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DESIGN AND ANALYSIS OF PASSIVE AND ACTIVE DAMPER FOR WOOD WORKING MACHINE

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ABSTRACT

In the various working field, the vibration may cause injurious to human body. Especially, the vibration which is non-uniform, constantly and repeatedly transferred to the human body. This vibration gives serious physical problem to worker hand. Hand-arm vibration is the continuous vibration transmitted from a machine 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. Multiple studies have shown that regular and frequent exposure to HAV can lead to temporary/permanent adverse health effects, which are most likely to occur when contact with a vibrating machine 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. In this paper we reduced the hand vibration by using the damper system to the machine.

INDEX TERMS— Hand-arm vibration, vibration syndrome, vibration white finger [VWF].

INTRODUCTION

Vibration is the motion of a particle or a body or system of connected bodies displaced from a position of equilibrium. Most vibrations are undesirable in machines and structures because they produce increased stresses, energy losses, cause added wear, increase bearing loads, induce fatigue, create passenger discomfort in vehicles, and absorb energy from the system. Rotating machine parts need careful balancing in order to prevent damage from vibrations. Vibration occurs when a system is displaced from a position of stable equilibrium. The system tends to return to this equilibrium position under the action of restoring forces (such as the elastic forces, as for a mass attached to a spring, or gravitational forces, as for a simple pendulum). The system keeps moving back and forth across its position of equilibrium. A system is a combination of elements intended to act together to accomplish an objective. For example, an automobile is a system whose elements are the wheels, suspension, car body, and so forth. A static element is one whose output at any given time depends only on the input at that time while a dynamic element is one whose present output depends on past inputs. In the same way we also speak of static and dynamic systems. A static system contains all elements while a dynamic system contains at least one dynamic element. A physical system undergoing a time-varying interchange or dissipation of energy among or within its elementary storage or dissipative devices is said to be in a dynamic state. All of the elements in general are called passive, i.e., they are incapable of generating net energy. A dynamic system composed of a finite number of storage elements is said to be lumped or discrete, while a system containing elements, which are dense in physical space, is called continuous. The analytical description of the dynamics of the discrete case is a set of ordinary differential equations, while for the continuous case it is a set of partial differential equations. The analytical formation of a dynamic system depends upon the kinematic or geometric constraints and the physical laws governing the behavior of the system.

PROBLEM STATEMENT

Wood working jig saw machine is a high speed wood working machine used to cut wood work-piece in furniture making, Casting pattern making, wooden seat design, wood prototyping etc. Subsequent vibrations makes it difficult to operate the machine for longer time and so also power consumption per unit cut has been found to be very high, and vibrations lead to inaccuracy in cutting and error in profile shape.

Thus methodology used in vibration Isolate the vibrations in the tool from the grip surfaces by introducing a viscous fluid damper in between the cutter body and the grip handle. The damper selected for the purpose is a semi-active one where in the damping coefficient of device is adjustable.

Project work comprises of design and development of wood jig saw machine with 350 watt power where in the handle mounting will be designed to operate with and without fluid damper. Mathematical modelling of semi-active fluid damper to isolate vibrations produced during cutting process fluid damper where in damping coefficient is varied by use of modified damper orifice design.

OBJECTIVES

1. Design and development of hole saw machine 350 watt power with reduction gearbox to, increase cutting efficiency for hole sizes diameter 15 mm to 35 mm using high speed steel jig saw cutter.
2. Design and development of the passive and active type fluid damper to isolate and reduce the vibrations generated during sawing operations
3. Testing of the developed jig saw cutter with and without the passive and active damper to determine the Overall damping coefficient & RMS values at cutting speeds.
4. Comparative analysis of the performance of the hole saw machine with and without viscous fluid damper as to cutting speed (m/min) & dimensional accuracy. Validation of strength calculations of critical components using ANSYS. ie the post processing part for some parts.

DESIGN

"Machine design is an art and technique of planning the construction of a new or improvised machine. The machine may be entirely new in concept or modification of the existing machine for better utilization & economy."

Development Design needs considerable scientific & innovative design ability in order to modify existing design into a new idea by adopting new materials or methods of manufacture. In this case although the designer starts from existing design the final product may differ quite markedly from the original product.

Design consists of application of scientific principles, technical information and imagination for development of new or improvised machine or mechanism to perform a specific function with maximum economy & efficiency. Hence a careful design approach has to be adopted. The total design work has been split up into two parts;

A. System design
B. Mechanical Design.

System design mainly concerns the various physical constraints and ergonomics, space requirements, arrangement of various components on main frame at system, man + machine interactions, No. of controls, position of controls, working environment of machine, chances of failure, safety measures to be provided, servicing aids, ease of maintenance, scope of improvement, weight of machine from ground level, total weight of machine and a lot more.

In mechanical design the components are listed down and stored on the basis of their procurement, design in two categories namely,

- **Designed Parts**
- **Parts to be purchased**

For designed parts detached design is done & distinctions thus obtained are compared to next highest dimensions which are readily available in market. This amplifies the assembly as well as postproduction servicing work. The various tolerances on the works are specified. The process charts are prepared and passed on to the manufacturing stage.

The parts which are to be purchased directly are selected from various catalogues & specified so that anybody can purchase the same from the retail shop with given specifications.

CONCEPT OF VIBRATION CONTROL:

Design principles

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.

Here in our approach of reduction in –Hand –Arm-Vibration we have adopted the third method to isolate the vibrations in tool from the grip surface ie, the handle by use of active passive viscous damper.

FORCE ANALYSIS

Router machine is used to excavate the material as a cavity by plunging the router tool into the material, thus the router process takes place in two stages;
a) Drilling the given profile hole size into the material: This process consumes maximum power and accounts for maximum vibration.
b) Milling process involves the lateral movement of tool with reference to the work-piece to achieve the desired length of cut, this process accounts for lesser power consumption as compared to drilling process hence accounts to lesser vibration.
Thus the plunge drilling operation characteristics are used to determine the power requirements to account for maximum factor of safety.

3.4 Teak Wood Details:

Teak is found in tropical areas of the world. Thailand, Burma and India are just three countries. Teak is a natural wood, ideal for outside furniture. It contains natural oils that protect it against wet and cold weather. It can also be treated with teak oil giving it more protection against the elements. Teak is expensive although the growth of sustainable teak plantations means that the price will eventually fall and it will be more widely available.

DESIGN OF DAMPER PISTON

Material selection:

Ref :- (PSG – 1.12)

Designation	Tensile Strength N/mm^2	Yield Strength N/mm^2
AL	400	280

Direct Tensile or Compressive stress due to an axial load :-
Piston force = Pressure x area = 0.3 x (π /4) 28^2 = 184

$$fc_{act} = \frac{W}{A}$$

$$(\pi/4) \times dc^2$$

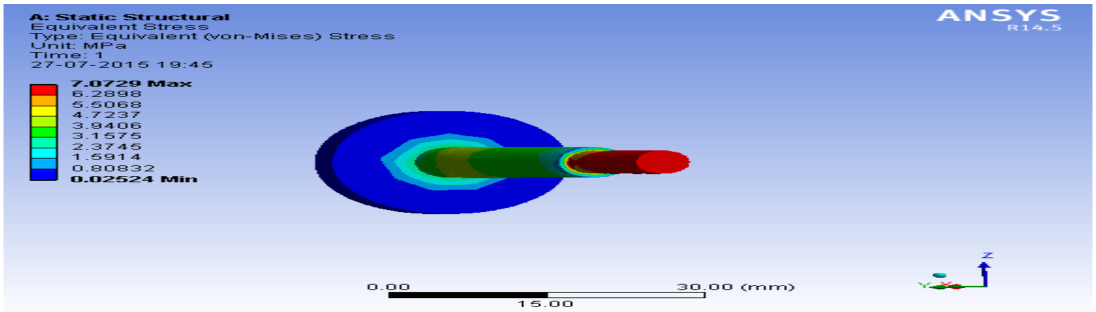
$$fc_{act} = \frac{184}{\Pi/4 \times 6^2}$$

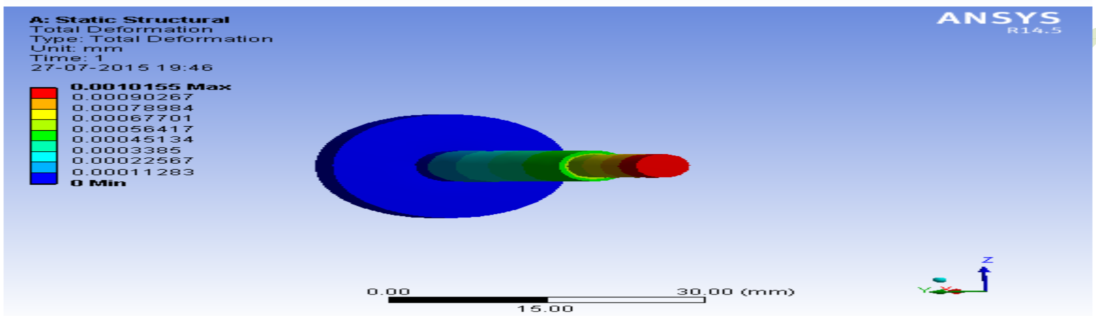
$$\Rightarrow fc_{act} = 0.92$$

As $fc_{act} < fc_{all}$;   Piston rod is safe in compression.

ANALYSIS OF PISTON

GEOMETRY





RESULT & DISCUSSION

Part Name	Maximum theoretical stress N/mm^2	Von-mises stress N/mm^2	Maximum deformation Mm	Result
Piston	0.92	7.07	0.001	Safe

CONCLUSION.

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

DESIGN OF HYDRAULIC DAMPER BODY

Material selection.

Designation	Ultimate Tensile strength N/mm^2	Yield strength N/mm^2
Aluminium	380	270

Hoope's stress due to exhaust gas pressure :-

Maximum pressure induced in system due to steam= 3 bar

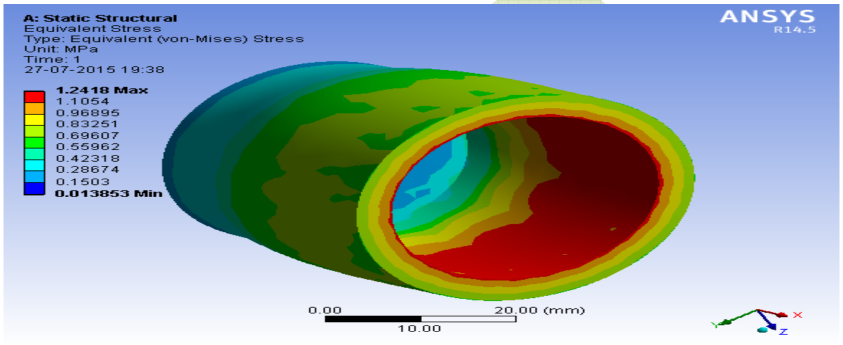
$$fc_h = \frac{P\,xd}{2t}$$

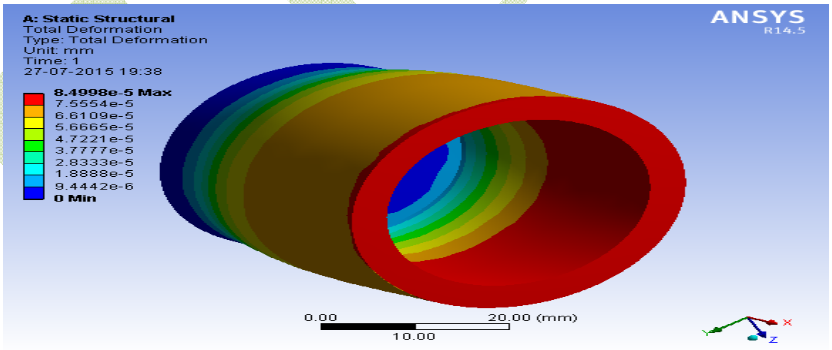
$$fc_{act} = \frac{0.3 \times 28}{2 \times 3}$$

$$\Rightarrow fc_{act} = 1.4 N/mm^2$$

As $fc_h < fc_{all}$; damper body is safe

ANALYSIS OF DAMPER BODY





RESULT & DISCUSSION

Part Name	Maximum theoretical stress N/mm^2	Von-mises stress N/mm^2	Maximum deformation Mm	Result
DAMPER BODY	1.4	1.24	$4.68.5 \times 10^{-5}$	safe

CONCLUSION

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.

DESIGN OF ROUTER MACHINE HOLDING BRACKET

Material selection.

Designation	Ultimate Tensile strength N/mm^2	Yield strength N/mm^2
EN 9	600	480

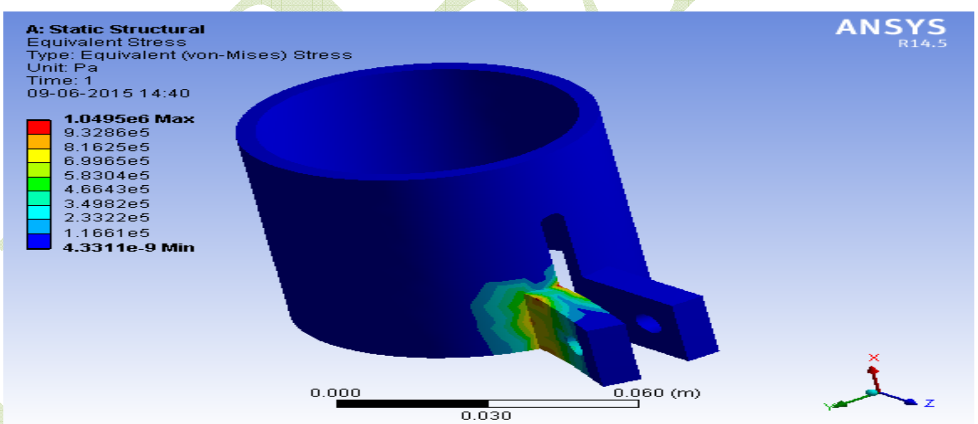
Shear stress = shear force / area

$\Rightarrow fs_{act} = 25.31 / 25 \text{ X } 6 \ N/mm^2$

$fs_{act} = 0.17/mm^2$

As; $fs_{act} < fs_{all}$ $(150\ N/mm^2)$

$\Rightarrow$ Follower arm is safe



RESULT & DISCUSSION

Part name	Max theoretical stress N/mm^2	Maximum stress N/mm^2	Allowable Stress N/mm^2
M/c Holder bracket	0.17	10.49	2.83×10^{-7}

CONCLUSION

1. Maximum theoretical stress and Equivalent Von-mises stress are far below allowable value for collet nut hence collet nut is safe.
2. Maximum theoretical stress and Equivalent Von-mises stress are far below allowable value for collet hence collet nut is safe.
3. Maximum theoretical stress and Equivalent Von-mises stress are far below allowable value for collet nut hence holder bracket is safe.

CONCLUSION

Fabrications and Testing of the developed wood router cutter without damper and with the semi-active damper to determine the Overall damping coefficient & RMS values at two cutting speeds. Comparative analysis of the performance of the jig saw machine by varying materials (Teak wood & packaging wood) so as to cutting speed (m/min), Material removal rate & dimensional accuracy. 3-D modeling of set-up using Unigraphix Nx-8.0 CAE of critical component and meshing using Ansys.ie the pre-processing part. Mechanical design validation using ANSYS critical components of the system will be designed and validated Validation of strength calculations of critical for both modal and strength analysis.

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