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DESIGN AND ANYLYSIS OF VISCOUS DAMPER FOR VIBRATION REDUCTION IN HAND OPERATED POWER TOOLS

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ABSTRACT

Vibration-reducing viscous damper have been used to reduce the hand-transmitted vibration exposures from machines and powered hand tools but their effectiveness remains unclear, especially for finger protection.The objectives of this study are to determine whether viscous damper can attenuate the vibration transmitted to the fingers and to enhance the understanding of the mechanisms of how these viscous damper work.

Thesis is presented on the basis of hand-arm vibration with the application of jigsaw tool. Attention is given to the damper design requirement for vibration reduction. The analysis of jigsaw power tool is helpful in determination of vibration exposure evaluation along with damper. The study of evaluation of exposures to the vibration produced within hand or body during operating the power tools is main purpose of this paper. This paper summarizes 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. The purpose of this design 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.

KEYWORDS: Hand-arm vibration, Finger vibration ,Hand-transmitted vibration,Viscous damper design

INTRODUCTION

Exposure to mechanical vibrations at the workplace, such as hand-transmitted vibrations, can arise in numerous labors (e.g., in construction or manufacturing industries), for example when manually handling powered tools. These hand-transmitted vibrations are associated with a variety of signs and symptoms including vascular and neurological disorders . More specifically, it has been shown in several reviews that hand transmitted vibrations are associated with upper extremity complaints for example, shoulder pain and specific pathologies like tenosynovitis and epicondylitis Although evidence is slightly inconsistent as there are also studies reporting weak evidence for the association of hand-arm vibration and upper-extremity complaints,

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, 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

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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.

PURPOSE OF STUDY

There have always many problems regarding hand arm vibrations. Firstly measure to measure correct amount of vibration velocity or acceleration and quantify the amount of exposure with respect to risk damage to operator. The main reference is given by ISO standard 5349:2001 in accordance with hand arm vibration and exposure evaluation. The purposes of basic vibration generation causes are important in machinery to effective control of vibration reduction and studying the effect of vibration on human health [6]

What is Machine Vibration?

Vibrations arise when a body oscillates due to external and internal forces. Vibration may be transmitted to the human body through the part in contact with the vibrating surface: the handle of a machine, the surface of a piece of equipment, or the seat of a mobile machine.

Two forms of exposure to be studied: **whole-body vibration** (WBV), which is transmitted by mobile or fixed machines where the operator is standing or seated, and **hand-arm vibration** (HAV), which is transmitted by hand-held or guided tools. The term defines:

1. Hand-arm vibration is the most common form of vibration experienced during hand operated power tool. Hand-arm vibration occurs when a person holds or guides a vibrating tool or machine with their hand or hands and vibration is transmitted from the tool to the hand and along the arm.

2. Whole body vibration occurs when a person stands or sits on a vibrating machine or surface. The vibration is transmitted through supporting end of machine such as the standing person's feet and the supporting areas of a person in contact with machine. [4].

Hand arm vibration is vibration transmitted from work processes into workers' hands and arms. It is associated with use of hand held power tools, hand guided equipment and by holding materials being processed by machines. 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 operator's job

Fig.1.Operator With hand held power tool.

Working on Standard and Pre-standard Projects related to hand-held tool vibration testing, also pointed out the need of measuring grip force and contact pressure between hand and handle, together with the total force applied by the operator Workers using hand-held power tools in workplaces can be exposed to harmful levels of hand–arm vibration.

OBJECTIVE

The Operator is responsible for using the tools according to the given instructions and to react when he or she has reason to believe that vibrations are unusually high. The operator is also the person exposed to vibrations and therefore the one that should be protected from unnecessary vibration exposure [9].The exposure comes from working with vibrating tools and from other objects such as vibrating handles or controls on larger equipment. Exposure could also be from vibrating work pieces that are hand-operated during a process. Such objects often expose the operator to high vibrations.

Due to all these circumstance the following objectives are to be tolerated:

1. Design and development of Jigsaw machine 400 to 600 watt power with pendulum action (also known as orbital action) that swings the blade forward and backward slightly as the blade travels up and down. As most jigsaw blades cut on the upward stroke of a jigsaw's oscillating action, the pendulum action ensures the blade is pressed firmly up against the material on this stroke, increasing cutting efficiency.

2. Design and Analysis of the viscous damper to isolate and reduce the vibrations generated during cutting.

3. Testing of the developed jigsaw cutter with and without the viscous fluid damper to determine the Overall damping coefficient.

A.Jigsaw Power Tool Analysis

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 aluminium sheet cut outs, using S-400 high speed steel blades 16 to 18 tpi. The conventional saw available and used is of following specifications 400 watt power.Aluminium cutting is slightly difficult than other materials cutting due to fact that chips of aluminium 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.

1. Definition of Jigsaw:

Jig saw machine is a sawing machine with a narrow, vertically reciprocating saw used to cut curved and irregular lines or ornamental patterns in open work.

2. Features of jigsaw:

- Variable speed improves the quality of cut through various materials and tasks.
- Universal blade clamp holds both U&T shank blades.
- Integral dust blow feature keeps the line of cut clear.
- Dust extraction to keep the work place clean.
- Sightline channel makes following a line easier.
-

3. Specification of Jigsaw:

TABLE I
MANUFACTURER'S SPECIFICATION FOR JIGSAW

Parameter	**Valu**
Voltage	230 V
Power	450W
Speed	Variable
Strockes	0-3000rpm
Bevel Cut	0-45 Degree
Depth of Wood- Cut	60mm
Depth of Steel- Cut	5mm
Depth of Aluminium- Cut	10mm

Fig.1.Jigsaw power tool

B.Variable Control Speed Mechanism For Jigsaw

- Maximum speed = 3000 s/min
- Minimum speed = 0

The operating speed depends upon, how far the switch is pressed. This tool can be operated with an orbital or a straight line (up and down) cutting action. The orbital cutting action thrusts the blade forward on the cutting stroke and greatly increases cutting speed. To change the cutting action, just turn the cutting action changing lever to the desired cutting action position.

DESIGN OF DAMPER

Damping is a critical tool in shock and vibration isolation. 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 [8, 10].

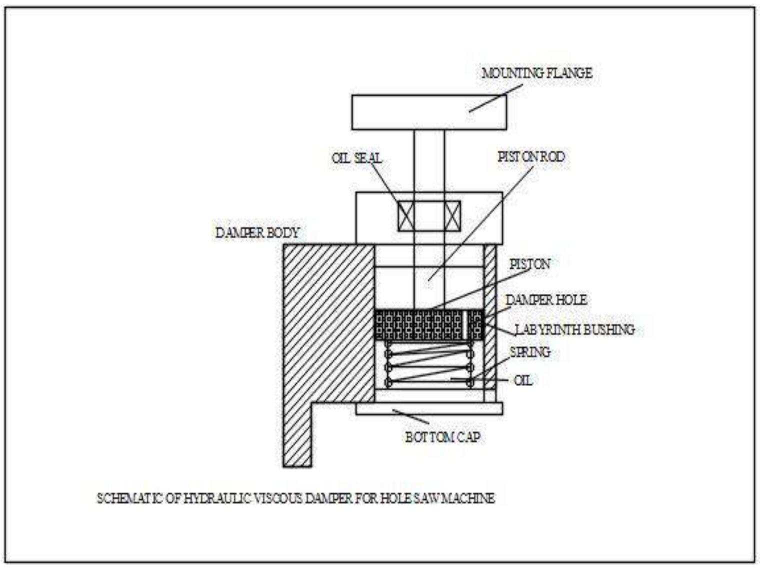

Fig. No.2 Viscous Damper

Vibration control is the design or modification of a system to eliminate unwanted vibration or to reduce the force or motion transmission. The design parameters include inertia properties, stiffness properties, damping properties and even the system configuration including the number of degrees of freedom.

Input Data:-
Weight of machine = 1.9 kg
Maximum depth of cut = 60 mm ----for wood
Speed = 3000 rpm
Power input = 450 watt
Maximum acceleration = 7.7 m/sec^2
Angular speed (ω) = $2 \pi N / 60$
(ω) = $2 \pi \times 3000 / 60 = 314.16$ rad/sec

Let F_o =Force transmitted to machine handle / foundation

$F_o = m_o e\, \omega^2$

$m_o e$ = Rotating imbalance owing to the cutting action

$$p = \frac{2\pi NT}{60}$$

$$450 = \frac{2\ X\ \pi\ X\ 3000\ X\ T}{60}$$

P = 1.43N-m

P = 0.15kg-m

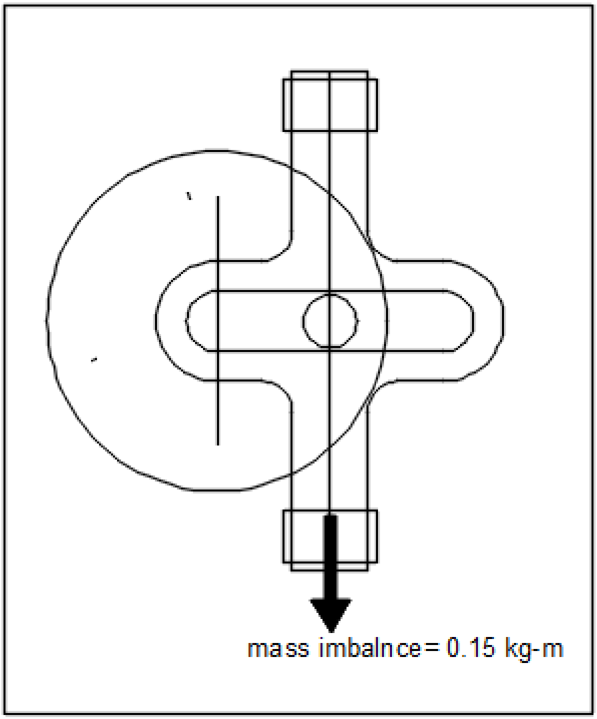

Fig. No.3 Mass Imbalance

A. Modelling of Equivalent Stiffness of Damper

$F_0 = m0e\omega^2$

$F_0 = 0.15 \times 314.2^2$

$F_0 = 2385.165$ N

Now, considering the maximum transmitted ratio as

$T = F_T / F_0$

The maximum permissible amplitude of force transmitted not to exceed value 3500 N

T = 3500 / 2385.16

T= 1.46

Now as T>1,

T = 1/ (r2-1)

r = Sq. rt (1 +1/1.46) = 1.29

Now,

Natural frequency (ω_n)

(ω_n) = ω /r

(ω_n) = 52.36/ 1.29 = 40.33 rad /sec

Now Equivalent stiffness of the damper is given by,

$K_{eq} = m\ \omega_n^2$

$K_{eq} = 1.9 \times 40.33^2$

K_{eq}= 3090.36 N/m

A. Determination of Maximum Theoretical Displacement of System:

K_{eq} = W/ δ

δ = W / K_{eq}

δ = (1.9X 9.81 X 1000) / 3090.36

δ = 6.031 mm

Thus maximum displacement of the system

δ =6.031mm

B. Determination of Maximum Theoretical Acceleration of System:

Determination of Damping Coefficient of Damper:

If the machine is subject to an excitation F(t) which induces a displacement x(t) the force transmitted to the foundation through isolator is given by,

Ft = kx + cx

Cx = Ft – kx

=(1.9 +0.15) x 6.031 – (3090.36 /9.81) x 6.031

=0.8744

C= 0.8744/6.031 =0.1454

Thus damping coeffcient of the Damper is = 0.1454

Determination Of Maximum Theoretical Acceleration Imparted To Machine:

If the base of the system is subject to displacement y (t). Then the acceleration transmitted to the machine of mass m is determined as

ā̄ = (c z + k z) / m

Where,

ā̄ = acceleration transmitted to the machine m/sec^2

z = displacement of the machine relative to its base and is equal to the total displacement of the isolator.

Ā̄ = (0.1454 X 6.032) + (3090.36/9810 X6.032)

= $0.23002 m/sec^2$

Thus maximum acceleration of the machine at no load condition is $0.23002\ m/sec^2$

Design of the spring for Damper:

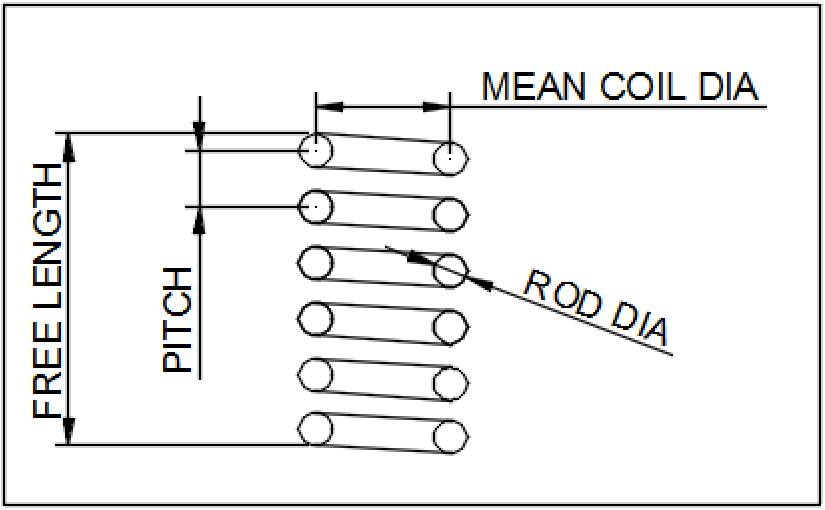

Figure No.4. Helical Compression Spring Draws on Auto- Cad 2009

As per geometry of damper the maximum size of spring is not to exceed 20mm outside diameter, hence selecting following dimensions of spring as input data:

Mean coil diameter (D) = 18.4 mm

Rod diameter (d) = 1.6 mm

Spring index (C) = D /d = 18.4 /1.6 = 11.5

Material of spring –Spring steel

Modulus of rigidity (G) = 85 x 10^5 N/mm^2

We know that the maximum displacement of the machine is 0.46

The maximum deflection of spring (δ) = 0.5 mm--- rounded off value

The maximum load on spring = M x FOS = (1.9 +0.15) x9.81 x4 = 80 N

Now deflection of spring is given by the relation;

$\delta = 8\ W\ C^3\ n/\ Gd$

$n = Gd\ \delta\ /8\ W\ C^3$

$n = 85 \times 10^5 \times 0.5 \times 1.6 / 8 \times 80 \times 11.5^3$

n= 6.99 = 7 turns

Free length of spring = Lf = nd +δmax +0.15 δmax

Lf = 7 x 1.6 +0.5 + (0.15x 0.5) =11.78 = 12mm

TABLE II

Damper spring dimensions

Spring rod diameter (d)	1.6 mm
Mean coil diameter (D)	18.4 mm
Outside diameter (Do)	20 mm
No. of turns (n)	7
Free length (Lf)	12mm
Pitch (p)	2 mm

CONCLUSION

We Decided Minimize These Hand Arm Vibrations by Using, Experimental Set Up Of Rockwell Viscous Damper for Reducing Vibration of Hand Held Power Machinery. After testing we conclude that,

1. The Vibration in power tool is reduced by use of viscous damper.
2. The Displacement in machine using damper is reduced.
3. The Acceleration in machine using damper is reduced.
4. The System is easy to handle for operators.
5. Simple system to implement.
6. Increases operator efficiency

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