by varying the electrical current supplied to it [7]. This causes the transition of the material phase from martensite to austenite phase which in turn increases the spring's Young's Modulus. This result in generation of great potential which can be used to control the vibration.

2. EXPERIMENTAL SET UP

The cantilever beam used in the experiment is made up of aluminum of length 600mm, breadth 40.08mm and thickness 6.1mm. SMA helical springs used in this experiment were procured from Dynalloy Inc, USA.



(a)



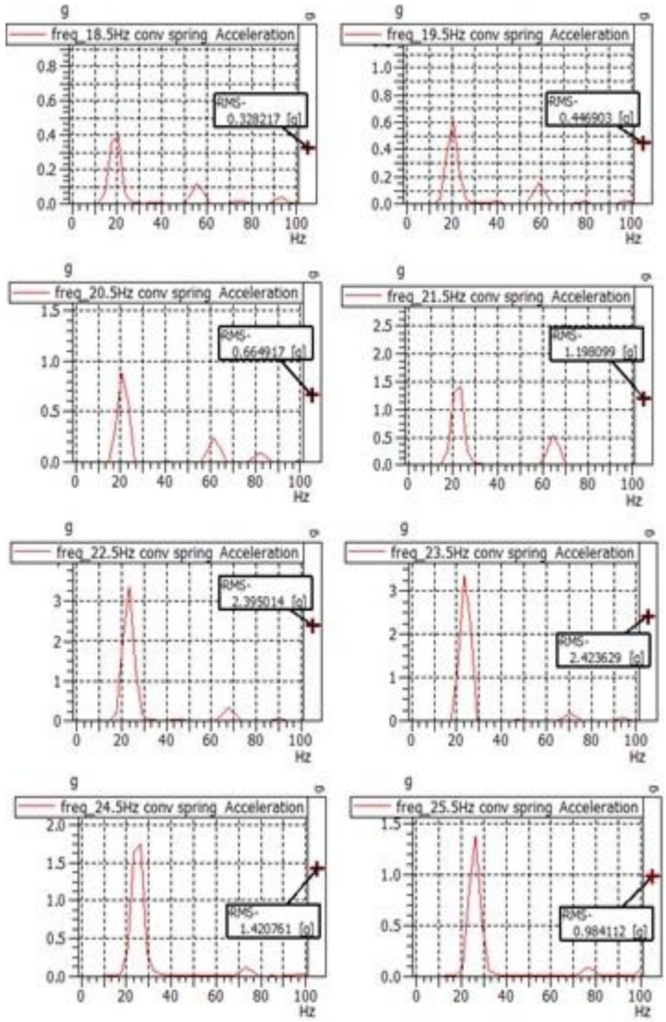
(b)

Fig.1. (a) & (b) Experimental set up

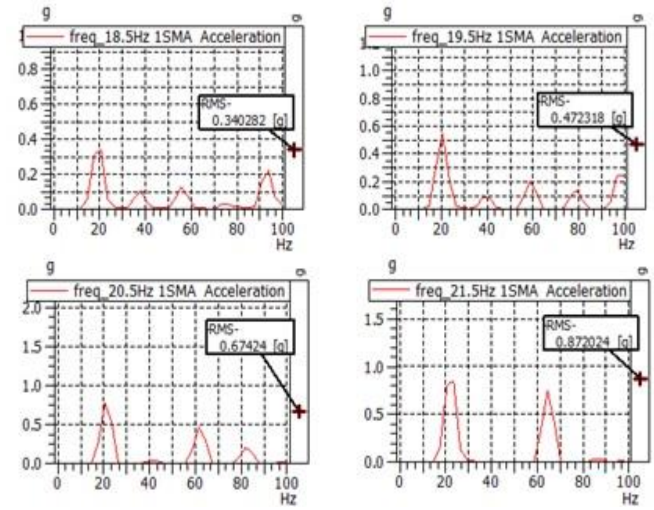
The wire diameter of spring is 0.75mm, Mean diameter is 6mm and the number of active turns is 20. The shaker is used to generate the real time vibration which is regulated by function generator. The stiffness of the spring is calculated experimentally. An accelerometer of sensitivity 100 mV/g is attached to the beam which is coupled to the FFT to record the amplitude of vibration. The Non contact type displacement sensor of range ± 50mm is fixed over the beam. The FFT and non contact type displacement sensor are interfaced with computer along with PAK software. The force excitation frequency of cantilever beam is determine experimentally as 21.5 Hz so a frequency range of 18.5 Hz to 25.5 Hz is selected to check the capability of SMA spring to control the vibration. The experimental set up is shown in Fig 1.

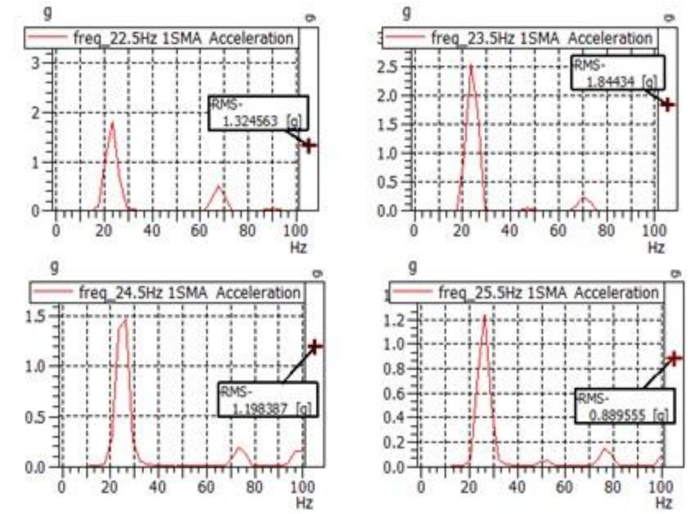
3. MEASUREMENT OF AMPLITUDE AND ACCELERATION USING CONVENTIONAL AND SMA SPRINGS

The dimensions of the conventional spring are same as that of the SMA spring. The beam was excited over a frequency range of 18.5 Hz to 25.5 Hz and frequency Vs amplitude and acceleration Vs amplitude is recorded. The conventional spring is replaced by Single SMA spring, two SMA spring in series and three SMA spring in series and result are noted which is shown in following graphs.

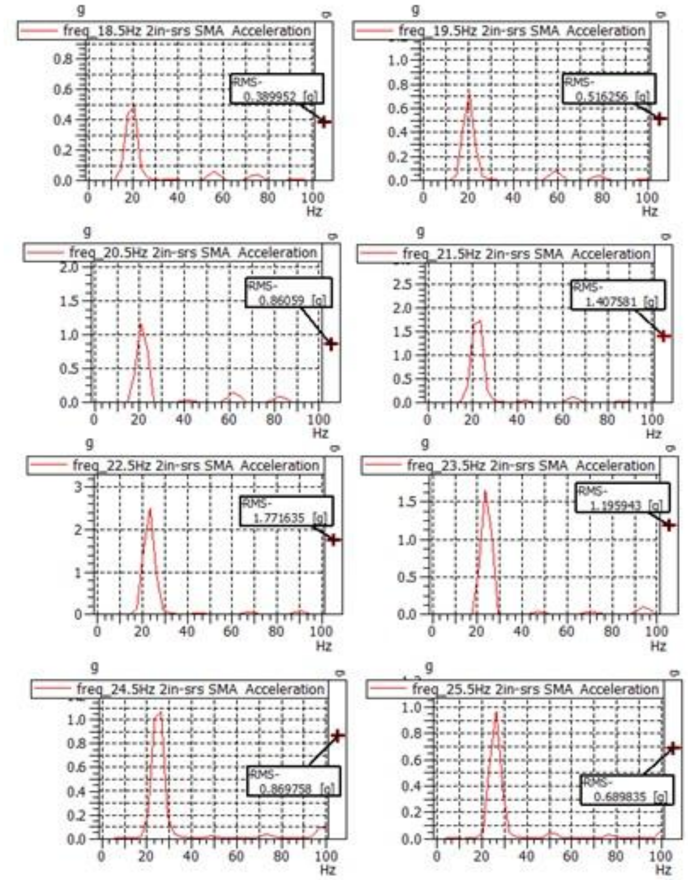


Graph 1. Frequency Vs Acceleration for conventional spring

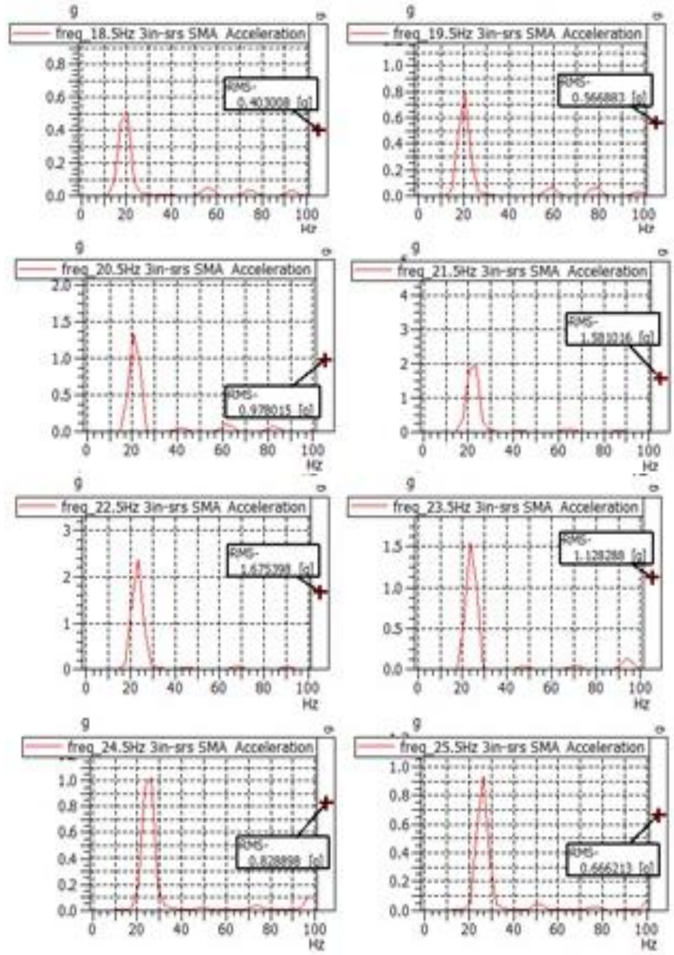




Graph 2. Frequency Vs Acceleration for 1 SMA spring



Graph 3. Frequency Vs Acceleration for 2 SMA spring.



Graph 4. Frequency Vs Acceleration for 3 SMA spring.

3. CONCLUSIONS

The performance of SMA helical spring was evaluated through experimentation to control the structural vibration in a cantilever beam. The closely coil helical springs are used for conducting the experiment and it is noticed that SMA spring can generate large force and are very useful to control the vibration as compare to the conventional spring. The result demonstrates that the single SMA spring is more effective than 2 or 3 spring connected in series in vibration control.

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BIOGRAPHIES

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