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Investigation and Analysis of Viscous Fluid Damper for Vibration Reduction in Hand Held hole Saw

#1Sayli M. Jadhavr, #2, P.G.Karajagi,

#12Mechanical Department, Savitribai Phule Pune University
Siddhant College of Engineering Chakan Pune India

ABSTRACT

This paper is devoted to study of HAV in hand held hole saw. 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. Multiple studies have shown that regular and frequent exposure to HAV can lead to permanent adverse health effects, which are most likely to occur when contact with a vibrating tool or work process is a regular and significant part of a person's job. Hand-arm vibration can cause a range of conditions collectively known as hand-arm vibration syndrome (HAVS), as well as specific diseases such as white finger or Raynauld's syndrome. Vibration syndrome has adverse circulatory and neural effects in fingers. A hole saw also known as a hole cutter is a saw of 250 watt power is considered for a present study. Plywood cutting is slightly difficult than other materials cutting due to fact that fibers of ply 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. In this project cutting forces are the source of vibration. The basic principles to control vibration used is to isolate the vibrations in the tool from the grip surfaces by using viscous fluid damper. It includes design and development of hole saw machine. Design and development of the viscous type hydraulic viscous damper to isolate and reduce the vibrations generated during cutting. Testing of the developed hole saw cutter with and without the viscous fluid damper to determine the Overall damping coefficient & RMS values at two cutting speeds.

Keywords— **HAV, Raynauld's syndrome, Viscous fluid Damper, Finite Element Analysis**

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I. Introduction

American Conference of Governmental Industrial Hygienists (ACGIH) has developed Threshold Limit Values (TLVs) for vibration exposure from hand-held tools. The exposure limits are given as frequency-weighted acceleration that represents a single number measure of the vibration exposure level. Table 1.1 lists acceleration levels and exposure durations to which, ACGIH has determined, most workers may be exposed repeatedly without severe damage to fingers.

Total Daily Exposure Duration (hours)	Maximum value of frequency weighted acceleration (m/s^2) in any direction*
4 to less than 8 hours	**4**
2 to less than 4 hours	**6**
1 to less than 2 hours	**8**
less than 1hour	**12**

Table 1. The ACGIH Threshold Limit Values (TLVs) for exposure of the hand to vibration in X, Y, or Z direction

A hole saw also known as a hole cutter, is a saw blade of annular (ring) shape, whose annular kerf creates a hole in the work piece without having to cut up the core material. The same hole can be made faster and using less power. The conventional saw of 250 watt power is considered for a case study. Plywood cutting is slightly difficult than other materials cutting due to fact that fibers of ply 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. Hand-arm vibration (HAV) can be caused by operating hand-held hole saw. Hand-arm vibration can cause a range of conditions collectively known as hand-arm vibration syndrome (HAVS), as well as specific diseases such as white finger or Reynaud's syndrome, car Vibration syndrome has adverse circulatory and neural effects in the fingers. The signs and symptoms include numbness, pain, and blanching (turning pale and ashen). Cold-provoked color changes in the hands (as in the figure 1.1)

Fig 1 white fingers

The paper includes design and development of hole saw machine 400 watt power with reduction gear box to increase cutting efficiency. Design and development of the viscous type hydraulic viscous damper to isolate and reduce the vibrations generated during cutting. Testing of the developed hole saw cutter with and without the viscous fluid damper to determine the Overall damping coefficient & RMS values at two cutting speeds. Comparative analysis of the performance of the hole saw machine with and without hydraulic damper as to cutting speed (m/min) & dimensional accuracy. Mathematical model of damper system for optimal vibration damping, optimal weight, development of mathematical model of system of forces derivation and resolution of system forces by drawing free body diagram of linkage, determination of forces and utilizing system of forces to determine the linkage dimensions of critical parts of drive. 3-D modeling of set-up will be done using Unigraphix Nx-8.0 and CAE of critical component and meshing using Ansys Work-bench 14.5. The experimental validation of force transmissibility values to that obtained by use of ANSYS software. By application of iterative techniques predictions will be made on appropriate dimensions of the viscous damper for different sizes of holes cutter.

II LITERATURE SURVEY

1. Safety Note 23 Health & Safety Guidance on Hand-Arm Vibration (HAV) The University of Reading Health and Safety Services -The safety note had given the definition of HAV as HAV is vibration which can reach your hands when you are working with hand held power tools . In this note the detail effects of HAV had described HAV can cause damage to Blood circulatory system, vibration white finger (VWF) often occurs when fingers or the body are cold or wet, initially finger tips become white. They may become numb and you may get 'pins and needles'. The guidelines described risk of HAV depends on: - vibration levels are time span use the equipment for methods of using & to grip the equipment. The study found that problems can appear after months or years of use and depend on what levels have been experienced and for how long. Equipment in areas such as Grounds, Maintenance, Agriculture, Farms, workshops and engineering processes and those involved in cleaning activities. In particular, individuals using tools with a hammer action for more than half an hour each day or using rotary or similar action equipment for more than 2 hours a day. examples include chainsaws, circular saws, hand-held grinders, hand-held sanders, nut runners, powered lawnmowers, brush cutters and buffing machines. They suggested to provide anti-vibration dampers and mountings or vibration isolating handles may help reduce HAV.

According the study understanding vibration data Vibration magnitude Exposure to HAV is measured in terms of acceleration of the surface in contact with the hand as it moves one way and back again. This is normally expressed in m/s. Particular frequencies, 5-20 Hertz (Hz, cycles per second of energy), cause most damage. Owing to the Health and Safety Guidance Notes on Hand-Arm Vibration frequency dependence, a frequency weighting is applied to measurements. Hazard to health is usually assessed from the average (root mean square or rms) acceleration level where: - ahw in m/s (h means hand transmitted and w means weighted)

2. Hand-Held Power Tools Health and Safety Executives 246/31.HSE leaflet INDG 338 Power Tools Reducing Risk of Hand-Arm Vibration Injury: In the leaflet they said that tool suppliers should not recommend anti-vibration gloves as a means of attenuating the vibration from hand-held power tools unless models of anti-vibration gloves have been demonstrated to provide protection in accordance with the requirements of the Personal Protective Equipment at Work Regulations 1992.However, gloves may help prevent vibration injury by keeping hands warm and dry.

3. SAFE WORK AUSTRALIA, National Code of Practice for Hazardous Manual Tasks. This Code provides guidance on risks involved in manual tasks. 2011

In this manual they said that considerable variation in emitted vibration between tools of the same type. Tools that incorporate vibration-reduction innovations in their design, or are manufactured to higher specifications may vibrate less than other tools. To make an informed choice, obtain as much information about the vibration emissions of the tool as possible. Consider the suitability of hand-held power tools for the work being undertaken - an underpowered or blunt tool may take longer to do the job, increasing the time of exposure, and an overpowered or oversized tool may emit more vibration than necessary. In Europe there are mandatory requirements which may be used as a guide. You should select tools that can be used with the daily vibration exposure of a user remaining below 2.5 m/s^2 averaged over an 8 hour working day. If this is not achievable, consider changing or rearranging the task so this can be met. Sometimes it is not possible to reduce exposure to below 2.5 m/s^2, however you should never allow a worker to be exposed to more than 5 m/s^2 over an 8 hour day

4. Erik Greenslade , Tore J. Larsson , "Reducing vibration exposure from hand held grinding, Sanding, Polishing Power tolls by improvement in equipment and Industrial Process" Safety Science Vol. 25, No. 1-3. pp. 143-152, 1997-In this paper they had discussed HAV in hand-held grinding, sanding and polishing tools .They studies Swedish industrial process & suggested that remove, or reduce, the need of such processes. As the production requirement for this operation is reduced, the duration of the operator's exposure to vibration will also be lessened. But that is not useful to minimize the effect of HAV for that better tool design is required to reduce some of the vibration transmitted to the operator. The relatively recent availability on the market of a grinder with an automatic balancing device, as well as the development of anti vibration grinders, less vibration prone grinding wheels, and more effective anti vibration handles and gloves, may lead to a reduced incidence of vibration disease.

5. J.E.Hansson, S.Khilberg Applied Ergonomics1983,14.1,11-18 A Test Rig for the measurement of vibrations in hand held power tools-They studied vibrations and noise in Hand held power tools and for measurement test rig was. Test rig was developed to give same effect on tool handle vibration as the human hand. Drilling process is studied drilling with test rig and manual drilling was compared. The difference between the two was about 1dB for iso-weighted values in the critical direction.

III EXPERIMENTAL SETUP

Hole saw tool (Router) - The tool usually consists of a base housing a vertically mounted universal electric motor with a collet on the end of its shaft. The Control of the router is derived from a handle or knob on each side of the device, or by the more recently developed "D-handle". Hole Saw Machine holder-The tool is mounted with the help of coupler shaft .Coupler shaft connects the motor & Tool. The Power is given by the motor to the tool. The motor is single phase selected for designed torque of 0.81 Nm &Power 450 WATT with 15000RPM speed The reduction gear box standard spiral bevel gear box for 1:3 reduction ratio ·Load cells are used to measure vibration level.

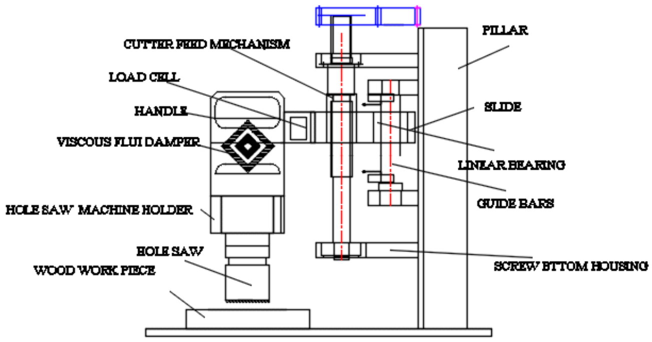

Fig 2 Experimental Setup

Details of the viscous damper:

The most unique elements of this damper are the frictionless seals made from a welded metal bellows. This type of seal does not slide, but rather flexes without hysteresis as the damper moves. Two metal bellows seals are used to seal fluid in the damper. As the damper moves, the two metal bellows alternately extend and retract, by flexure of the individual bellows segments. Since the seal element elastically flexes rather than slides, seal hysteresis is nearly zero. The volume displaced by the compressing bellows passes through the crossover ports to the extending bellows at the opposite end of the damper. While this is occurring, damping forces are being produced by orifices in the damping head, and the pressures generated are kept isolated from the metal bellows by high restriction hydrodynamic labyrinth bushings. Because hydrodynamic bushings are used, no sliding contact with the piston rod occurs, assuring frictionless performance.

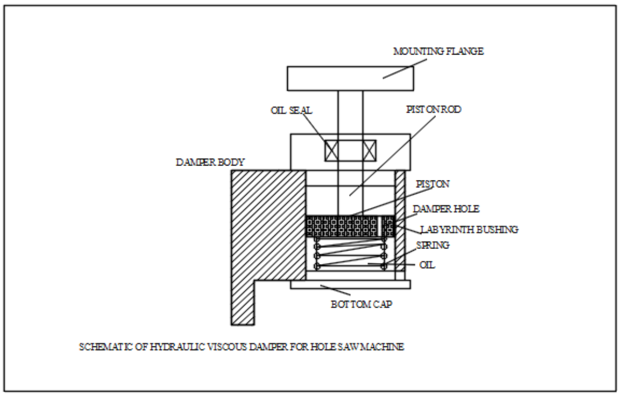

Fig 3 Schematic representation of fluid damper

IV EXPERIMENTAL VALIDATION

Experimental validation of force transmissibility values to that obtained by use of ANSYS software. By application of iterative techniques predictions will be made on appropriate dimensions of the viscous damper for different sizes of hole cutter.

Finite Element Modeling

In this work, the analysis was carried out for different parts of hole Saw & Damper as follows:-

Design & Analysis of Collet

Material –EN24

Ultimate Tensile strength N/mm^2=800

Yield strength N/mm^2=680

Geometry

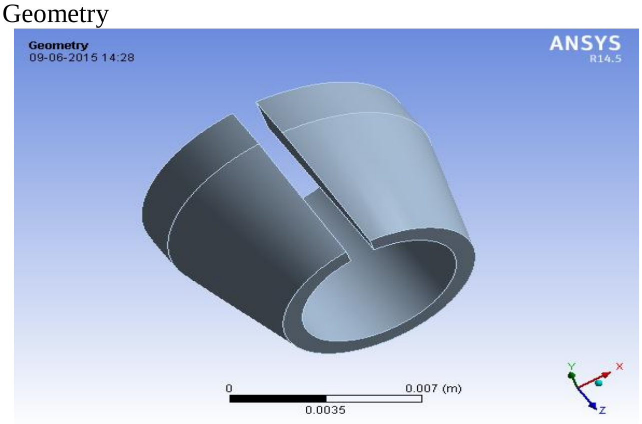

Fig 4 Geometry of collet

Applying Mesh

Mesh generation is the process of dividing the analysis continuum into a number of discrete parts or finite elements.

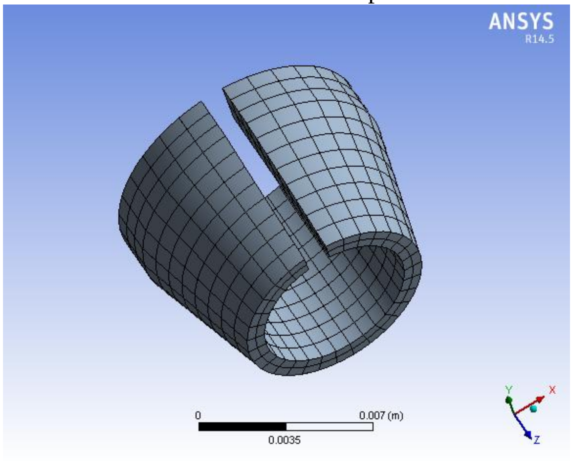

Fig 5 Meshing of collet

Apply loads and Boundary conditions

Some type of load is usually applied to the analysis model. The loading may be in the form of a point load, a pressure or a displacement in a stress. The loads may be applied to a point, an edge, a surface or an even a complete body.

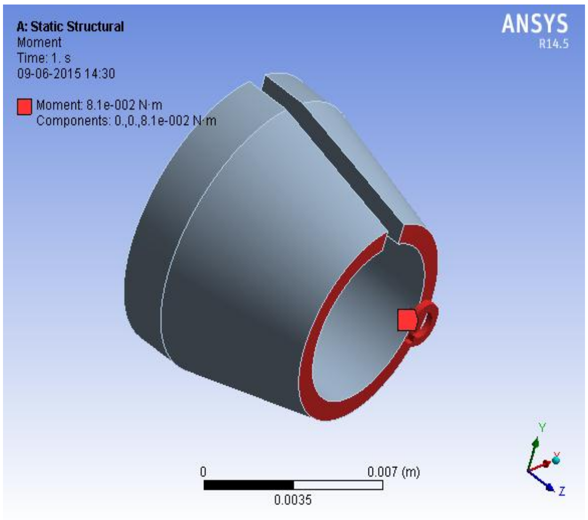

Fig 6 Boundry conditions for collet

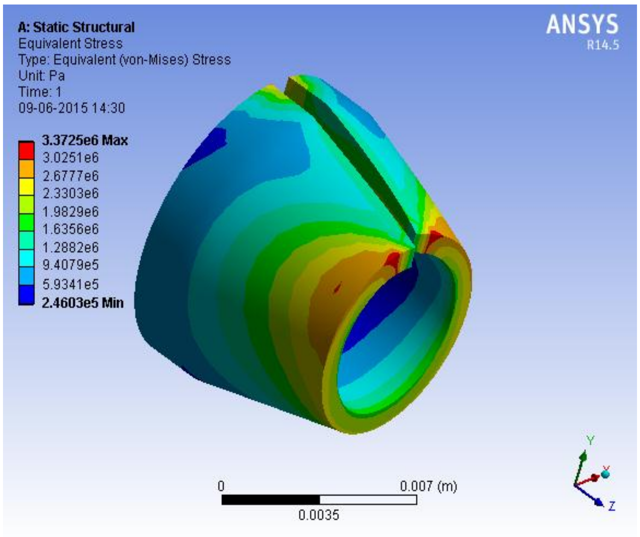

Fig .7 Stress Analysis for collet

Design & Analysis of Cutter Saw

Material –HSS

Ultimate Tensile strength N/mm^2=900

Yield strength N/mm^2=810

As Per ASME Code;

fs_{max} = 130 N/mm^2

Actual shear force for cutter size 28 mm is calculated it is 1.66 N/mm^2 $F_{s\ act}$ is very less than allowable.

Geometry

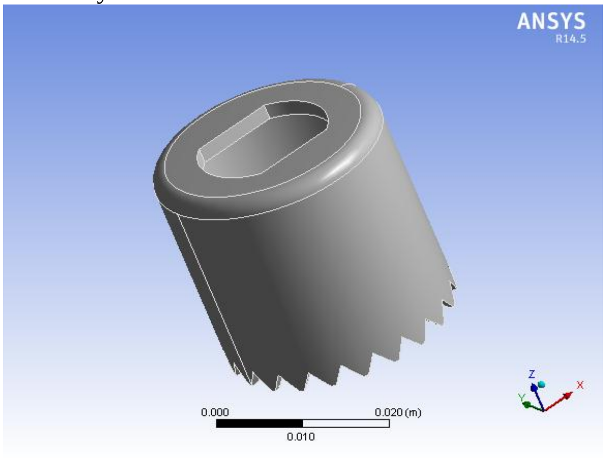

Fig 8 Geometry of saw

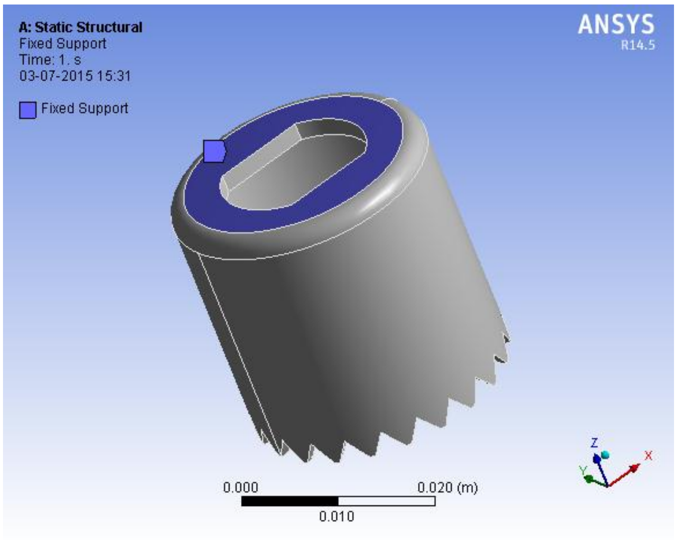

Fig 9 Boundry conditions for saw

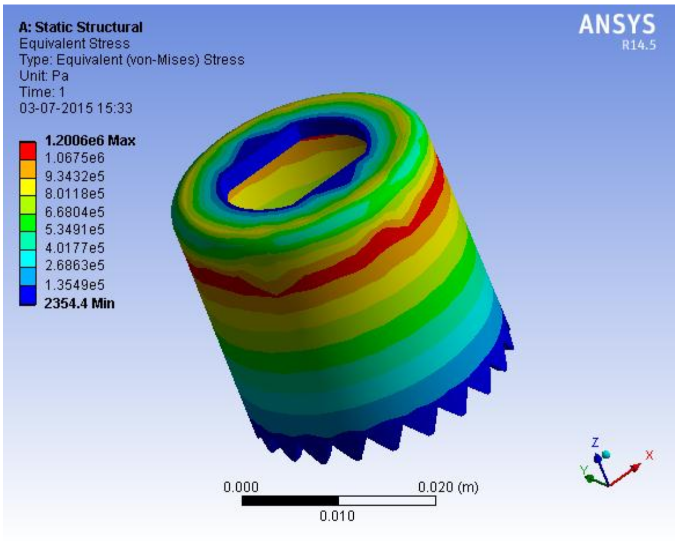

Fig. 10 Stress Analysis for saw

Design of Hydraulic Damper Body

Material=Aluminium

Ultimate Tensile strength N/mm^2=380

Yield strength N/mm^2=270

Hoope's stress due to exhaust gas pressure :-

Maximum pressure induced in system due to steam= 3 bar

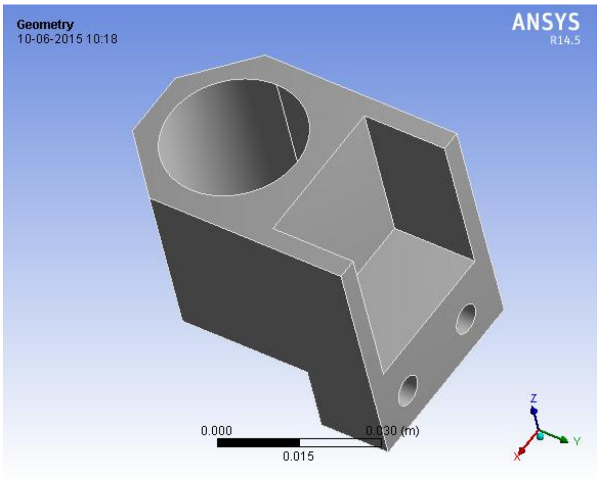

Fig. 10 Geometry of damper body

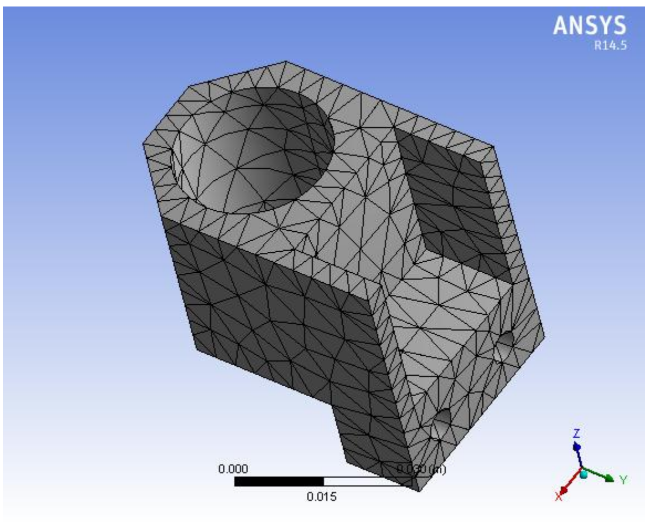

Fig. 11 Meshing of damper body

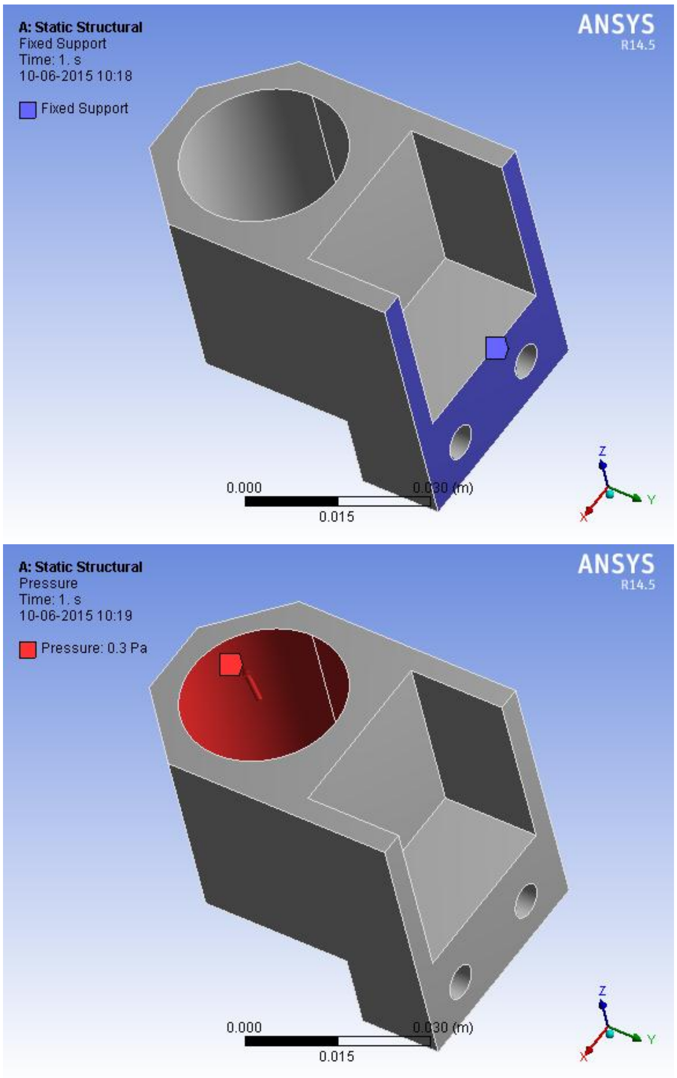

Fig. 12 boundary conditions for damper body

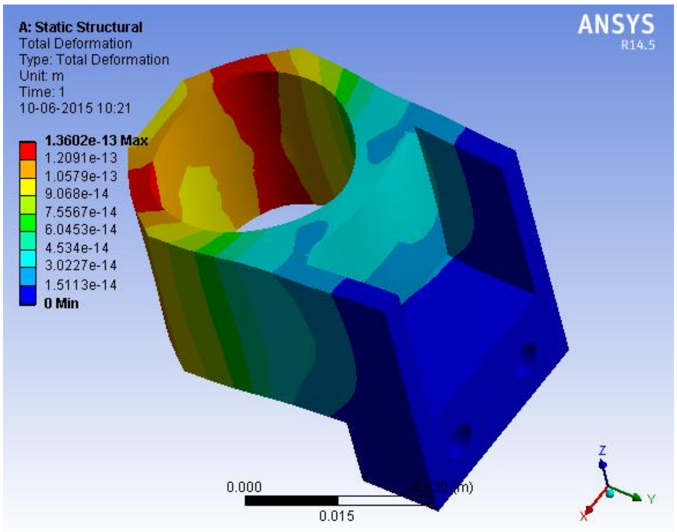

Fig 13 Stress Analysis for damper body

v. Result & discussion

Part Name	Maximum theoretical stress	Von-misses stress/	Maximum deformation mm	Result

	N/mm^2	N/mm^2		
Damper body	1.4	1.6	1.36×10^{-13}	Safe

Table 2. Analysis Results

Maximum stress by theoretical method and Von-misses stress are well below the allowable limit; hence the damper body is safe Damper body shows negligible deformation under the action of system of forces.

CONCLUSION

In this paper the hand arm vibration syndrome is studied. Effect of HAV while working with hand held hole saw for plywood cutting is considered for present study. To minimize HAV use of Fluid damper is most effective way. For required power hole saw is designed & analyzed for working force in this paper. To minimize Vibration generated due to cutting force fluid damper is designed .Future scope is to check vibration in hole saw with & without Damper.

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