INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 4.295
(Volume3, Issue3)
Available online at www.ijariit.com

Design and Fabrication of Hand Operated Vacuum Cleaner

Pravesh Kumar Singh
Students, Dept. of Mechanical Engineering, SJBIT, Bangalore
praveshmech13@gmail.com

Ritesh Kumar
Students, Dept. of Mechanical Engineering, SJBIT, Bangalore
riteshkumar288@gmail.com

Shashi Kant
Students, Dept. of Mechanical Engineering, SJBIT, Bangalore
kants8525@gmail.com

Vivek Kumar Tiwari
Students, Dept. of Mechanical Engineering, SJBIT, Bangalore
akshitpandita@rocketmail.com

T Madhusudhan
Professor, Head of Dept. of Mechanical Engineering, SJBIT, Bangalore
mechhod@sjbit.edu.in

Abstract*— Dust removing problem are increasing more and more now a days. Hence it has become to provide some equipment for removing dust. There different types of waste, dry waste, vegetable waste, dust particles and soon. Generally little equipment has been evolved in the market for cleaning the dust particles which are known as vacuum cleaner. But these vacuum cleaner costs more in the market and not every human being can afford it. These devices need an electrical energy for its operation and not user friendly. In India, especially in summer, there is power crisis and most of the cleaning machine is not used effectively due to this problem, particularly in bus stands. Hence it is a need to develop low cost, user friendly vacuum cleaning machine. In this project, an effort has been made to develop a manually operated vacuum cleaning machine so that it can be an alternative for conventional vacuum cleaning machines. In this work, modelling and fabrication of the vacuum cleaning machine was done using suitable commercially available software and components. The conventionally used materials were considered for the components of vacuum cleaning machine. These vacuum cleaners may be used in homes as well as in industry.

Keywords: ***Spur Gear, Shaft, Centrifugal Impeller, Chain Drive, Dust Particle, Bearings.***

I. INTRODUCTION

Presently available vacuum cleaner is electrically operated and cannot work by any other means. These vacuum cleaner are quite expensive and have a high maintenance cost as per our research done in market. In our project we have invented a manually operated vacuum cleaning machine that serves approximately the same functions as available in present electrically operated machine. Dust removing problem are increasing more and more now a days. Hence it has become to provide some equipment for removing dust. There different types of waste, dry waste, vegetable waste, dust particles and soon. Generally little equipment has been evolved in the market for cleaning the dust particles which are known as vacuum cleaner. But these vacuum cleaner costs more in the market and not every human being can afford it. Meanwhile this equipment removes dust from the floor and collects in the dust bag present inside the equipment. We aim at fabricating a manual vacuum cleaner with the use of mechanical components to minimize the cost as well as to make it user friendly. If we go past into the history of the vacuum cleaner, we find different types of dust remover. A manual vacuum cleaner is one type of device which is usually using to remove the dust, this device uses a gear train assembly coupled to a centrifugal impeller which creates more vacuum which will be utilized to suck dust and dirt, and it mostly utilized for floors. This vacuum cleaner may be used in homes as well as in industry. Presently available vacuum cleaner is electrically operated and cannot work by any other means. These vacuum cleaner are quite expensive and have a high maintenance cost as per our research done in malls, automotive service centres etc. In our project we have invented a manually driven vacuum cleaner machine that serves approximately the same functions as available in present electrically operated machine.

II. Bill of Materials

1. Big spur gear of 108mm diameter having 58 teeth, of 4no.
2. Small spur gear of30mm diameter having 15 teeth, of 4no.
3. M. S shaft of diameter 12mm and length 190mm, of 5no.
4. Ball bearing 6200zz, of 10no.
5. Centrifugal Impeller
6. Screw rod 10mm diameter of 210mm length, of 4no.
7. Aluminium alloy sheet 330*145*12mm, of 2o.
8. Bicycle flywheel 190mm diameter, 6mm thickness and 44 teeth.
9. Bicycle freewheel 77mm diameter, 15 teeth.
10. Bicycle chain, length 1244mm, pitch 12.7mm.
11. Body, 545*300*205mm
12. Suction hose, 40mm diameter and 1m length.

III. PARTS OF MACHINE

1. SPUR GEAR

Spur gears or straight-cut gears are the simplest type of gear. They consist of a cylinder or disk with teeth projecting radially. Though the teeth are not straight-sided (but usually of special form to achieve a constant drive ratio), mainly involute but less commonly cycloid, the edge of each tooth is straight and aligned parallel to the axis of rotation. These gears mesh together correctly only if fitted to parallel shafts. No axial thrust is created by the tooth loads. Spur gears are excellent at moderate speeds but tend to be noisy at high speeds. When two gears mesh, if one gear is bigger than the other, a mechanical advantage is produced, with the rotational speed, and the torques, of the two gears differing in proportion to their diameters.Here we have used spur gear which have required gear ratio to obtain the required rpm to drive manual vacuum cleaner ,which drive the impeller shafts which creates suction for industrial usage.Gears are generally made from metallic materials but recently advanced polymers materials were developed which have sufficient strength and properties similar to the metallic materials so it can easily replace the metallic gears if some care will be taken. Nylon, polycarbonate, acetals and delrin are the structure polymers materials are used for gears in printing and robotics mechanism with good functionality but polymers gears are not used in heavy loading type application. Specially polymers gives extra benefits compared to metallic gears like less noise-vibration, low requirement of maintenance-lubrication, low cost and easy manufacturing. Static finite element analysis requires performing the design optimization process on both materials. In our project the major factor of choosing this nylon gear is to reduce weight, friction, noise, vibration, cost as well as human effort to operate manual vacuum cleaner.

2. SHAFT

The term Drive shaft is used to refer to a shaft, which is used for the transfer of motion from one point to another. Whereas the shafts, which propel (push the object ahead) are referred to as the propeller shafts. Propellers are usually associated with ships and planes as they are propelled in water or air using a propeller fan. However the drive shaft of the automobile is also referred to as the propeller shaft because apart from transmitting the rotary motion from the front end to the rear end of the vehicle, these shafts also propel the vehicle forward. The shaft is the primary connection between the front and the rear end (engine and differential), which performs both the jobs of transmitting the motion and propelling the front end.

In our project we are using mild steel shaft in order to give transmission to impeller through gear train arrangement.

PURPOSE OF SHAFT

The torque that is produced from the free wheel shaft and transmission must be transferred to the impeller shaft that will rotate the impeller to create suction pressure. The drive shaft must provide a smooth, uninterrupted flow of power to the axles. The drive shaft and gears are used to transfer this torque.

3. BEARINGS

In our project we have used 6200zz Ball Bearing which has standard size of 10mm inner diameter as per our requirement which help us to reduce friction between chassis and shaft.

As in our project considerable amount of axial load as well as radial load is acting. Hence we have selected Ball bearing due to its compatibility with both radial as well as axial load.

Bearings are one of the most important components in mechanical systems, and their reliable operation is necessary to ensure the safe and efficient operation of rotating machinery. For this reason, a multipurpose dynamic roller bearing model capable of predicting the dynamic vibration responses of rotor-bearing systems is important.

4. CENTRIFUGAL IMPELLER

We are using a centrifugal pump which consists of set of rotating vanes called as impellers which are enclosed in volute housing called as casing. Due to rotation of impeller the dirt particles from inner radius moves towards the outer radius during this, suction is created at the eye of the impeller. Therefore, continuous lifting of dust particles from floor to the pump is carried out and kinetic energy is converted into pressure energy and head is developed from the dust particle coming out from delivery pipe.

5. GEAR BOX

In our project Gearbox that uses gears and gear trains to provide speed and torque conversions from a rotating power source to another device as impeller.

6. CHAIN DRIVE

Chain drive is a way of transmitting mechanical power from one place to another. It is often used to convey power to the wheels of a vehicle, particularly bicycles and motorcycles. It is also used in a wide variety of machines besides vehicles. The power is conveyed by a roller chain, known as the drive chain, passing over a sprocket gear, with the teeth of the gear meshing with the holes in the links of the chain. The gear is turned, and this pulls the chain putting mechanical force. This is use to drive the gear box and to rotate the impeller for suction in manual vacuum cleaner machine.

7. SUCTION HOSE

A hose is a flexible hollow tube designed to carry fluid from one location to another. Hoses are also sometimes called pipes (the word pipe usually refers to a rigid tube, whereas a hose is usually a flexible one), or more generally tubing. The shape of a hose is usually cylindrical (having a circular cross section).

Hose design is based on a combination of application and performance. Common factors are size, pressure rating, weight, length, straight hose, and chemical compatibility.

Hoses are made from one or a combination of many different materials. Applications mostly use nylon, PVC or synthetic or natural rubbers, based on the environment and pressure rating needed.

8. CASING BODY

In our project we have used alloy sheet for making the body of vacuum cleaner machine which consist of complete gear box assembly as well as impeller also collector bag. It has belt to fix the body on human back which makes the equipment portable easily and easy to operate.

We have chosen alloy sheet to reduce the weight and to resist the load of the gear box which makes compact equipment and fancy.

IV. WORKING PROCEDURE

It is operated by one person who give rotation to the handle by one hand which rotate the flywheel and the flywheel rotates the freewheel by the means of chain drive, freewheel is connected to the main shaft of gear box when the freewheel rotates it provide rotation for all the gears which rotates impeller through which suction is created and dust is collected in collector bag.

V. CALCULATIONS

Speed Calculation of Gear Train

Stage1 - N1/N2= Z2/Z1

1/N2 =15/38

N2 =3.866rpm

Stage2- N2/N3 = Z3/Z2

N3 =3.866*58/15

=14.95rpm

Stage3 - N3/N4 = Z4/Z3

N4 =14.95*58/15

=57.80rpm

Stage 4- N4/N5 = Z5/Z4

N5=57.80*58/15

=223.51rpm

Assuming initial possible rotation 20 rpm

Now,

N6 =223.51*20

=4470rpm

Input chain sprocket ratio

i = no. of teeth on sprocket/ no. of teeth on freewheel

=44/18

=2.44

Final output rotation of impeller shaft=4470*2.44

=10907rpm

Calculation of Torque

Diameter of fly wheel =190mm

Length of fly wheel handle=210mm

Thickness =6mm

Volume of flywheel=πr^2h

=3.14*95^2*6

=170117.24mm^3

Diameter of bigger hole=27mm

Diameter of smaller hole=19mm

Volume of bigger hole=πr^2h

=3.14*13.5^2*6

=3435.33mm^3

Total number of bigger hole=4

Total volume of bigger hole=3435.33*4

=13741.32mm^3

Volume of smaller hole=πr^2h

=3.14*9.5^2*6

=1701.17mm^3

Total number of smaller hole=2

Total volume of smaller hole=1701.17*2

=3402.34mm^3

Total volume=170117.24-(13741.33+3402.34)

=152973.33mm^3

=1.529*10^-4m^3

Total mass=density*volume

=7850*1.52973

=1.2kg

Total mass of flywheel=1.2*10% of 1.2

=1.2-0.12=1.08 kg

Length of handle =170mm

Thickness of handle=13mm

Width of handle =16mm

Volume of handle v1=l*b*w

=170*13*16

=35360mm^3

=3.536*10^-5m^3

Volume of circular cross section

v2=πr^2h

=3.14*13.5^2*26

=14886.43mm^3

=1.486*10^-5m^-3

Total volume = 3.536*10^-5) + (1.486*10^-5)

=5.022*10^-5m^3

Total mass=volume * density

= 5.022*10^-5*7850

=.3942 kg

Kinetic energy of circular fly wheel=1/2*m*r^2

=1/2*1.08*0.095^2

=4.8735 kg-m^2

Kinetic energy of handle=1/3*m*l^2

=1/3*.3942*.21^2

=5.794 kg-m^2

Total Kinetic energy, I=4.8735+5.794

=10.667 kg-m^2

Since we know that,

9.54 Rpm=1 rad/sec

Angular Acceleration, α =20/9.54

=2.1 rad/sec

Torque=α*I

=2.1*10.667

=22.40 N-m

VI. ADVANTAGES

- No external power supply is required.
- It is reliable.
- Low maintenance.
- It is portable.
- . Easy operation by carrying on human back.
- Eco friendly in nature.
- No requirement of skilled labour
- Cost efficient.
- Operating cost is less.

VII. DISADVANTAGES

- More effort required to operate the machine
- Overall weight of the model is more.
- Less efficiency compare to electrical device
- Regular lubrication required.

VIII. EXPERIMENTAL

TESTING

We are collecting the dust particle through suction to clean the surface.

By this process we came to know the suction pressure of our vacuum cleaner.

IX. DETERMINATION OF REMOVING DUST PARTICLE

The dust particle and wastage which are selected for cleaning with this machine to determine the cleaning time and its efficiency.

X. MACHINE TESTING

The vacuum cleaner machine was tested for the suction processes.

XI. RESULTS AND DISCUSSION

This is manual vacuum cleaner used for removing dust particle from the surface. The result of test is carried out to determine the suction pressure and efficiency. This is very use full process for removing dust particle without any help of extra source.

CONCLUSION

The design of the manual vacuum cleaner was based on the standard data available. The fabrication was done using locally available materials. In this report it is discussed that the need for manual vacuum cleaner in the current world. We have studied the different mechanisms that can be implemented. In today world different varieties of vacuum cleaner are present but all they are costly as well need external power source for operation. So we came up with an idea of designing and fabrication of manual operated vacuum cleaner. During the study we have made several attempts while selection of materials for gears, shafts and gear box chassis. Initially we have used hardened form for gear for gear box chassis but that is not capable to withstand the load as well as we have faced alignment problems. Finally we came to a conclusion of using aluminium sheet for gear box chassis which is a successful idea.by proper machining of aluminium sheet we have assembled the shaft and gear and finally reaches to our desired outcome. And we came to know about the detail working principle of the dust remover which is commonly known as vacuum cleaner.In comparison of existing one our model is economical and it requires less maintenance and it has better portability for transportation. It requires only one person to rotate the handle by one hand and to hold the hose by other hand during operation

REFERENCES

[1] Rohan, B. Beulah Martin, Kandula Rajitha, “fabrication of a dust remover as well as floor sweeper with deodorizing effect”, International Journal of Research in Engineering and Technology, Volume: 05 Issue: 06-Jun-2016,.

[2] M. keerthi, k. sandya, k. srinivas, “Static & Dynamic Analysis of Spur Gear using Different Materials”, International Research Journal of Engineering and Technology, Volume: 03 Issue: 01- Jan-2016,.

[3] Mahebub Vohra Kevin Vyas Professor, “Design Stress analysis of Metallic and Non-metallic Spur Gear”, International Journal for Scientific Research & Development, Vol. 2, Issue 04, 2014.

[4] SingiReddy Ravinder, Ramesh Banothu, “Design and analysis of Gear Shaft”, International Journal of Mechanical Engineering (SSRG-IJME) – volume 2 Issue 9 – September 2015,.

[5] Vijaypratap R Singha, M J Zinzuvadiaa, Saurin M. Shethb, “Parametric Study and Design Optimization of Centrifugal Pump Impeller”, Vijaypratap R Singh et al Int. Journal of Engineering Research and Applications”, ISSN : 2248-9622, Vol. 4, Issue 1(Version 1), January 2014, pp.216-220,.

[6] Mr. Nilesh Nemgonda Patil, “development of impeller of centrifugal pump using computational fluid dynamics”, International Journal of Engineering Sciences & Research Technology, September, 2015,.

[7] Rahi Jain and Pratik Goyal, “design and analysis of gear-box using spur gear and eliminating the differential unit”, International Journal of Mechanical Engineering and Technology (IJMET) Volume 7, Issue 6, November–December 2016, pp.510–517,.

[8] Rahul U. Urunkar, Prof. P. P. Deshpande, “Study of Drive Mechanisms of Bicycle, Tricycle or Like Vehicles to Optimize Operating Performance”, Journal of Engineering Research and Applications, ISSN : 2248-9622, Vol. 4, Issue 1(Version 2), January 2014, pp.214-219,.

[9] Mr. R. R. Kulkarni1, Dr. P. R. Kulkarni, “A Review of Research on Tapered Roller Bearings’, IJMEIT, Vol.04 Issue 03-March, Page No:1623-1627, ISSN-2348-196x,.

[10] Shruti Paunikar1, Sandeep Shrivastava, “Performance Evaluation of Nut and Bolt Recognition System Using Artificial Neural Network”, International Journal of Advanced Computer Research, Volume-3 Number-3 Issue-12 September-2013,.

[11] S.U. Maji M. S. Mane C. Kshirsagar3 A. Jagdale4 D. Malgar, "Conventional Free Energy using Flywheel", International Journal for Scientific Research & Development, Vol. 4, Issue 02, 2016, ISSN (online): 2321-0613,.

[12] A. Chellil, A. Nour, S. Lecheb, H. Mechakra, L. Addar, H. Kebir, "Mechanical Characteristics on Fatigue Crack Propagation in Aluminium Plate", International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering Vol:8, Issue on: 5-2014,.

