



Design Development and Analysis of Viscous Damper for Vibration Reduction in Hand Held Power Tools

#1 A.A.Koli, #2 M.M.Tayde

¹amit2624ar@rediffmail.com

²mmtayde.sit@sinhgad.edu

#1 ME Design Engineering, Savitribai Phule Pune University, Pune, India.

#2 Professor at Sinhgad Institute of Technology, Lonavala, Pune, India

ABSTRACT

Machines always cause for vibration either operated automatically or manually. While operating hand held power tools there are always effect of vibration on human. The project work is presented on the basis of hand arm and whole body vibration. Attention is given on the evaluation of exposures to the vibration produced within hand or body during operating the power tools. Hand-arm vibration (HAV) is vibration transmitted from a work processes into workers' hands and arms. It can be caused by operating hand-held power tools, hand-guided equipment, or by holding materials being processed by machines. This work is necessary for the vibration reduction in hand held power machinery with application of damping device. The vibration emission can be measured and controlled by effective mounting of damper on power tool. This paper summarizes the design development and analysis of viscous damper with ANSYS. The purpose of this guide is to aid the design engineer in selecting the proper damping device to reduce the amount of vibration or shock that is transmitted to human hand from equipment during operating condition. Vibration-control techniques in the form of shock and vibration isolators have been devised to provide dynamic protection to all types of hand held power tools.

Keywords— HAV (Hand Arm Vibration), Power Tool, Viscous Damper, Vibration Control.

ARTICLE INFO

Article History

Received : 18th November 2015

Received in revised form :

19th November 2015

Accepted : 21st November , 2015

Published online :

22nd November 2015

I. INTRODUCTION

Machines of some kind are used in nearly every aspect of our daily lives; from the vacuum cleaner and washing machine we use at home, to the industrial machinery used to manufacture nearly every product we use on a daily basis. Machines are always causing for vibration. In hand held power tools there is always large amount of vibration with best operating conditions that directly transmitted to human hand. Daily exposure to hand and arm vibration by workers who use vibrating tools powered by compressed air, gasoline or electricity (e.g. powered hammers, jackhammers, chisels, chainsaws, jigsaw, sanders, grinders, riveters, breakers, drills, compactors, sharpeners and shapers) can cause physical damage to the hands and arms. These vibrations to human hand may causes Hand Arm Vibration Syndrome (HAVS) which is the disease that includes

circulatory disturbances, motor and sensory and musculoskeletal disorders. These vibrations can be greatly reduced by mounting viscous damper or vibration absorbing device.

Studies show that, depending on the conditions of exposure, 6 to 100 percent of workers can suffer from HAVS after using vibrating power tools. On average, about 46 percent get HAVS symptoms. (HAVS) Study regarding this aims the standardization in the field of mechanical vibration and shock, including methods for measuring mechanical vibration and shock, methods for assessing exposure to mechanical vibration and shock, methods for reducing risks resulting from exposure to mechanical vibration and shock by machine design, methods for measuring and assessing the vibration and shock reduction characteristics of personal protective equipment.

However there are many standards exist in order to evaluate human exposure to both hand-arm and whole-body vibration. For vibration testing and reduction of hand held power tools it is necessary to declare the levels of vibration that tool transmit to the operator[1].For hand-held power tools, the declared vibration level will generally be derived from a CEN or ISO standard test code, such as, for electric tools, the, EN 60745 series. For pneumatic tools, test codes are described in the EN 28927 series of standards. The scope of the new EN 28927 test codes states that they apply to all tools, whether pneumatically driven, or driven by other means [3].

II. HISTORY OF HYDRAULIC VISCOUS DAMPER

The first production usage of high performance hydraulic dampers was in the 75 mm French artillery rifle of 1897. The damper was used to reduce recoil forces and had a stroke of over 48 inches. The exact design of this damper was considered a national secret of the French Government, and was shared with the U.S. and Great Britain during World War-I only after extensive negotiation [10].

Viscous dampers can protect structures against wind excitation, blast and earthquakes. Viscous damper technology originated with military and aerospace applications. Approximately 10 years ago it was found that the same fluid viscous dampers that protect missiles against nuclear attack and guard submarines against near-miss underwater explosions could also protect buildings, bridges and other structures from destructive shock and vibration. This paper describes fluid damper technology, analysis considerations, installation methods and development work in progress [9].The damper can absorb vibrations. The fluid viscous dampers are designed to behave as linear viscous device and accordingly they are very effective for vibration control [3].

Dampers aim to continuously remove energy from a moving system to control its response through the reduction of velocity, relative motion and/or mechanical strain. Most dampers react with a force that is a function of velocity. Some dampers react with a force that is a function of position as well as velocity [4]. Damping is a critical tool in shock and vibration isolation. Types of dampers include hydraulic or viscous dampers, coulomb or friction dampers, elastomeric dampers, structural damping materials, and tuned mass dampers and much more depending upon application.

This paper outlines the design analysis of viscous damper for various applications in power tools and implementation of method with validation.

III. PURPOSE OF DESIGN

In order to measure the grip force and the pressure distribution at the hand-handle, a hydraulic viscous damper has been developed and analyzed. Depending on these data acquisition we can use viscous fluid damper to take account of vibration emission reduction to human hand. With new design consideration of damper we can analyze the value of vibration emission with the application of power tool either reduces or not.

A. Design Principals

In all cases forces are the source of vibration. This leads to the three basic principles to control vibration:

1. Control the magnitude of the vibrating forces: Examples are the balancing unit on a grinder or the differential piston in a chipping hammer.
2. Make the tool less sensitive to the vibrating forces: Examples can be when the mass of the guard on a grinder is rigidly connected to the tool to increase the inertia of the tool.
3. Isolate the vibrations in the tool from the grip surfaces: Examples are vibration dampening handles on grinders or pavement breakers, the air-spring behind the blow mechanism in a riveting hammer or the mass spring system in a chipping hammer.

B. Details of Power Tool

A jigsaw [power tool](#) is a [jigsaw](#) made up of an [electric motor](#) and a [reciprocating saw blade](#). The jig saw in our case is to be used to cut aluminum sheet cut outs, using S-400 high speed steel blades 16 to 18 Psi. The conventional saw available and used is of following specifications 400 watt power. Aluminum cutting is slightly difficult than other materials cutting due to fact that chips of aluminum tend to stick in the gap between two teeth leading to chip blockage and subsequent vibrations makes it difficult to operate the machine for longer time and so also blade consumption per unit cut has been found to be very high [8].

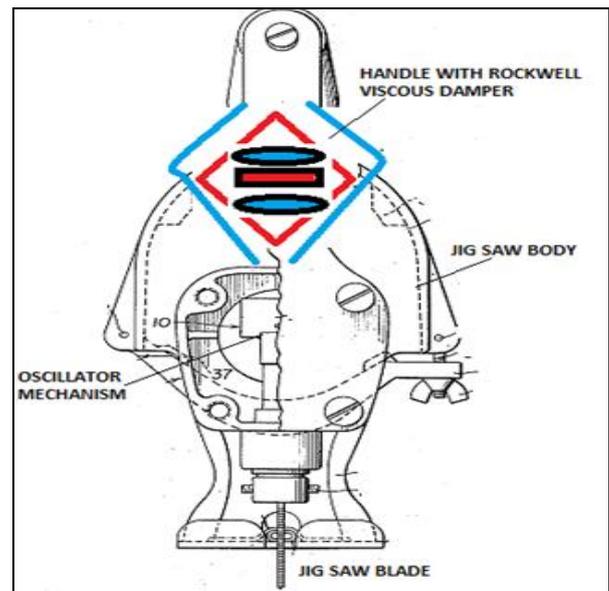


Fig.1 Example of an unacceptable low-resolution image

Jig saw (power tool) comprises of the motor 500 watt power coupled to the oscillator mechanism which carries jig saw blade that reciprocates to achieve the cutting action at high speed. The viscous damper is introduced between the body and handle such that vibrations thus generated during cutting do not reach the handle.

Vibration isolation handles represents a suitable possibility for some tools. Due to the wide range of variable parameters, e.g. the spring stiffness, the damping rate, the masses or the geometry, vibration isolation systems can only be adapted in consideration of the vibration characteristics of the respective machine. A numerical simulation is a helpful tool for finding an effective system. With this simulation, different systems can be tuned to a selected

machine for an optimal result. But the theoretical results also have to be verified [2].

C. Details of Hydraulic Viscous Damper

Fluid viscous dampers operate on the principle of fluid flow through orifices. A stainless steel piston travels through chambers that are filled with silicone oil. The silicone oil is inert, non flammable, non toxic and stable for extremely long periods of time. Here we are going design all parts of hydraulic viscous damper. It consists following two main parts:

1. Hydraulic damper body
2. Piston rod

In the case of semi-active control systems, the control forces are developed by the vibration itself through appropriate adjustment of the stiffness or damping characteristics of semi-active control devices [5]. This is also one of the type of semi-active damping device.

1. Hydraulic Damper Body

Material Selection: Material selection data taken from PSG handbook.

TABLE I
MATERIAL SELECTION FOR DAMPER BODY

Material	Ultimate Tensile Strength (N/mm ²)	Yield Strength (N/mm ²)
Aluminium	380	270

Hoop's Stress due to internal Pressure:

Stress in the longitudinal section that resists force F is obtained by dividing it by area of two cut surfaces. This gives

$$\sigma_t = \frac{\rho DL}{2tL} \dots\dots\dots (i) \qquad \text{from } \sigma = \frac{F}{A}$$

$$\sigma_t = \frac{\rho D}{2t} \dots\dots\dots (ii)$$

Maximum Pressure induced in body=3 bar

$$\sigma_t = \frac{0.3 \times 28}{2 \times 3}$$

$$\sigma_t = 1.4 \text{ N/mm}^2$$

Analysis of damper body

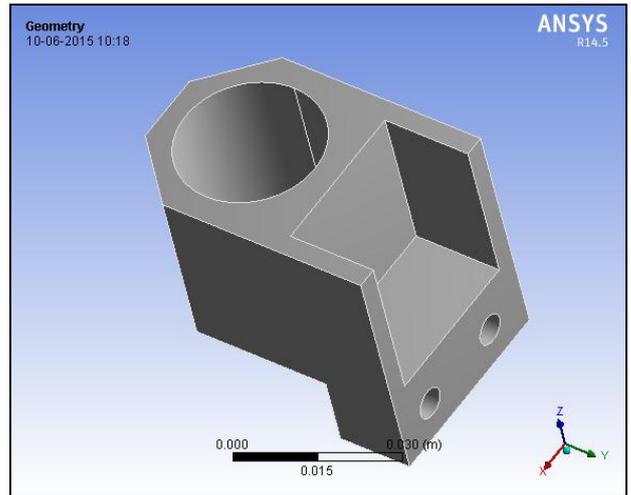


Fig.1 Geometry of damper body.

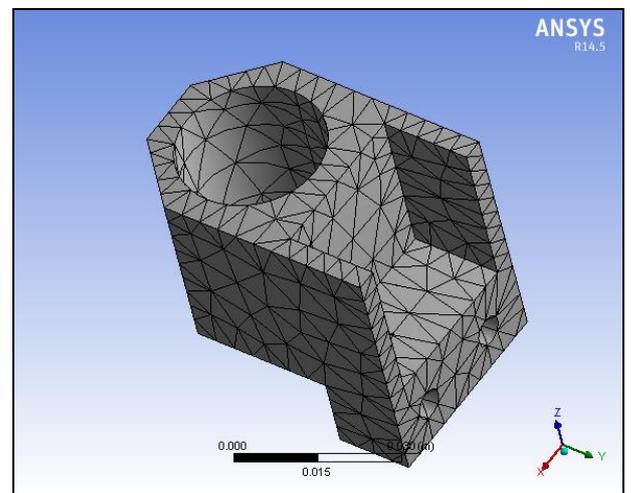


Fig.3 Mesh generation.

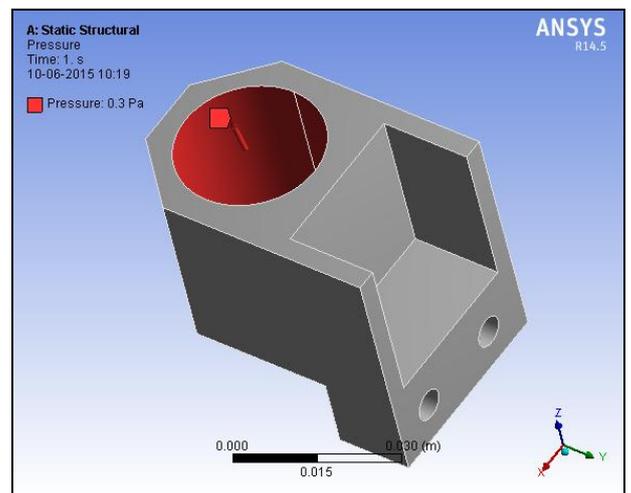


Fig.4 Circumferential pressure.

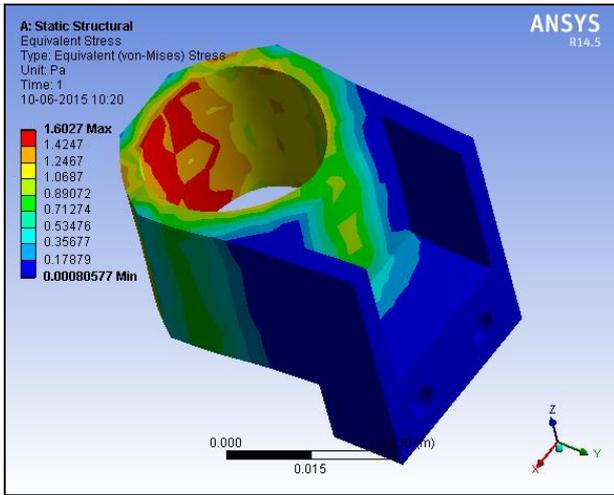


Fig.5 Von-Mises stress.

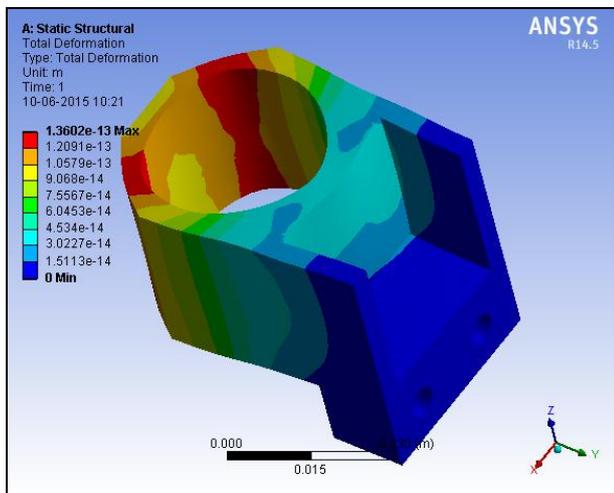


Fig.6 Total deformation.

According to result for the pressure 3 bar at circumference of the damper body is obtained safe design.

2. Design of Piston Rod

Material Selection: Material data selected from PSG handbook.

TABLE III
MATERIAL SELECTION FOR PISTON ROD

Material	Ultimate Tensile Strength (N/mm ²)	Yield Strength (N/mm ²)
EN24	800	680

Direct Tensile or Compressive stress due to an axial load:

$$Piston\ Force = Pressure \times Area$$

$$\sigma_t = \rho \times \frac{\pi}{4} D^2$$

$$= 0.3 \times \frac{\pi}{4} 2$$

$$\sigma_t = 184.72 N/mm^2$$

$$\sigma_{act} = \frac{\sigma_t}{A}$$

$$\sigma_{act} = \frac{184.72}{\frac{\pi}{4} 14^2}$$

$$\sigma_{act} = 1.19 N/mm^2$$

The piston rod is safe under compression.

Analysis of piston

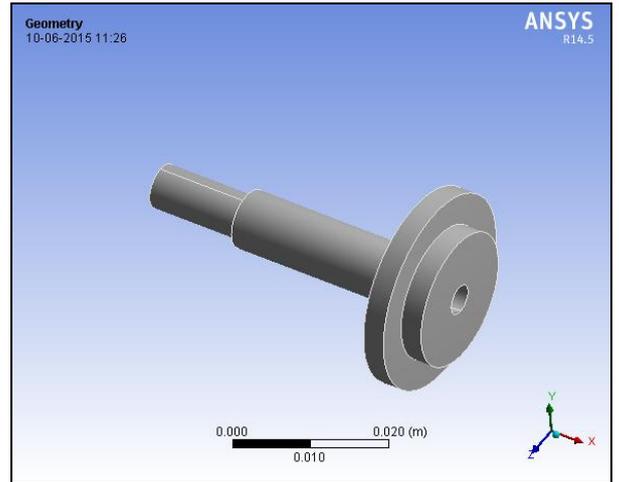


Fig.7 Geometry of piston.

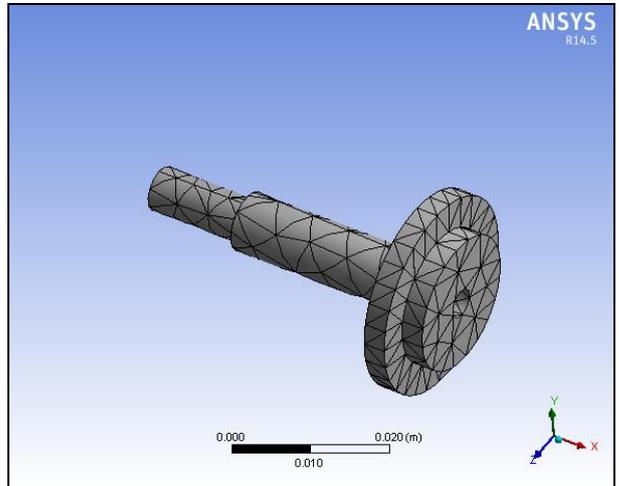


Fig.3 Mesh Generation.

After mesh generation, piston rod end is fixed along x-direction and compressive stress applied along same direction on top of piston end. The maximum equivalent stress (Von-Mises stress) developed on piston rod is 2.96N/mm².

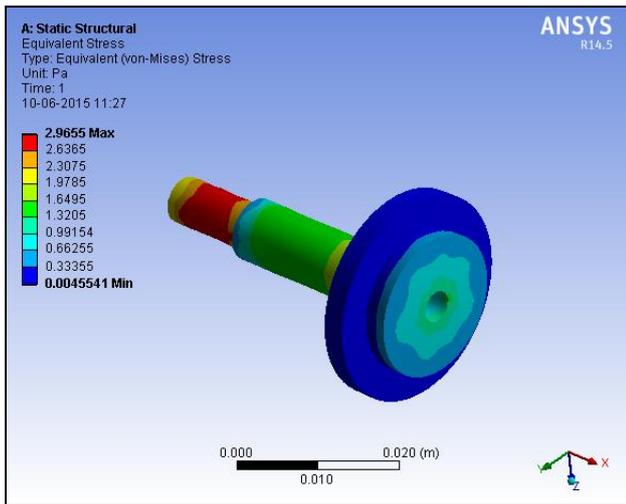


Fig.8 Von-Mises Stress.

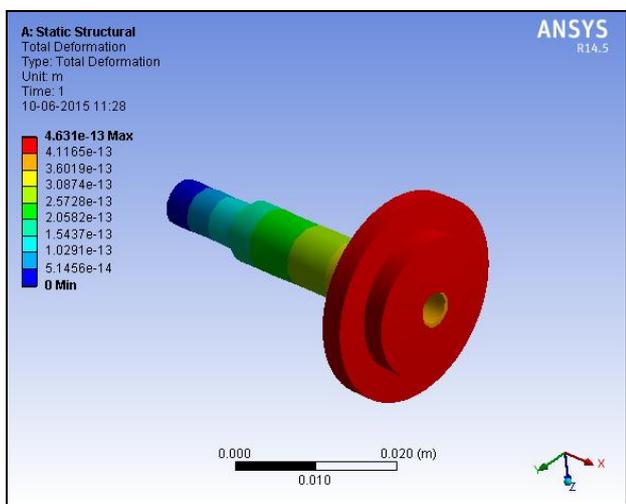


Fig.9 Total deformation.

IV. RESULT AND CONCLUSION

TABLE IIIII

TABULATED RESULTS FOR DAMPER BODY AND PISTON

Part Name	Maximum Therotical Stress N/mm ²	Von-Mises Stress N/mm ²	Maximum Deformation mm	Result
Damper Body	1.4	1.6	1.36×10^{-13}	Safe
Piston	1.19	2.9	4.63×10^{-13}	Safe

A. Design Principals

1. Maximum stress by theoretical method and Von-mises stress are well below the allowable limit; hence the damper body is safe.
2. Damper body shows negligible deformation under the action of system of forces.
3. Maximum stress by theoretical method and Von-mises stress are well below the allowable limit, hence the piston is safe.
4. Piston shows negligible deformation under the action of system of forces.

Owing to the advantages use of damper along with power tool can be effective using the design and analysis data of damper.

ACKNOWLEDGMENT

I wish to express my sincere gratitude thanks to Dr. M.M. Tayde for his valuable guidance and encouragement. With his cooperation I am able to complete my work .I also thankful to all faculty members of SIT, Lonavala.

Last but not least this acknowledgement would be incomplete without rendering my mother who always encouraged me in completion of this work.

REFERENCES

- [1] P. Christ, A. Cristalli, R. Deboli, G. Di Giulio, M. Geuder, G. Miccoli, N. Paone, G.L. Rossi, New measurement procedure of Hand-Arm Vibration from the DOPTEST Research Project, Hand Arm and Whole Body Vibration,2000,pp 4-8.
- [2] BS EN 60745-2-11,Richard Heaton, Reciprocating saws, Health and Safety Laboratory,2003,pp.5-7.
- [3] M.C. Constantinou, M.D. Symans, P. Tsopelas, "Fluid viscous dampers in applications of seismic Energy dissipation and seismic isolation," State University of New York Buffalo, NY 14260.pp.1-2
- [4] A. R. Klembczyk, "Introduction to shock and vibration isolation and damping system,"Chief Engineer Taylor Devices, Inc. 90 Taylor Drive North Tonawanda,NY 14120-0748.pp-1-4.
- [5]P. Donati , M. Schust, D. Reinert, Workplace exposure to vibration in Europe: an expert review, European Agency for Safety and Health at Work, ISSN 1830-3946,EN 7,2008,pp.17-18
- [6] M. Bovenzi, "Response of finger systolic pressure to cold provocation in healthy subjects and in Reynaud's phenomenon of occupational origin," In: Proceed 6th International Conference of Hand-Arm Vibration, Bonn, Germany, May 1992, pp. 75-80.
- [7]L Burström, A. Sörensson, "The influence of shock-type vibration compared with non impulsive vibration on the absorption of vibration energy in the human hand," 8th International Conference on Hand-Arm Vibration, 9-12 June 1998, Umeå, Sweden,pp.25-28.
- [8]O Backetman, "Aspects on hand-arm vibration ,"Eighth International Conference on Hand-Arm Vibration 9-12 June 1998, Umeå, Sweden,pp.11-14.
- [9]D. Lee and D. P. Taylor, Viscous Damper Development and Future Trends, Copyright @ 2001 John Wiley & Sons, Ltd., 2007, pp.1-2.
- [10] D. P. Taylor, "The application of energy dissipating damping devices to an engineered structure or mechanism," President Taylor Devices, Inc. 90 Taylor Drive P.O. Box 748 North Tonawanda, NY 14120-0748.May 1997.