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A Procedural Framework to Design and Fabrication Controlled by Pneumatics

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ABSTRACT— This project deals with design development and fabrication of "MULTI PURPOSE PNEUMATIC MACHINE". This machine is designed for the purpose of multi-operation i.e. Grinding, punching, and cutting . This machine performs multipurpose operation at same time with required speed and this machine is automatic which is controlled or operated by pneumatic pressure. This model of multi-operational machine may be used in industry and domestic operation which can perform mechanical operation like grinding, punching, and cutting of a thin metallic as well as wooden model or body .A high pressure compressed air is forced on a fan and the fan is made to rotate. This rotation is transmitted to the machining head by a shaft and the required operation is carried out.

1. Introduction

Pneumatic systems are power systems using compressed air as a working medium for the power transmission. Their principle of operation is similar to that of the hydraulic power systems. An air compressor converts the mechanical energy of the prime mover into, mainly, pressure energy of the compressed air. This transformation facilitates the transmission, storage, and control of energy. After compression, the compressed air should be prepared.

Pneumatics has long since played an important role as a technology in the performance of mechanical work. It is also being used in the development of automation solutions. Pneumatic systems are similar to hydraulic systems but in these systems compressed air is used in place of hydraulic fluid.

A pneumatic system is a system that uses compressed air to transmit and control energy. Pneumatic systems are used extensively in various industries. Most pneumatic systems rely on a constant supply of compressed air to make them work. This is provided by an air compressor. The compressor sucks in air from the atmosphere and stores it in a high pressure tank called a receiver. This compressed air is then supplied to the system through a series of pipes and valves.

The word 'Pneuma' means air. Pneumatics is all about using compressed air to do the work. Compressed air is the air from the atmosphere which is reduced in volume by compression thus increasing its pressure. It is used as a working medium normally at a pressure of 6 kg/sq mm to 8 kg/sq mm. For using pneumatic systems, maximum force up to 50 kN can be developed. Actuation of the controls can be manual, pneumatic or electrical actuation. Compressed air is mainly used to do work by acting on a piston or vane. This energy is used in many areas of the steel industry.

2. Literature Review

In an industry a considerable portion of investment is being made for machinery installation. So in this project we have a proposed a machine which can perform operations like drilling, sawing, shaping (grinding) some lathe operations at different working canters simultaneously which implies that industrialist have not to pay for machine performing above tasks individually for operating operation simultaneously. This paper presents the concept of Multi-Function Operating Machine mainly carried out for production based industries. We have developed a conceptual model of a machine which would be capable of performing different operations simultaneously and is also economically efficient. In this machine we are actually giving drive to the main shaft to which scotch yoke mechanism is directly attached, scotch yoke mechanism is used for sawing operation. On the main shaft a bevel gear system is used for power transmission at two locations.

Yang et al [1], The positive impact plate, a pneumatic holder, a pneumatic element, a piston rod, a guide device, a die device And a lower fixed plate. The cylinder is fixed on the upper fixed plate; the gas holder is formed on one side of the cylinder; the pneumatic element is installed on one side of the cylinder; an electric control cabinet is on one side of The upper end of the piston rod is connected with the cylinder of the upper fixed plate; the lower end of the piston rod is connected with the sliding template; the guide device is followed connected with the upper fixed plate and the Lower fixed plate through the sliding template; a highest contact and a lowest contact are arranged on one side of the guide device; the die is installed on the lower fixed plate; a photoelectric sensor is installed on one side of the manual switch is based on one side of a punching machine.

Pan Ling Steel et al [2**]** ,The portable type provides a portable pneumatic cutting machine and a bearing to the technical field of pneumatic cutting machine. State and a normal cutting machines is generally not provided with a handle so that operation and carrying are inconvenient. The portable pneumatic cutting machine loads a machine body, a cutting slice is constituted on an output shaft of the head of the machine body, a High pressure airflow air inlet connecting port is formed in the tail side of the machine body, a trigger and a speed regulator switch are arranged on the side portion of the machine body, a protective sleeve is arranged outside the cutting slice and the output shaft And connected with the head of the machine body, and a cutting machine handle is fixedly

connected on the protective sleeve in a thre Adular mode. The portable area of the lifting capacity and the hand is large and the amount of raw materials copied is Less, structural firmness is increased, cost is reduced as much as possible at the same time, and the overall structure is simple and practical.

Wu Zhe et al [4**]** ,The pneumatic equipment and a pneumatic device are arranged at the tail portion and the head of the handle respectively. A pressing switch is arranged at the connecting position of the Pneumatic equipment and the handle, the head of the pneumatic device is connected with a dust exhaust device, the head of the dust exhaust device is connected with a rotation speed tester, and the rotational speed tester is connected with a grinding wheel cover. Grinding machine can effectively achieve a dust collection effect through the so dust exhaust device, so that dust will not fly around, the amount of dust inhaled by working staff in the process of grinding is reduced, effective protection is brought to the body health of the Working the staff, and the pollution to the environment is reduced. Through the adjustable rotation speed tester, the working staff can be reminded when a grind.

Markur AUGSBURG et al [4], A chamfering method comprising defining a tooth edge utilizing theoretical data, defining an actual tooth edge utilizing the theoretical tooth edge data, defining a motion path of a chamfering tool and chamfering the actual tooth edge by moving the chamfering tool and the actual tooth edge relative to one another according to the motion path to chamfer the actual tooth edge.

Yasutaka nishioka et all (5**),** A new principle for pneumatic valve is proposed. This new principle makes pneumatic valve possible to be driven without electric wire. The proposed valve which is simple and cheap is only configured with two vibrators and springs, a servo system is constructed where multiplex pneumatic transmission from the servo system can control several proposed valves independently. This valve was developed for pneumatic mechatronic systems configuring many actuators and having many degree of freedom. The basic

principle is confirmed by dynamic simulation and real time experiments. Simple model was used in the simulation while the experiment model is similar to proposed principle model. The rubber bellows have function as spring and also as flow channel while the liner guide is for keeping the axial position. Spring constant of rubber bellows is decided by structural analysis using FEM.Koichi suzumori et al [6] **,**Multiplex pneumatic transmission has been proposed. This method realized great simplification of pneumatic system consisting of many actuators. A control valve for this pneumatic system is driven only through an air tube without electric wires. In this paper, experimental models was developed and adapted to pneumatic system. In this experiment, the independent driving of two pneumatic cylinders is realized. pneumatic actuator has several advantages, which are lightweight, low cost, high compliance, and reliability to humans. However, the system using pneumatic actuators is complicated in general with a compressor, control valves, and air tubes. Solving a lot of control wires to control valves. The purpose of this research is simplifying pneumatic system having many degrees of freedom. For this purpose we have proposed a new method of multiplex pneumatic transmission for the multi-pneumatic servo system. The pneumatic valve for this system consists of two vibrators and springs. The working principle of the valve is based on vibrator resonance caused by multiplex pneumatic vibration. This valve works as an ON/OFF valve without electric wire but works just through one air supply line. This pneumatic system using the valve realizes independent control of valves with only air tubes. It is effective for the pneumatic system having many degrees of freedom. The basic working has been confirmed.

In order to perform this project, literature review has been made from various sources like journal, books, article and others. This chapter includes all important studies which have been done previously by other research work. It is importance to do the literature review before doing the project because we can implement if there are information that related to this project. The most important thing before starting the project

we must clearly understand about the topic that we want to do. So by doing the literature review we can gain knowledge to make sure we fully understand and can complete the project. A review of the article was performed to identify studies that relevant to the topic.This machine is designed for the purpose of multi- operation i.e. grinding, punching, hacksaw cutting. This machine performs multipurpose operation at same time with required speed and this machine is automatic which is controlled or operated by pneumatic pressure. This model of multi-operational machine may be used in industry and domestic operation which can perform mechanical operation like grinding, punching, and hacksaw cutting of a thin metallic as well as wooden model or body.

3. Methodology

I. Literature study

- Make review on other model and focusing on how to make it simple and relevance to the project objective.

II. Conceptual design

- Sketching several type of design based on concept that being choose.
- State the dimension for all part.

III. Materials Selection

- Selected the true material based on model design and criteria.
- Light, easy to joining and easy to manufacture.
- Assemble all the part to the design.

IV. Fabrication model refinement.

- Fabricate the tricycle according to the main frame and design. Refinement in each stages of fabrication.

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V. Performance testing.

- Speed.
- Load distribution
- Power developed.

VI. Documentation

- Preparing a thesis report of the project.
- Presentation

4. Components

- Rotor
- Air compressor
- Gear box
- Grinding wheel
- Base bed
- Holding post
- Cutting tool
- Punching machine

Grinding wheel

A grinding wheel is a wheel composed of an ompound and used for various grinding (abrasive cutting) and abrasive machining operations. Such wheels are used in grinding machines.The wheels are generally made from a composite material consisting of coarse-particle aggregate pressed and bonded together by a cementing matrix (called the bond in grinding wheel terminology) to form a solid, circular shape. Various profiles and cross sections are available depending on the intended usage for the wheel. They may also be made from a solid steel or aluminium disc with particles bonded to the surface. The manufacture of these wheels is a precise and tightly controlled process, due not only to the inherent safety risks of a spinning disc, but also the composition and uniformity required to prevent that disc from exploding due to the high stresses produced on rotation.Grinding wheels are consumables, although the life span can vary widely depending on the use case, from less than a day to many years. As the wheel cuts, it periodically releases individual grains of abrasive, typically because they grow dull and the increased drag pulls them out of the bond. Fresh grains are exposed in this wear process, which begin the next cycle. The rate of wear in this process is usually very predictable given application, and is necessary for good performance.

Cutting tool

A hacksaw is a fine-toothed saw, originally and principally made for cutting metal. They can also cut various other materials, such as plastic and wood; for example, plumbers and electricians often cut plastic pipe and plastic conduit with them. There are hand saw versions and powered versions (power hacksaws). Most hacksaws are hand saws with a C-shaped frame that holds a blade under tension. Such hacksaws have a handle, usually a pistol grip, with pins for attaching a narrow disposable blade. The frames may also be adjustable to accommodate blades of different sizes. A screw or other mechanism is used to put the thin blade under tension. Panel hacksaws forgo the frame and instead have a sheet metal body; they can cut into a sheet metal panel further than a frame would allow. These saws are no longer commonly available, but hacksaw blade holders enable standard hacksaw blades to be used similarly to a keyhole saw or pad saw. Power tools including nibblers, jigsaws, and angle grinders fitted with metal-cutting blades and discs are now used for longer cuts in sheet metals.

Punching

Punching is a metal forming process that uses a punch press to force a tool, called a punch, through the work piece to create a hole via shearing. The punch often passes through the work into a die. A scrap slug from the hole is deposited into the die in the process. Depending on the material being punched this slug may be recycled and reused or discarded. Punching is often the cheapest method for creating holes in sheet metal in medium to high production volumes. When a specially shaped punch is used to create multiple usable parts from a sheet of material the process is known as blanking. In forging applications the work is often punched while hot, and this is called hot punching.

5. Working

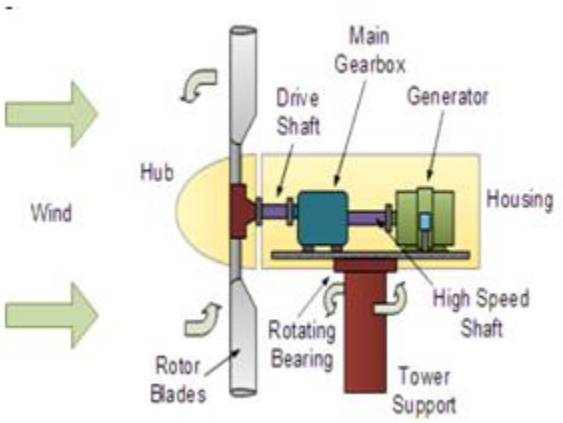

Fig: 1 Turbine

The pneumatic multipurpose device is an air operated device used for many small operations. It is a portable one. Compressed air is the source of energy for this device. The compressed air is allowed through the nozzle in such a way to rotate to fan. The rotation obtained is utilized for machining. The nozzles are welded to the barrel at an angle to facilitate free rotation. The fan can be rotated in either direction by operating the one way corks. The rpm and torque of the shaft depends upon the pressure of the air admitted so by varying the pressure the rpm and torque can be varied. Here the compressed air from the compressor firstly enters the control unit.

6. Bevel Gear Calculation

Step: 1: Selection of materials

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Material for gear: Cast Iron

Material for pinion: Steel

Step: 2: Assume Z_1 = 20, then Z2 = i x Z_1

Z_2 = 1 x 20 = 20 (Where N_1 = N_2, so (i=1)

Z2 =20

Step: 3: Calculation of pitch angle [(ie) δ1 and δ2] and the virtual number of teeth (ie) zp_1 and zp_2 using the following relations ,

In the control unit the pressure of the air is controlled and sent to the barrel to rotate the fan in any one direction. The air from the compressor enters the gate valve. The gate valve controls the pressure and volume of air. Then the pressure is read by a pressure gauge. Then the air is admitted to the barrel through any one of the two one way corks to rotate fan. In the barrel, a shaft is placed and if carries the fan. The shaft is supported in either and by bearings. The bearings are placed in the couplings, which covers the ends of barrel.

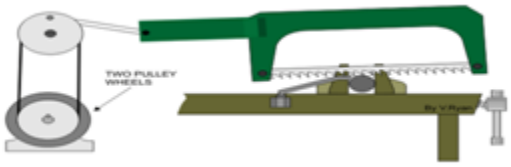

Fig: 2 Cutting

tan δ 2 = i = 1 or δ2= tan -1 (1) = 45°

Then δ1 = 90° - δ2

δ1= 90° - 45° = 45°

The virtual number of the teeth on the gears is given by

$$1= \frac{Z_1}{\cos \delta_1} = \frac{20}{\cos 45} = 28$$

$$2= \frac{Z_2}{\cos \delta_2} = \frac{20}{\cos 45} = 28$$

Then form factors based on virtual number of teeth are given by

$$Ý_1 = 0.154 - \frac{0.912}{Zv1} = 0.154 - \frac{0.912}{28} = 0.121$$

$$Ý_2 = 0.154 - \frac{0.912}{Zv2} = 0.154 - \frac{0.912}{28} = 0.121$$

For pinion: [σb1] x ý1 = 100 x .121= 12.1**N/mm²**

For gear: [σb2] x ý2 = 72 x .121 = 8.712 **N/mm²**

Hence the value of gear is less than pinion. Thus we have to design for gear only.

Step: 4: Calculating the tangential load using the relation we know that,

$$F_t = \frac{P}{V} * k_0$$

Where

$$V = \frac{\pi dN}{60} = \frac{\pi m_t Z_1 N}{60*1000} = \frac{\pi * m_t * 20 *}{60*100}$$

$$V = .879\, m_t$$

Therefore

$$F_t = \frac{40*10^3*1.25}{.879 m_t} \quad (K_0 = 1.25)$$

$$F_t = \frac{56882.82}{m_t}$$

Step: 5:

$$F_d = \frac{F_t}{C_v}$$

(where V= 5 m/s)

Where

$$C_v = \frac{5.6}{5.6+\sqrt{V}}$$

$$C_v = 0.715$$

Hence

$$F_d = \frac{79596}{m_t}$$

Step: 6: Calculating the preliminary value of dynamic load using the relation

$$Fs = * m_t * b * [\sigma_b] * ý * \frac{[R - b]}{R}$$

Where

b = 10mt, Zv Y2 = 0.1497,

σb_2 = 72 N/mm², $R = 0.5 * m_t * \sqrt{(Z_1^2 + Z_2^2)}$

Then

$FS = 237.62\, m_t^2$

Step: 7:

Calculation of transverse module m_t

We know that Fs ≥ Fd

$$237.62\, m_t^2 \geq \frac{79497.9}{m_t}$$

$$m_t \geq 6.94 \text{ mm}$$

Step : 8:

Calculate the values of b , d1 and v

Face width b = 10 mt = 10 x 7 = 70 mm

Pitch circle diameter d1 = mt x Z1 = 7 x 20 = 140 mm

Pitch line velocity V2 = V1 = = 6.61 m/sec

Step: 9:

Recalculation of the beam strength

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Fs = 237.62 x mt² = 11643.38 **N**

Step: 10:

Calculation of the dynamic load, using Buckingham's equation,

$$F_d = Ft + \frac{21\,V\,(bc + Ft)}{21\,V + \sqrt{(bc + Ft)}}$$

$$F_t = \frac{P}{V} = \frac{40*10^3}{6.16} = 6493.55\,N$$

c = 11860 x 0.017 = 201.62 **N/mm**

Then

F_d = 27077.5 N

Step :11:

Check for the beam strength or tooth breakage, but Fd >> Fs

Taking module as 14

Face width b = 10 mt = 10 x 14 = 140 **mm**

Pitch circle diameter d1 = mt x Z1 = 14 x 20 = 280 **mm**

Pitch line velocity

$$V2 = V1 = \frac{\pi dN}{60} = 12.315\ \text{m/sec}$$

$$F_t = \frac{P}{V} = \frac{40*10^3}{12.315} = 3248\,N$$

c = 11860 x 0.025 = 296.62 **N/mm**

$$F_d = Ft + \frac{21\,V\,(bc + Ft)}{21\,V + \sqrt{(bc + Ft)}}$$

Hence

F_d = 47969.4 N

We find Fs > Fd , now the design is safe and satisfactory against the tooth failure

Step: 12:

Calculation of wear load (Fw)

$$F_s = \frac{0.75 \times d1 \times b \times Q \times Kw}{\cos \delta 1}$$

$$Q = \text{Ratio Factor} = \frac{2 \times Zv2}{Zv1 + Zv2} = \frac{2 \times 215}{21 + 215} = 1.822$$

Kw = 0.919 N/mm² , for steel gears hardened to 250 BHN ,

Finally

F_S = 51578.25 **N**

Step : 13:

Checking for wear, we found that Fw > Fd , it means the gear tooth has adequate wear capacity and will not wear out. Thus the design is safe against wear failure also.

Step : 14

Module mt = 14 mm

Face width b = 10 x mt = 140 mm

Pitch diameter d1 = mt x Z1 = 14 x 20 = 280 mm

d 2 = mt x 20= 14 x 64 = 280 mm

Conclusion

- Initial cost is less; hydraulics equipment cost as much as twice the price of pneumatic equipment.
- A pneumatic water treatment automation system reduces the costs of installation and operation compared with conventional electrical installations. For opening and closing of underwater valves, pneumatic systems work well because they can sustain overload pressure conditions.
- Pneumatic actuators also have long life and perform well with negligible maintenance requirement throughout their life cycle.
- Very suitable for power transmission when distance of transmission is more

7 Benefits

The air used in pneumatic devices is dried and free from moisture so that it does not create any problem to the internal parts of the system. Moreover, to avoid corrosive actions, oil or lubricants are added so that friction effects can be reduced. Compressed air is used in most of the machines and in some cases compressed carbon dioxide is used. As most of the pneumatic devices are air based, they have a less complicated design and can be made of inexpensive material. Mass production techniques can be adopted to produce pneumatic systems, which not only save money but save time too. Initial cost is less; hydraulics equipment cost as much as twice the price of pneumatic equipment. Pneumatic actuators also have long life and perform well with negligible maintenance requirement throughout their life cycle.

By developing this Fabrication Model ,we have gained experience by welding the structures and gear designing we have learned in developing a multipurpose functioning machine with mechanical output which has to be used for commercial as well as industrial purpose. From this project three major operations can be done at a time with the same pneumatic pressure .

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