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A Review of Waist Belt Mounted Flexible Shaft Multi-Function Power Tool

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***Abstract*— In case of conventional portable drilling machine while working on ceiling or roofs standing in up-right position with power tool in both the hands, the operator has to balance himself while performing the operation. This awkward position of working leads to cramps, back ache, discomfort leading to fatigue and health disorders. This portable waist belt mounted power tool is a special purpose machine in which weight of tooling is reduced so that it can be operated with single hand, while other hand holds on to the support. Also it can perform drilling, hole sawing, jig sawing operations. In this machine there is a waist belt on which motor is mounted which fits on operator's waist. There is a flexible shaft which can transmit torque from motor up to the tooling handle.. As the motor is mounted on waist belt, there is a need of isolating the vibrations from operator's body. So to isolate vibrations there is elliptical leaf spring mounted between motor body and belt. There is also a hydraulic viscous fluid damper at the spinal cord location of mounting to isolate and eliminate any machine vibrations reaching the body.**

Keywords—Drilling, Damper, Elliptical Leaf Spring, Vibrations.

I. INTRODUCTION

Drill bits are the cutting tools which are used to make circular holes. Drill bits are held in a tool called a chuck, which rotates to provide torque as well as axial force for creating a hole. These machine are used in many applications for drilling operation. These machines are hand held so they give rise to Hand arm vibration (HAV) which is vibration transferred from a work process to workers hands and arms. These effects can be caused due to operating hand held power tool as well as holding material which is being processed by machines [1].

Work using hand held power tool is generally seen in many industries throughout the world. This kind of work will give rise the operators to different loads like grip forces, feeding forces, noise and vibration and the dust exposure. Designing a power tool from ergonomics point of view is a better compromise in this regard. Just observe an example where increasing the mass which is not acceptable, simply because it will increase the forces which are required to treat the tool. At the same instance increasing mass can reduce the vibrations. Vibration disorders related to the use of hand held power tools are observed and they are focused since long ago. Therefore this is very much essential to develop and use the low vibrating tools [2].

Flexible shafts are power transmission devices which are used to transmit rotary motion through bends and curves. These can be routed over, under, and around obstacles which might be difficult or in some cases impossible for a conventional solid shaft. These flexible shafts are made of different layers of high-tensile wire which wound over each other at opposing pitch angles [4].

Elliptical leaf spring is the type of shock and vibration isolator that was purposefully designed for mobile applications. The basic design contains two or more tensile stainless steel "U" formed leaves, placed at each end and which becomes an elliptical shape when we join them together in the center portion by using face plates [8].

A. Problem Statement

In many applications the operator has to work on ceiling or roofs standing in up-right position with the power tool in hand, majority of the times the power tool needs to be supported by both hands, thus the operator has to balance himself while performing the operation, this awkward position of working further leads to cramps, back ache, discomfort leading to fatigue and health disorders. Thus there is a need for special purpose machine that address to the problem above by reducing the weight of the tooling so that it can be operated with single hand , while other hand holds on to the support, the machine be multi-functional i.e., should perform drilling , hole sawing ,jig sawing operation.

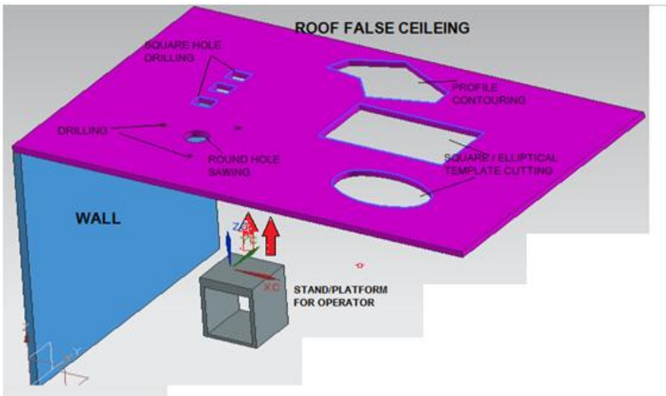

Fig -1: The false ceiling of plaster of Paris or plywood

II. HAND ARM VIBRATION

Health & Safety Guidance on Hand-Arm Vibration (HAV) has provided guideline for using handheld equipment. Work with hand held power tools under the presence of hand arm vibration is difficult. NERC health & safety procedure try to ensure the risks from exposure to vibration, which may be to hands and arms or to the whole body, those are adequately controlled. Hand arm vibration (HAV) is a major hazard for workers those who work with hand operated power tools, hand guided machines or feeding work by hand to a machine where this exposes their hands as well as arms to high levels of vibration. For long periods and regular exposure to very high levels of HAV can affect the operator's health badly which particularly may causes Hand Arm Vibration Syndrome (HAVS), for which the best known condition is Vibration White Finger (VWF). Those peoples which are suffering from few of the medical conditions like diabetes, disorders in circular or nervous system may be on high risk of developing HAVS [2].

Daily Exposure Limit and Exposure Action Values for Hand arm vibrations for operators hand are:

i. Daily exposure limit value (ELV) = 5 m/s2

ii. Daily exposure action value (EAV) = 2.5 m/s2

Mirta Widia et.al, have conducted an experiment on effect of handheld vibrating equipment on human body. The purpose of this study is to observe the effect of hand held vibrating power tools on muscle movement as well as on grip strength. The experiment was conducted on seven different machines. The experiments were carried out using two kinds of exposure time, 5 minutes and 15 minutes. The drilling operation was carried out on wood material using an electric drill.

The results showed that mean vibration level of electric drill was 10.53 m/s2 for 15 minutes and 10.39 m/s2 for 5 minutes duration. The muscle which was suffered badly by vibration factor was found to be extensor Carpi radial muscle. Extensor Carpi radial muscle is one of the muscles which is situated in the forearm [3].

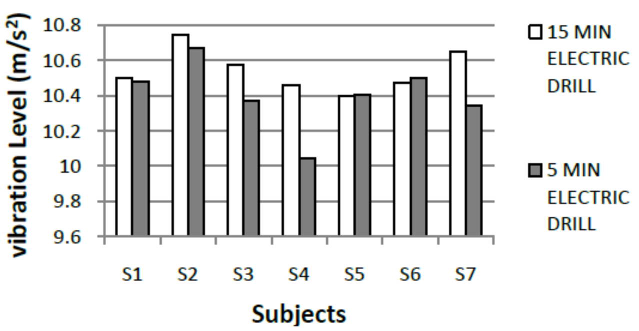

Fig -2: Vibration Level Drilling Wood Material [3]

From fig.2 it is noted that muscle activity as well as grip strength increases as the vibration level goes on increasing.

Table -1: Vibration level effect on Grip strength [3]

Subjects	5 min electric drill			15 min electric drill		
	GS (Before) (N)	GS (After) (N)	Decrease Ratio	GS (Before) (N)	GS (After) (N)	Decrease Ratio
S1	147.69	114.51	33.18	101.91	91.66	10.25
S2	121.50	52.01	69.50	119.32	36.73	82.59
S3	138.90	128.89	10.01	159.76	141.03	18.73
S4	72.36	34.65	37.71	75.24	20.78	54.46
S5	106.02	75.91	30.11	103.49	73.71	29.78
S6	90.01	58.49	31.52	103.65	59.78	43.88
S7	75.09	68.10	6.98	67.19	46.68	20.51
Mean	107.37	76.08	31.29	104.37	67.20	37.17

From above Table-1 it is clear that grip strength decreases as the operating time of interval of the tool increasing.

Andrew K. Costain et.al, have given five methods of control vibrations. The generally most useful methods for vibration control for industrial equipment's are Excitation force Reduction, Tuning, Mass Addition (Inertia), Damping system and Isolation [4].

i. The Reduction of Force excitation such as unbalances or misalignment will decreases the vibration response of the corresponding system.

ii. Adding the mass may reduce the system response of a constant excitation force.

iii. By tuning or changing the natural frequency for a system or component that will help to reduce or in some cases completely eliminate the amplification due to resonance.

iv. Isolation can rearrange the excitation forces to achieve some reduction.

v. The process of conversing mechanical energy as a vibrations in the form of heat is called damping.

M. A. Salim et al, Study determines the vibration occurs in handheld tools using Fast Fourier Transform and Operational Deflection Shape methods. The experiments shows the point, where higher vibration level occurs. Fast Fourier Transform (FFT) and Operational Deflection Shape (ODS) results shows that the vibration at the rear handle is not the same for each considered point. But among all points, there is one point which is same in both method, which indicates the highest level of vibration. With the help of Fast Fourier Transform, we can calculate the frequency responses of a particular structure by measuring the given inputs and their corresponding responses [5].

Rene Granado studied the "reciprocating saw attachment for electric drill. He invented quick connect, reciprocating saw attachment for electric drills as a universal attachment, in which he designed an adapter that converts rotary drill power into a reciprocating saw. In this the rotary movement of a drill is converted into the reciprocating action of a saw blade. The objective of this invention to provide a device which permits a drill to be used as a reciprocating saw, which can save time, money and space. Another main object of the present invention to provide a device which is durable, long lasting, and requires less or no maintenance. The present invention is useful in this project to design a system in which drilling machine can be used as Jig saw machine with the help of this attachment [6].

III. VIBRATION CONTROL METHODOLOGY

For industrial purpose the tools used must be of very robust design for sustaining the vibrations they are dealing with. So for designing industrial purpose tools we made main parts using metal. From a vibration point of view which means that most of the tools can be treated as rigid bodies, reason is that the dominating frequency generally is equal to the rotational frequency in case of tool spindle. There are some examples in case of designs where the handles just happened to be non-rigidly connected as well as in some cases the resonance occurs inside the interested frequency region. So the oscillating forces act on the tool which results in vibration [1].

The three basic principles for controlling vibrations are:

• Control the magnitude of the vibrating forces. The examples are the unit of balancing on a polishing machine or the differential piston arrangement in case of a chipping hammer.

• Make the tool less sensitive to the vibrating forces which it experiences. The examples might be when the mass of the guard on a polishing wheel is rigidly connected to the tool increasing the inertia of the tool.

• Isolate the vibrations related to the tool from the grip surfaces. The examples are vibration dampening handles on polishing machine, the air-spring behind the blow mechanism in case of a riveting hammer or the mass spring system in a blow hammer.

The handles always may not be a part of this rigid body. The sources of vibration are the forces which acts on this rigid body. The acting forces are nothing but the forces which comes from the different processes like unbalancing in rotating parts bodies. From above methods of control the vibration we can chose that 'Isolate the vibrations related to the tool from the grip surfaces' [4].

If we overview of output force characteristics & they have given list of components, we have to design while designing the damper. A damper is an element which by adding to a system or a machine for providing the forces which will resist to the movement, thus we can provide a mean to dissipate energy produced. The output equation used for damper is:

$$F = C \text{ X } V^{\alpha} \quad (1)$$

Where, F is the output force,

V is the relative velocity across the damper,

C is the damping coefficient and

α is a constant exponent (value between 0.4 to 2).

From equation (1) we have concluded that Damper force varies only with velocity. For a given velocity the force will be the same at all the points in the stroke. The detailing of these elements varies strongly and become difficult and complex [7].

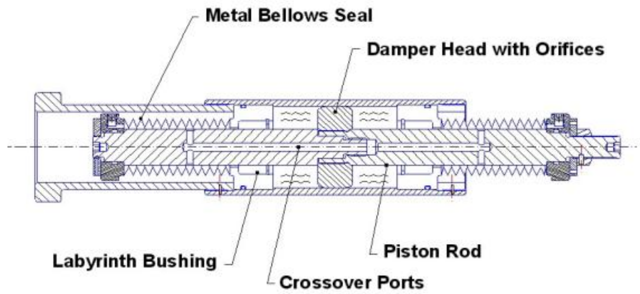

Fig -3: Viscous Damper [7]

By decreasing the response of a structure by adding energy dissipation to a structure using viscous dampers, we can reduce the vibration or shock response of system. A sectional view of a particular frictionless hermetic damper is as shown in Fig. 3. The unique elements of this damper are the frictionless seals which are made by using a welded metal bellows. Two metal bellow seals are used to seal fluid inside the damper. As the damper moves, the two metal bellow works simultaneously expand and contract, by flexure of the individual bellows segments. The volume displaced by the compressing bellows will passes through the crossover ports to the expanding bellows at the opposite end of the damper. Due to hydrodynamic bushings, no sliding contact with the piston rod occurs, we assume here frictionless performance.

A fluid viscous damper is operates on the principle of fluid flow through orifice. The oil used inside the damper chamber is silicone oil. The silicone oil is nontoxic in nature as well as nonflammable and can be used for long time with stable performance. Due to pressure difference between two chambers silicone oil will flow through an orifice in the piston head which will convert input energy into the heat, then this heat is dissipated to the atmosphere [7].

Leblouba Moussa et al, investigated that the inplane vertical compressive stiffness of Elliptical Leaf spring (ELS) mounts with and without damping compound (Fig. 4). Analytical solution is developed for the case of ELS without compound, this solution is based on Castigliano's theorem. For the case of ELS with compound of different material properties, analytical solution is developed based on a statistical analysis of data generated from parametric finite element analysis of the ELS three-dimensional solid models.

Fig -4: Elliptical Leaf spring mount [8]

In this present study theoretical and numerical analysis on the inplane compressive stiffness of Elliptical Leaf Spring antivibration mounts under line-loading have been studied. They concluded that the compressive stiffness will increases with the spring width and decreases with increasing outer radius. The spring stiffness is much more sensitive to the outer radius; by increasing the outer radius two times the stiffness decreases more than three times [8].

IV. OBJECTIVES

- Design of flexible shaft drive and reduction gear box to perform multiple functions like drilling, hole sawing and jig sawing operations.
- Design of Elliptical leaf spring mounts and hydraulic viscous fluid damper to isolate and reduce the vibrations generated during cutting.
- Testing the developed power tool with and without the vibration reduction mechanism to calculate vibration level for three operations namely drilling, hole-sawing and jig-sawing.

V. PROPOSED METHODOLOGY

A. Literature review

In this part literature survey of damper systems, hand held power machinery vibrations etc. will be carried out by referring journals like SAE journal, International papers, US patents , etc.

B. Design and Development

1. Power requirement calculations.
2. Selection of power tool, Selection and design of gear box for torque amplification.
3. Design of the flexi-shaft square end, socket, etc.
4. Design of Coupler, tool holder for drilling operation.
5. Design of reciprocator linkage for jig saw arrangement.
6. Design of waist belt, waist belt spring steel stiffeners, for proper back support.
7. Design of the elliptical spring damper for vibration reduction.
8. Design of hydraulic damper at the spinal cord location.
9. CAE of critical component and meshing using some suitable analysis software.
10. Testing on FFT to compare the vibration level for with and without vibration system.
11. Harmonic analysis of given model using FEA software and comparing results with FFT.

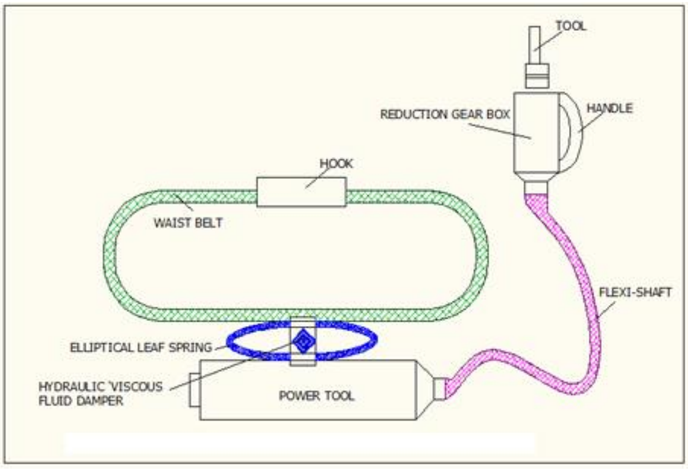

Fig -5: Schematic of Waist Belt Mounted Flexible Shaft Multi-Function Power Tool

VI. SCOPE

i. Increases operator comfort.

ii. Prevents damages to hands, joints etc.

iii. Fewer vibrations lead to lesser audible noise.

iv. Simple system to implement.

v. Increases operator efficiency.

vi. Increases dimensional accuracy.

VII. CONCLUSIONS

Due to adverse effect of hand arm vibrations we need to control those vibrations & we conclude that grip strength decreases as the interval time of operating tool increases. We have seen different methodology of control the vibrations of grip surface, the well method of controlling vibrations by using damping system. Also in designing the damper, we have concluded that damping force doesn't depend on stiffness of spring. It is depends upon only damping coefficient & velocity of piston. The stiffness of Elliptical Leaf spring is more sensitive to the outer radius as compared to other design parameters.

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REFERENCES

[1] Safe work Australia, Hand-arm vibration, Supersedes HSG88 published with ISBN 0717607437, September 2012, pp.1-3.
[2] NERC health & safety, Procedure Control of vibration hazards at work Jul-2011, Planet Earth magazine pp. 2-4.
[3] Mirta Widia, Siti Zawiah, Investigation on Upperlimb Muscle Activity and Grip Strength during Drilling Task, IMESC-2010, March-2003, pp-1-3.
[4] Andrew K. Costain, J. Michael Robichaud, Practical Methods for Vibration Control of Industrial Equipment, Bretech Engineering, Canada, 2003, pp-1-7.
[5] Mohd Azli SALIM, Fast Fourier Transform and Operational Deflection Shape Analysis for Vibration on Handheld Tools, Canadian Journal on Mechanical Sciences & Engineering, 2010, pp.54-59.
[6] Rene Granado US 6,264,211 B1, CA(US), Oct. 6, 1999, Reciprocating saw attachment for electric drill,1999.
[7] Philippe Duflot, Taylor Device Europe, Experience & practical considerations in the design of viscous damper, Third international conference,2008, pp-2-5.
[8] Leblouba Moussa, M. E. Rahman, Compressive Stiffness of Elliptical Leaf Spring Antivibration Mounts, Intl. Conf. on Advances in Civil & Structural, 2014, pp- 52-57.