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“To be a preferred institution in Engineering Education by achieving excellence in teaching and research and to remain as a source of pride for its commitment to holistic development of individual and society”

INSTITUTE MISSION

"To continuously strive for the overall development of students, educating them in a state-of-the-art-infrastructure, by retaining the best practices, people and inspire them to imbibe real time problem solving skills, leadership qualities, human values and societal commitments, so that they emerge as competent professionals"

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

“To be the centre of excellence in providing education in the field of Mechanical Engineering to produce technically competent and socially responsible engineering graduates”

MISSION

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The Graduates of the program will be able to

PEO1: Acquire core competence in Applied Science, Mathematics and Mechanical Engineering fundamentals to excel in professional career and higher study.

PEO2: Design, demonstrate and analyze the mechanical systems which are useful to society.

PEO3: Maintain professional and ethical values, employability skills and multidisciplinary approach to realize engineering issues in broader social context by engaging in life-long learning.

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1. Computational Analysis of Ceramic Regenerative Storage Air Heater for A Hypersonic Wind Tunnel

Introduction

Hypersonic wind tunnel (HWT) facilities normally operate as pressure vacuum driven enclosed tunnels. In these facilities, air is stored at high pressure, regulated to required stagnation pressure, and is expanded to the vacuum conditions to get the required velocity in the test section. High pressure air is preheated in order to avoid liquefaction of air in test section due to large expansion ratios. Preheating conditions depend on the pressure ratio and Mach number required in the test section. Ceramic cored brick regenerative storage air heater (RSAH) is the best choice for this type of heating to generate hot and clean air. RSAH contains a stack of ceramic mass with multiple holes aligned from top to bottom. This mass of ceramic is referred as the core of the heater sitting on a grate at the bottom. The core is surrounded by layers of refractory bricks acting as insulation to protect the shell from experiencing high temperature and also to minimize the heat loss from the core to the environment. RSAH is operated in three cycles namely heating cycle (charging cycle), blow down cycle (discharging cycle), and reheating cycle (recharge cycle), respectively. In heating cycle, the heater bed is heated to the required temperature by blowing hot combustion gases through the holes in the core of the bed. The combustion gases are produced by burning LPG in the burner placed on top of the heater. Heating is stopped once the core reaches the required temperature. In blow down cycle, the cold air at required pressure and mass flow rate is sent from the bottom of hotbed to top. During this process, the air gets heated to required temperature and the ceramic bed of the heater loses some of its heat content. In reheating cycle, the bed is reheated from the existing condition to required temperature as performed in heating cycle.

Objectives

The following are the objectives of the computational fluid dynamics analysis:

1. Develop the scaled-down geometry architecture to simulate the equivalent performance of full-scale heater.
2. Carry out the conjugate transient thermal analysis for heating cycle, blow down cycle, and reheating cycle to understand the conditions of air and core at the end of the respective cycles.
3. Arrive at the heating and reheating cycle times based on the temperature profile of the bed.

Geometry

The geometry of the RSAH is modeled with insulation layers and outer shell. The RSAH bricks are arranged in the circular manner to form a core diameter and it contains circumferential rings of bricks altogether having 448 Mechanical Engineering for Sustainable Development 18,500 holes. Computational fluid dynamics (CFD) simulation of full-size heater with end to end geometry (of the order ~ 5.5 m) and these large numbers of holes result in a large number of mesh elements. Hence, the symmetric scaled geometry is chosen for the analysis. In the heater, numbers of bricks are arranged in circumferential rings with an inter-circumferential ring gap as shown Figure 1. Owing to this arrangement, core bricks in the last circumferential ring are connected to the insulation layers and will be affected by the heat loss to the environment through the insulation layers.

Therefore, it is decided to carry out the simulation of the heater with brick in last ring, insulation layers, and casing as the geometry. Geometry consists of 96 holes and arc outer diameter of the core corresponds to 2.4 m.

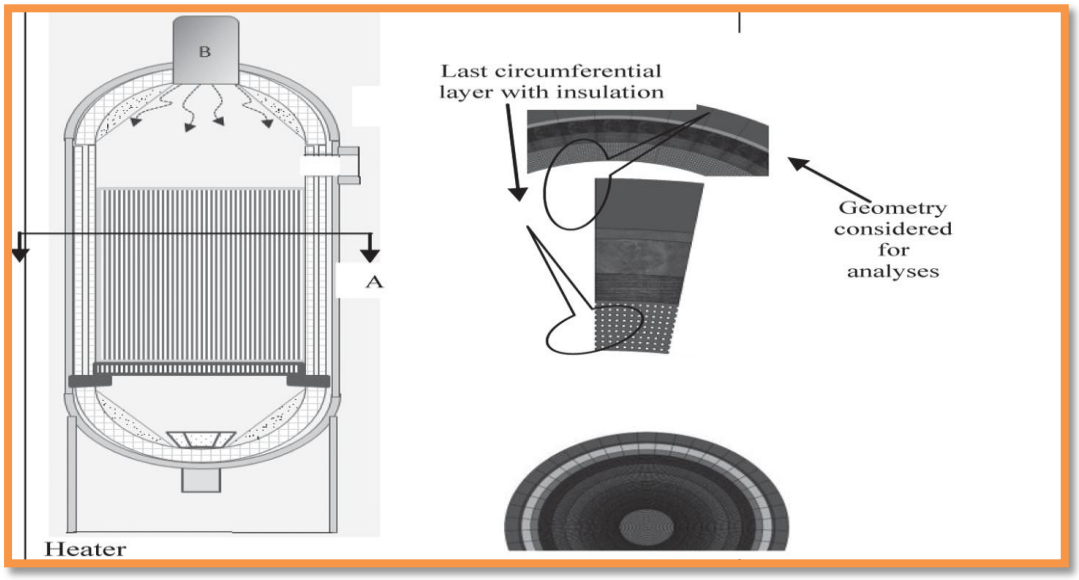

Figure 1.1 Schematic representation of the RSAH

Conclusions

1. Geometry selected for analysis proved to represent the physics of the full-scale heater. Precise block structured, mesh for heat transfer analysis has been generated to achieve wall y+ lesser than 20.
2. Unsteady conjugate heat transfer analysis using μRANS model has been successfully executed.

2. Performance Analysis of an Air Water Heater by Using HFC Refrigerants

Introduction

The heat pump is not commonly known in a domestic environment, but they are available for domestic purposes. The primary objective of a heat pump is to extract or absorb heat and transfer it from the heat source to heat sink. The advantage of using a heat pump is that useful heat can be extracted from the air water or ground and then transported to heating applications. An air water heater (AWH) is a device which provides both heating and cooling or heating. The heat pump uses electricity to absorb heat from outside air then transfer it to heat sink in heating mode. Refrigeration and allied fields are going through tough time due to the strict norms established due to environmental concern. Refrigerant plays an important role in thermal cycle. It is observed that refrigerants, mainly halogenated refrigerants, are banned due to their harmful results. Research and development in the refrigerant study leads to probable alternatives for traditional refrigerants. Hot water production for low-temperature application using heat pump is the energy-efficient method to meet the need of quality of hot water required.

Experimental Setup

The experimental work is carried out to analyze the performance of AWH system by using HFC refrigerant. The detailed analysis of AWH system by using different refrigerants is also carried out. The schematic diagram of the experimental setup used in present study is shown in Figure 2.1. The setup consists of evaporator coil, fan motor assembly, condenser, compressor, thermal expansion valve, switches, and so forth.

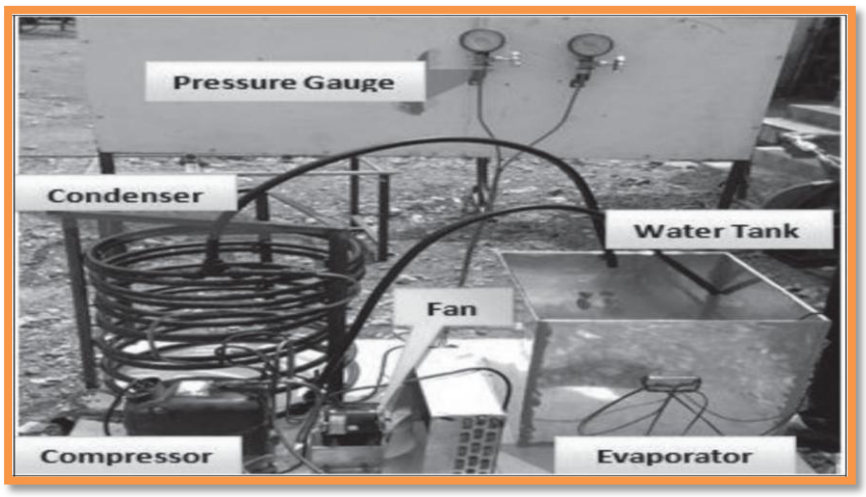

Figure 2.1 Photographic view of experimental setup

Results and Discussion

The effect of evaporator temperature on the performance of AWH system by using actual VCC system at 65°C condenser temperature and different refrigerants is shown in Figure2.2. Clearly, the COP of AWH system increases as the evaporator temperature increased. Moreover, it is clearly seen that the COP of AWH system is calculated by considering sub cooling and superheating.

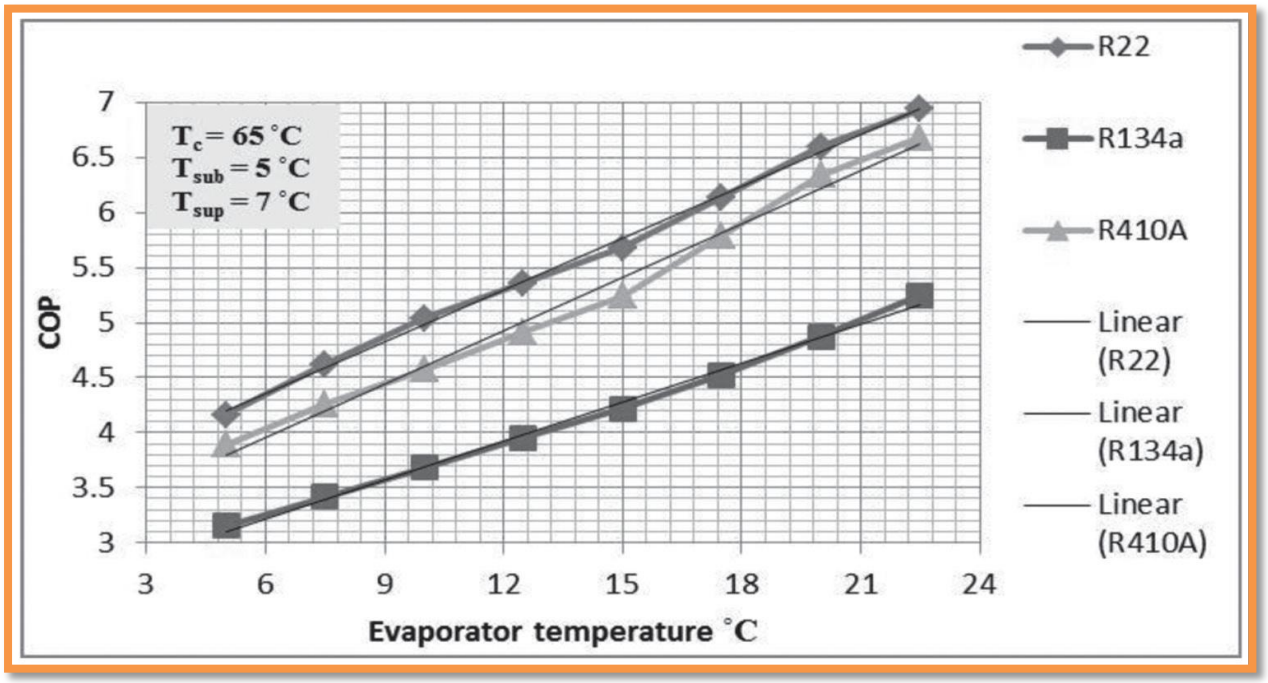

Figure 2.2 Graph of COP versus evaporator temperature at Tc = 65°C

Conclusions

The present experiment is performed to compare variations in COP of heat pump using refrigerants R22, R134a, and R410A. From the results, it is concluded that the COP of R22 is 5% greater compared with R410A and 20% greater compared with R134a for low-temperature heat pump applications. However, R22 is environmentally dangerous to use for AWH system due to higher global warming potential and ozone depletion potential values. Again, it is observed that the COP of refrigerant R410A is 16% higher compared with R134a and 5% lower compared with R22. Moreover, the COP decreases with a rise in hot water temperature and condenser temperature. From the above results, it is concluded that R410A is most suitable HFC refrigerant for replacing R22 with minimum investment and efforts. Therefore, the refrigerant R410A having COP 3.92 is more suitable for water heating applications.

3. Effective Mitigation of NO_x Emissions from Diesel Engines with Split Injections

Introduction

Diesel engines inherently possess high thermal efficiency, good durability, and superior fuel economy compared to other engines making them the most desirable ones in heavy-, medium-, and light-duty vehicle applications. However, high emission of oxides of nitrogen and particulate matter with their unresolved trade-off from diesel engines is a major challenge to be addressed by the researchers nowadays. Suitable after treatments, such as selective catalyst reduction, are effective in reducing diesel engine emissions but require extensive exhaust system modification. Moreover, conversion of NOx to nitrogen at the exhaust of diesel engines using three way catalytic converter is found to be less efficient due to excessive oxygen content present in the exhaust stream of compression ignition engines.

Validation of the Numerical Model

A comparison has been made in this section between the values obtained from the theoretical model and experimental values. For this purpose, two sets of experimental data are considered. One set of data of in-cylinder pressure histories from a single-cylinder, water-cooled, direct injection diesel engine with 80 mm × 100 mm stroke and bore and with a CR of 16.5:1 present in authors' laboratory and the other from the experiments carried out by Rakopoulos et al.16 on Ricardo-Hydra engine have been used in the present work. Figure 3.1 represents comparisons between predicted and experimental values of in-cylinder pressure histories diesel engine operating at 1500 rpm, at static IT of 23° before top dead center and at 25% load conditions.

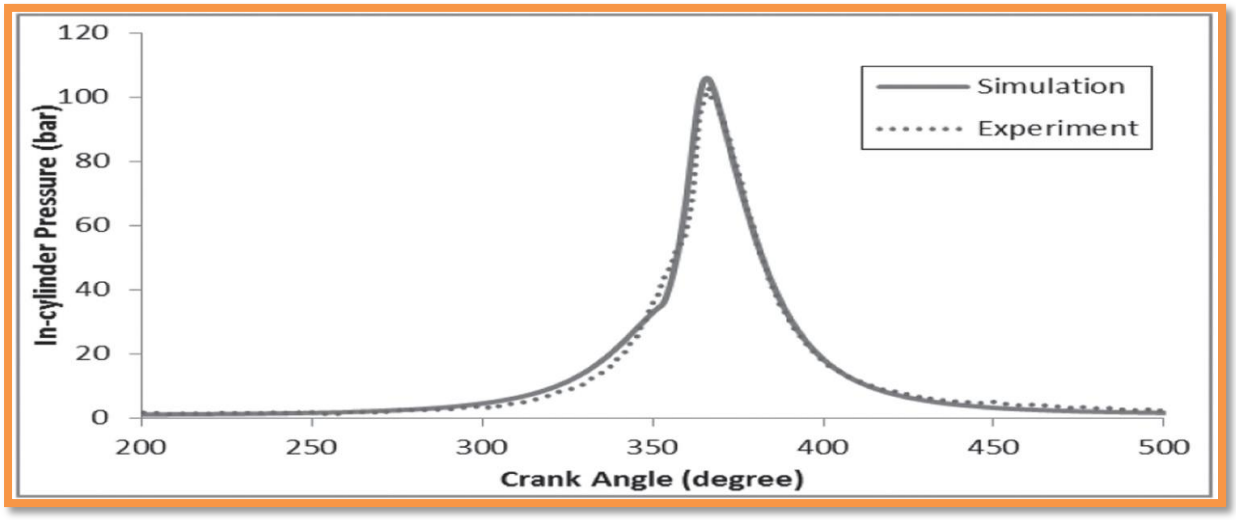

Figure 3.1 Comparison between predicted and experimental values for engine operating at 1500 rpm, at an IT of 23° bTDC at 25% load.

Figure 3.2 shows a comparison between the predicted and experimental cylinder gas pressure traces obtained from Figures 3.1 and a good agreement between the theoretical and experimental cylinder pressure curves, thus validating the model and its implementation.

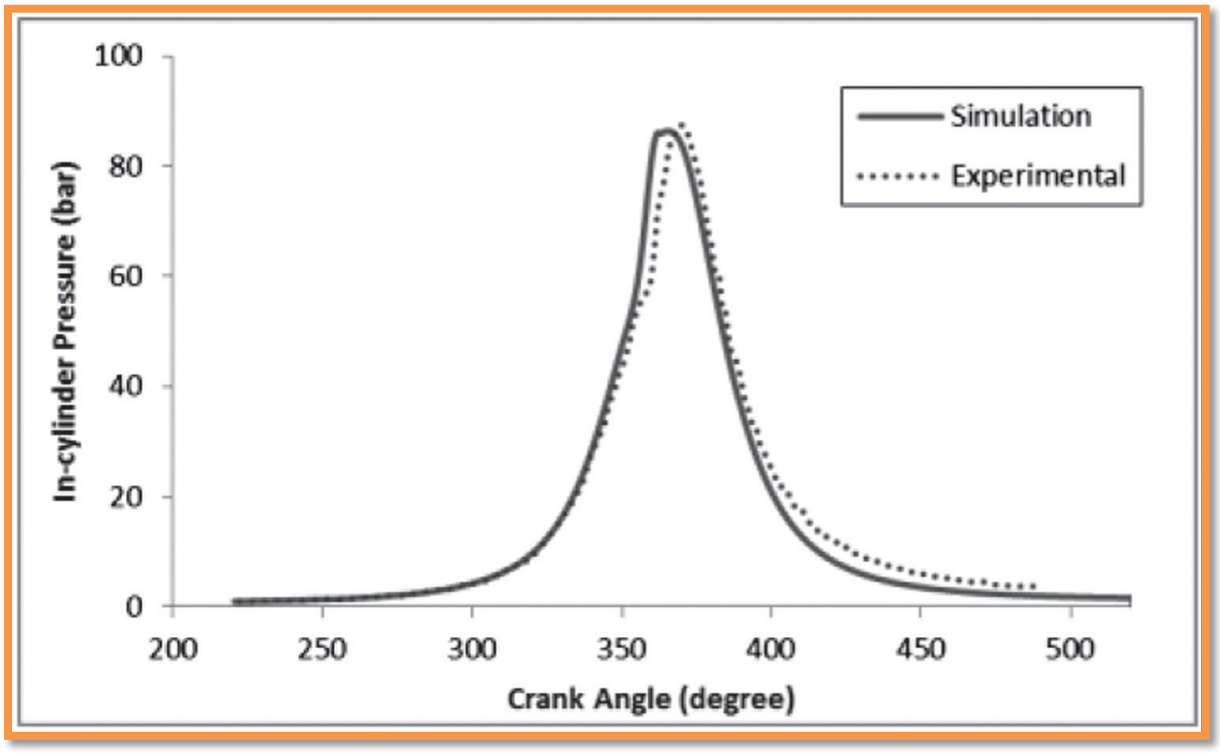

Figure 3.2 Predicted and experimental pressure (indicator) diagram versus crank angle (CA), at 2000 rpm, 75% of full load condition and 29° bTDC static IT.

Conclusions:

1. The model is insensitive to engine geometry.
2. The model is able to establish the trade-off between NO_x and soot emissions with variation in fuel IT.
3. It is observed that EGR can be effectively used for reduction of NO_x emissions, however, with a loss in piston work of the engine.
4. Split injections are observed to restrain premixed phase of combustion when compared to single injection at the same IT.
5. Split injection with a smaller quantity of fuel injected in the first pulse (25/75) is observed to lower NO emissions.

4. Topology Optimization of a Spur Gear

Introduction

Topology optimization (TO), a mathematical tool used in the conceptual design stage, has been found to fulfill the part weight reduction problem by optimal distributing of the material throughout the components body. Material distribution is done without any preconceived shape using different computational techniques for innovative and high-performance structures. Most of the TO problems are aimed at maximizing stiffness for a loading condition and within prescribed material usage. TO has wide application in aerospace and automotive sectors for lightweight structures. Reducing weight leads to less part manufacturing cost. The application of the TO in various fields of engineering will improve design cost and quality.

In additive manufacturing, a three-dimensional model is used to make objects by the process of joining materials layer upon layer. Parts of significantly greater complexity can be produced compared with traditional processes and this increased complexity generally does not have a significant effect on the cost of the process. This provides the designer with significantly greater design freedom. This chapter discusses the application of TO by considering a spur gear as computer-aided design model for optimization.

Process of Topology Optimization

A CAD model of spur gear was modeled initially on which TO be carried out shown in figure 4.1.

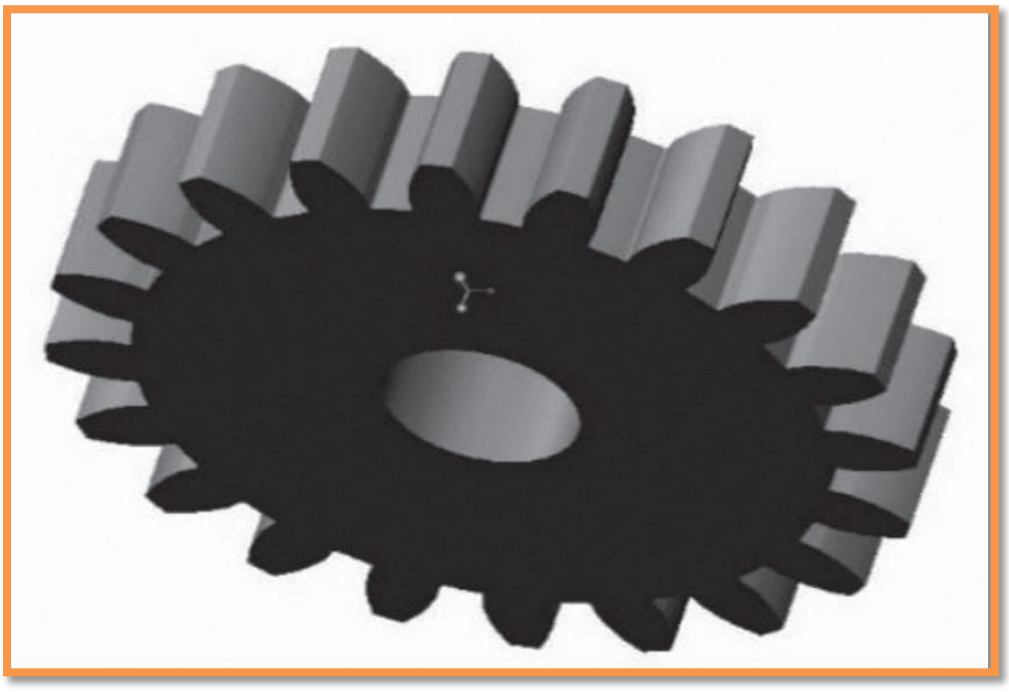

Figure 4.1 Computer-Aided Design Model of Spur Gear

For the same loading condition, the displacement was constrained to 0.8 mm and it is observed that a volume reduction of 25.6% is obtained. The stresses on the optimized spur gear are compared with the fully solid model. For optimization, each tooth is loaded simultaneously. For optimization process, the part is loaded more than 10 times of practical loading condition. Therefore, the stresses on the solid and optimized parts in finite element analysis during optimization are above the yield strength. Here, the work compares solid part with optimized part of similar material and under same boundary conditions, so the material properties need not be considered. It is observed that the stresses on the optimized spur gear are less than fully solid spur gear. Figure 4.2 shows averaged Mises stress for the optimized and solid part.

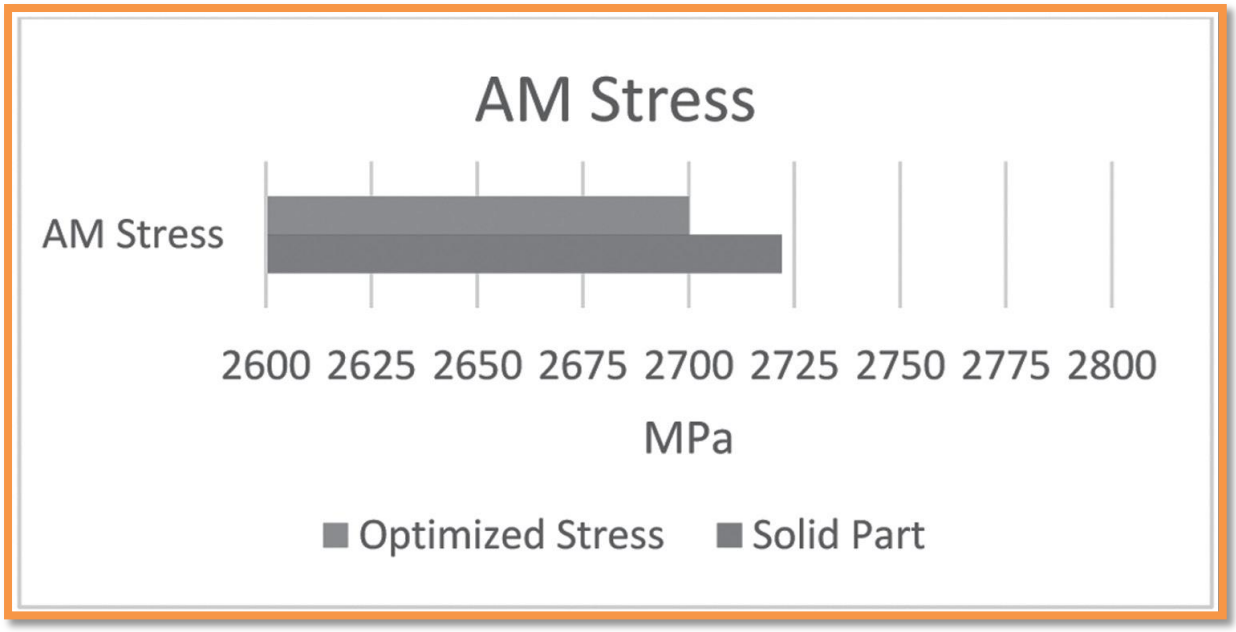

Figure 4.2 Averaged Mises Stress for the Solid and Optimized Model

Conclusions

TO of spur gear for volume reduction as primary objective was carried out. A volume reduction of 25.6% is obtained with a constraint of 0.8-mm displacement, which is a mass reduction of 1.3 kg, from 5 to 3.7 kg. Stresses after TO are less than that of fully solid spur gear even after 25.6% volume reduction. Optimized part puts forward a lightweight structure. Significant reduction in weight, material, and manufacturing cost can be achieved through TO. Mechanical simulation and practical analysis on optimized spur gear should be carried out for in-depth research on TO.

5. Electric Discharge Machining of Ceramic Particulate-Reinforced Aluminum Matrix Composite

Introduction

Electrical discharge machining is one of the most basic nontraditional, potential, major manufacturing processes of budding intricate surface geometry and integral angles. The process is applicable to any conductive material regardless of its hardness, toughness, and strength. The electrode is moved toward the work piece until the gap is little enough in order that the voltage is great enough to ionize the dielectric fluid in the gap between the tool and work piece. The material is removed with the erosive effect of the electrical discharges of the tool and work piece.

Aluminum and aluminum-based metal matrix composites (MMCs) have turned out to be striking engineering materials and used in aerospace, military and automobile industries, and on the addition of ceramic particles to aluminum improves its high toughness, strength, wear resistance, and corrosion resistance. Due to possession of superior hardness and reinforcement strength, MMCs are difficult to be machined by traditional techniques.

Fabrication of the Composite

Stir-casting apparatus consists of a cylindrical-shaped graphite crucible as it can withstand high temperature which is much higher than the required temperature [680°C] and also the aluminum does not react with graphite at this temperature. This crucible is mounted in a muffle which is made up of high ceramic alumina. This type of furnace is known as a resistance heating furnace. Aluminum, in liquid stage is very reactive with atmospheric oxygen and there is formation of oxide when it comes in contact with the open air. So it is necessary to carry out the process of stirring in a closed chamber with nitrogen gas as an inert gas in order to avoid the oxidation.

Closed chamber is made with the help of steel sheets. This reduces heat loss and gas transfer as compared to an open chamber. Due to the corrosion resistance to atmosphere, steel is selected as the stirrer shaft material. One end of the shaft is connected to a 5 hp motor with flange coupling and at the other end blades are welded. Aluminum alloy matrix is formed by heating the aluminum alloy ingots in the furnace. A stirring action is started and increased slowly from 30 to 350 rpm with a speed controller. The reinforcement (Al2O3) is incorporated in the metal matrix at the semisolid stage near 640°C. Schematic diagram of stir casting process is shown in Figure 5.1.The dispersion time taken is about 5 min. After that the slurry is reheated to a temperature above melting point to make sure the slurry is fully liquid and then it is poured into a mold.

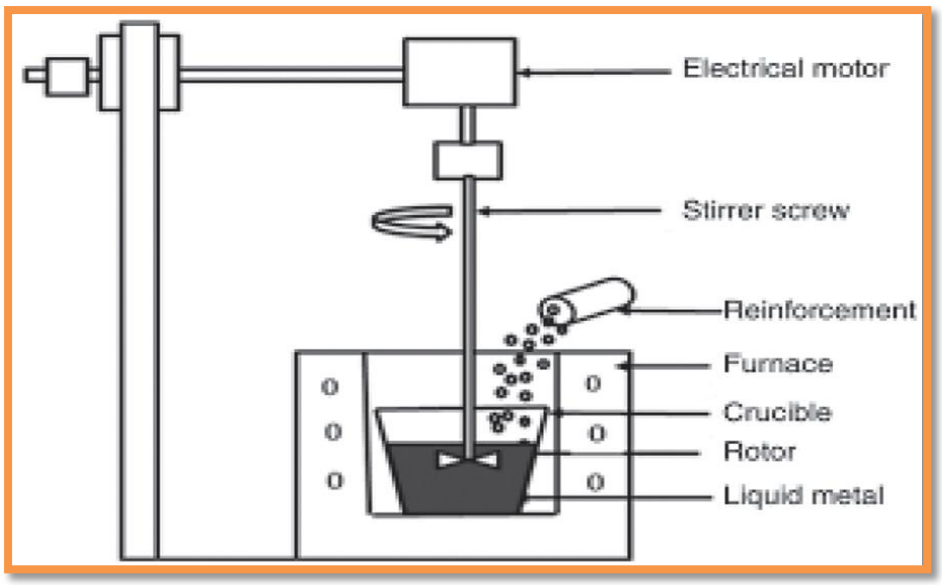

Figure 5.1 schematic diagram of stir casting process

Electrical Discharge Machining (EDM) Process

EDM is one of the most extensively used nonconventional manufacturing processes used for hard materials which are very difficult to machine with in conventional techniques. EDM is sometimes referred to as spark machining, spark eroding, burning, die sinking or wire erosion. Electrical discharge machine is shown in Figure 5.2.This is a manufacturing process whereby a Desired shape is obtained using electrical discharges.

Figure 5.2 Electrical discharge machine

6. Characterization of Fe–Co–Ni-Ternary Metal Catalyst for High-Yield Multiwall Carbon Nanotubes

Introduction

Carbon nanotubes (CNTs) are getting more attention after their discovery by Iijima in 1991 due to their exceptional mechanical and electrical properties. Volder et al. discussed various applications of CNTs with diversified products ranging from automotive, rechargeable batteries, sports material, electronics, large-area coating to water filter, and so forth 2. A high aspect ratio of CNTs enables it as a prominent reinforcement material in metal matrix and polymer matrix composites than glass fiber 3 However; the yields of CNTs are significantly low to cater the demand for the various applications. The rate of carbon precursor is responsible for the growth of nanotubes. Although the growth rate depends on hydrocarbon supply, much higher supply adversely affects the growth rate.

Experimental Procedure

These nitrates are dissolved in demonized water. The CaCO3 paste is prepared and the nitrate solution is added to it. Thus, the ternary (Co–Ni–Fe) precipitate is formed. The precipitate is dried in oven at 1200°C till it is converted to dry powder. While drying the mixture, it is continuously stirred so as to obtain the uniform dispersion of the catalyst in the substrate. The time required for drying of various samples varied between 5 and 7 h. This catalyst is used as a seed for CNT synthesis. The weight reduction study was carried out in the presence of inert atmosphere using argon with flow rate of 30 ml/min as a carrier gas. To understand the effect of temperature on the catalyst, the catalyst was heated at 6000–7500°C as the CNT synthesis at this temperature range varies. The catalyst is kept inside the furnace for 20 min. Then, it is furnace-cooled. It is observed that after the heating, the weights of the samples reduced from 16% to almost 38%, depending on the percentage of the catalyst and the furnace temperature. The result shows that maximum weight reduction occurred with 7% catalyst and at 7500°C.

Results and Discussion

XRD test was conducted using Cu–Kα ($\lambda = 1.54060$ Å) radiation in an Empyrean X-ray Diffract meter operating at 45 kV and 40 mA. Figure 6.1 shows the XRD results of catalyst prior to the furnace-heating. The graph shows that the sample of 5% catalyst has more crystalline peaks compared with other two samples, whereas the nature of all the three graphs is similar.

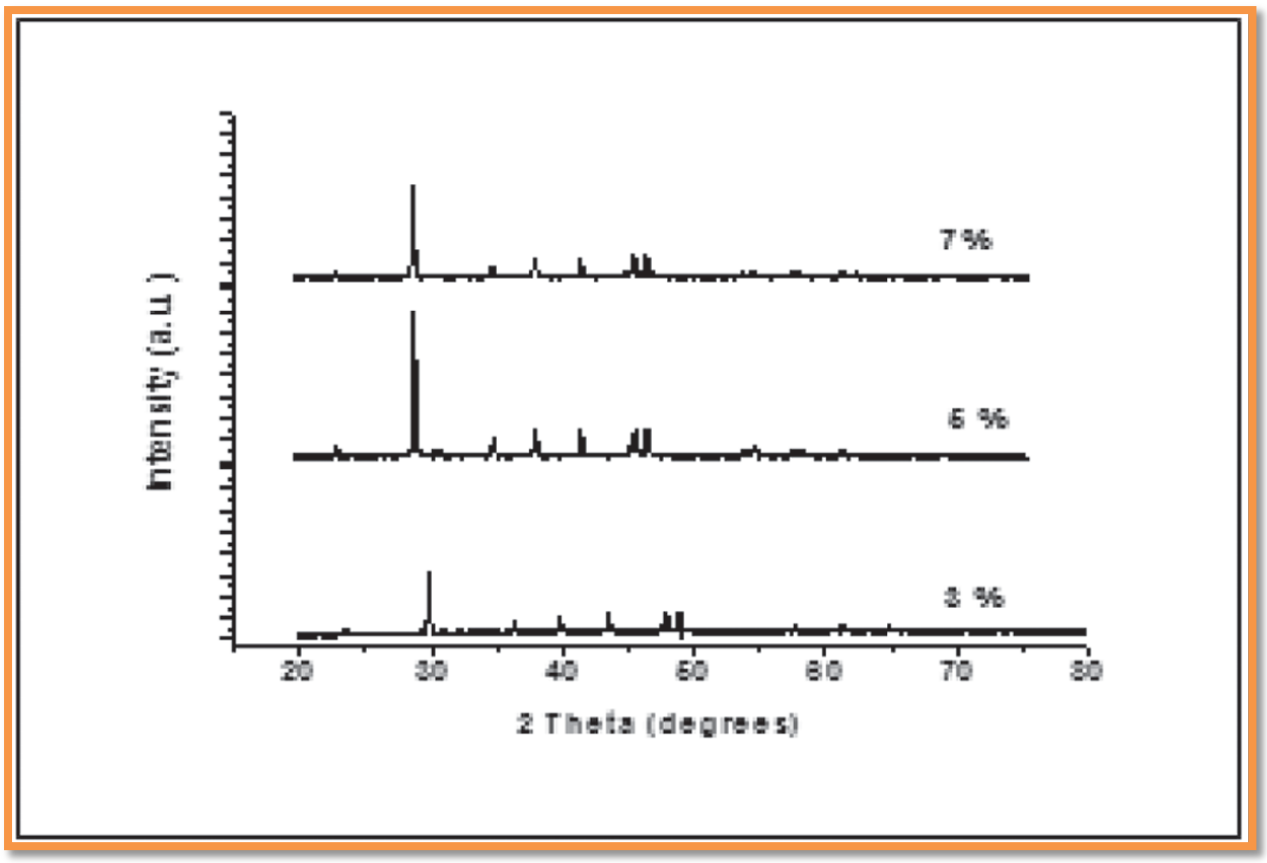

Figure 6.1 X-ray diffraction (XRD) pattern of precipitate of Ni/Co/Fe catalyst at various percentages without furnace-heating.

Conclusions

In this study, the ternary (Co–Ni–Fe) catalyst was prepared and its characterization is presented. The XRD suggests that 5 wt. % catalysts loading will be better in terms of small seed dimensions. This helps in CNT synthesis of better quality. Further, the catalyst is heated in the argon atmosphere up to 750°C. The active range of CNTs synthesis is 600–750°C in CVD method. The XRD characterization is carried out for the same range of temperature and it is observed that Fe2O3 and Fe3O4 are present in the catalyst samples, along with Ni2O3 and Co3O4 catalyst elements. The SEM-EDS analysis suggests that traces of S, Mg, and C were present in the catalyst samples. Further, the agglomerated morphology observed, which is porous in nature.

7. Optimization of Cutting Parameters in Turning of Maraging Steel

Introduction

Maraging steels are widely used in many technological sectors such as aerospace, military as well as for tools and dies. For most of the applications, these steels require high strength in combination with good toughness. Moreover good weld ability, high strength to weight ratio, and dimensional stability during aging are attractive features for applications. Machining of these steels require tool materials that can withstand the extreme forces. Cutting forces are important in machining as they provide unique signature of the mechanics of machining while determining the energy consumed and machining power required for the process, tool, and work piece deflections. There have been many studies concerning the effect of cutting parameters such as speed, feed, depth of cut, tool geometry, and so forth, on cutting forces while machining different materials.1–4 Yang and Tarng5 investigated cutting characteristics of S45c steel bars using tungsten carbide cutting tools using orthogonal array, the signal to noise (S/N), ratios, and the analysis of variance (ANOVA).

Lalwani et al. studied the effect of cutting parameters (cutting speed, feed rate, and depth of cut) on cutting forces and surface roughness in finish hard turning of MDN250 steel (equivalent to 18Ni (250) maraging steel) using coated ceramic tool. The results show that cutting forces and surface roughness do not vary much with cutting speed in the range of 55–93 m/min. A nonlinear quadratic model best describes the variation of surface roughness with major contribution of feed rate and secondary contributions of interaction effect between feed rate and depth of cut. Bartarya and Choudhury7 developed a force prediction model during finish machining of EN31 steel (equivalent to AISI 52100 steel) hardened to 60 ± 2 hardness on Rockwell C using hone edge uncoated CBN tool and to analyze the combination of the machining parameters for better performance within a selected range of machining parameters. The predictions from the developed models were compared with the measured force and surface roughness values to propose the favorable range of the machining parameter values for energy-efficient machining.

Experimental Details and Results

The turning experiments were carried out on a precision lathe setup using tungsten carbide cutting tools for the machining of maraging steel bar which is 50 mm in diameter and 100 mm in length. Carbide tool materials are employed in the machining of maraging steels due to their

improved performance in terms of tool life and surface finish. Carbide tool inserts CNMG 120408, along with the tool holder PCLNR 2020 M12 (tool geometry: approach angle: 95°, back rake angle: 6° and inclination angle: 6°) were used in the present investigation.

The force signals generated during machining were fed into a charge amplifier (Kistler, 5070) connected to the dynamometer. This amplifier converts the analog signal to digital signal that was continuously recorded by the data acquisition system connected to the charge amplifier. One of the cutting force signals obtained for v = 30 m/ min, f = 0.60 mm/rev, and d = 0.15 mm using DynoWare software is shown in Figure 7.1.

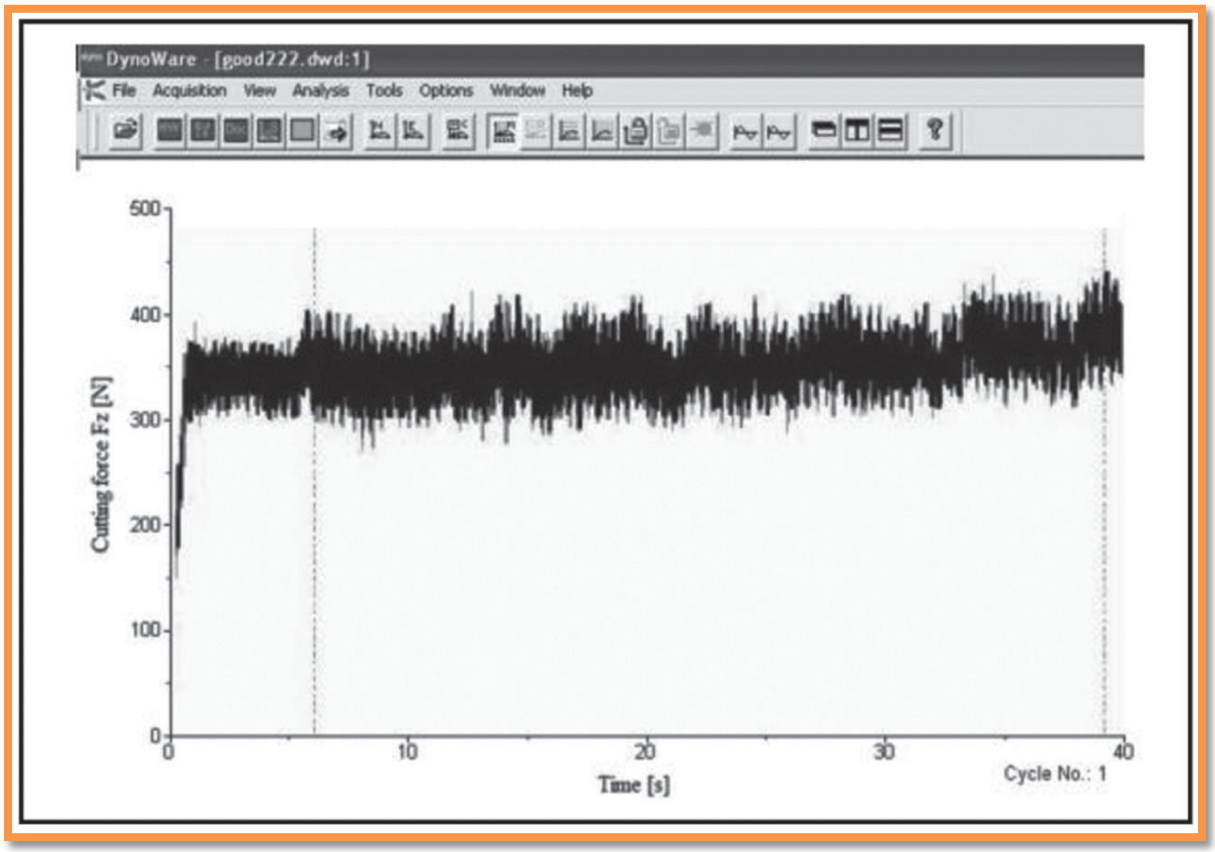

Figure 7.1 Cutting force signal from dynamometer

Conclusions

It has been shown that cutting force will be reduced significantly for turning operation by conducting experiments at the optimal parameter combination.

8. Eight-Legged Spider Robot

Introduction

Theo Jansen is a renowned Dutch artist best known for his Strandbeest (Dutch for beach animals). These kinetic sculptures are designed to be a fusion of art and engineering. Inspired from nature and bearing an uncanny resemblance to the movement of animals, these mechanisms are built using an array of triangles and connecting links that convert the rotation of an axle into the stepping motion of six or more limbs. Moreover, since these mechanisms mimic the movement of animals, they are far more efficient compared to wheels when operating in sand and on rough terrain. Designed to mimic the movement of arachnids, this eight-legged spider robot builds upon the ingenuity of the Theo Jansen Mechanism. This system uses a dual motor setup paired to six gears which in turn actuate the eight legs in synchrony. Its remote-control operation enables the operator to control this robot wirelessly. This system also has four 12v LED indicator lights on either side to signal its direction of movement.

System Features

- Uses Theo Jansen mechanism to mimic the motion of a spider
- Wheel free Movement
- Dual Motor Mechanism
- Uses 6 Gears to actuate the 8 Legs
- Wireless Remote-Controlled Operation

The spider robot makes use of a kinematic motion that is run by theo jansen linkages. This allows turning the rotational motion of a DC motor into a step motion that mimics animals. The robot makes use of 2 x DC motors o dive the mechanism. The motors are mounted on 2 opposite sides of the robotic chassis or main frame. The drives produced by the motors are used to drive a gear which in turn is connected to 2 more hears. The 3 gears are used to drive a combination of 8 legs. The gear movement is converted into a stepping motion by making use of jansen linkages. This linkage structure allows providing all direction motion to the combination of 8 legs.

The robot can not only move backward and forward but also turn in desired directions. The spider controller is made using a microcontroller based circuitry. The user makes use of a remote controller with 4 x Push buttons. The push buttons when pressed send a particular direction command wirelessly. The receiver controller mounted on robot receives this command and sends it to microcontroller for processing. The microcontroller receives this command and

uses the motor drivers to power motors in desired direction thus achieving forward backward left and right direction movement of the spider robot.

Block Diagram

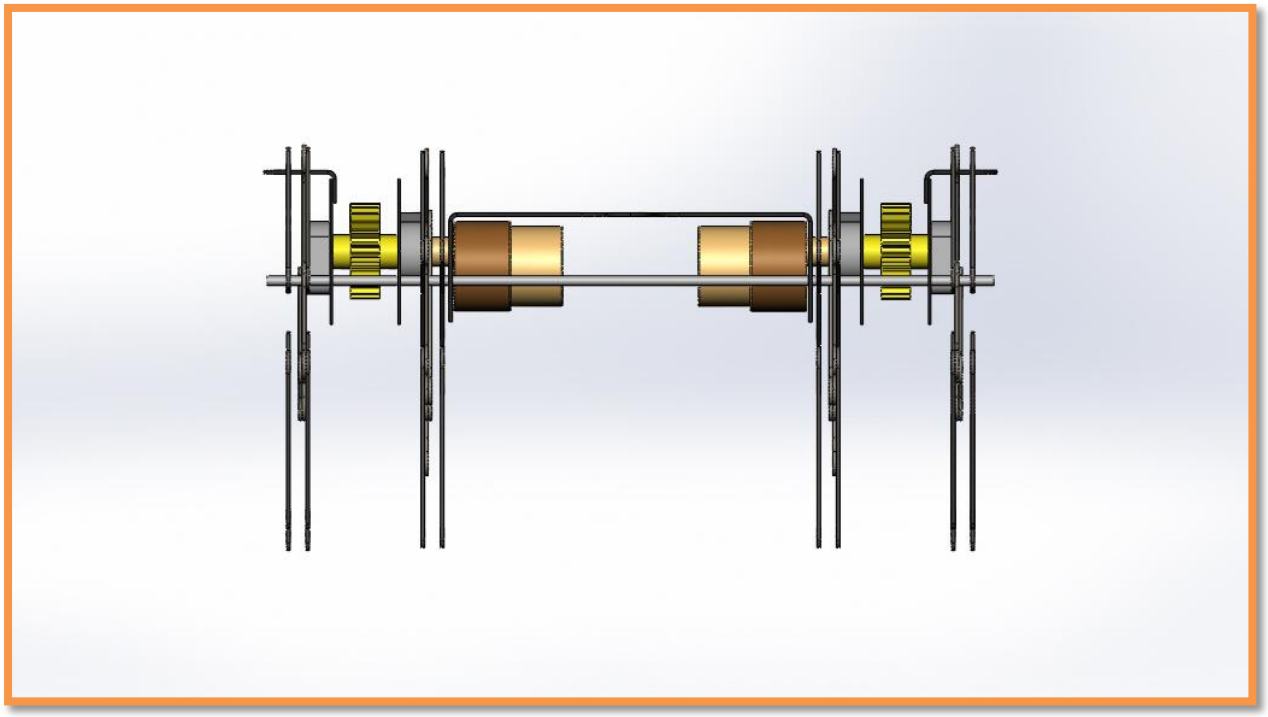

Figure 8.1 Schematic block diagram

Applications

- Mechanical Education
- Events and Exhibitions
- Sci fi Movie Sets
- Props and Showcasing

Advantages

- Can be operated remotely
- Works with fluid Spiderlike motion
- Geared design ensures optimum energy utilisation

Shri. V. G. Badiger
MED, HIT Nidasoshi

9. Solar Panel Cleaning Robot

Introduction

As climate change and global warming threaten the future of our planet, it is becoming increasingly crucial to find sustainable ways to fulfill our energy requirements. One of the most efficient ways of moving towards renewable and non-polluting energy sources is to generate electricity using solar panels to harness the sun's energy. Since they have no moving parts, solar panels are one of the most cost-effective and low-maintenance ways of generating. Despite all their benefits, the efficiency of solar panels can plummet if dust, dirt, and grime are allowed to accumulate. If maximum efficiency in power generation is to be maintained, solar panels need to be cleaned timely. However, manually cleaning solar panels is hazardous and time-consuming.

This Solar Panel Cleaning Robot aims to maintain the efficiency of solar power production by making sure the Solar panels are kept clean without putting humans at risk. This robot comes equipped with a roller brush and a water sprayer to clean all dirt and grime from the surface of the panels. The sprayer gets its supply of water through an onboard tank. The rubber caterpillar tracks ensure that this robot can adhere to the slick surface of solar panels. This robot operates remotely and wirelessly. Along with large-scale industrial applications such as dedicated solar power plants, this robot can also help boost the efficiency of solar panels in smaller applications such as rooftop solar panels in homes and offices.

Features of Solar Panel Cleaning Robot

- Maintains efficiency of solar panels by keeping them clean.
- Remote and wireless operation ensures workers aren't put in danger
- Roller brush cleans all dust, dirt, grime, and debris.
- Equipped with water sprayer supplied with onboard water tank.
- Compact, portable, and user-friendly design.

The solar panel cleaner robot makes use of a water tank with motorized pump along with 4x DC motors to achieve vehicle motion using caterpillar wheel motion. The robotic vehicle is built over a metal chassis with a controller circuitry operated over RF wireless remote.

A remote controller is used to wirelessly transmit control movement data to the robotic vehicle. The controller receives the data and operates the wheel motors in desired directions to achieve the desired movement. The front brush is fixed to the main chassis front and operated by a geared DC motor. The front panel also has an integrated water pipe that is used to drive water

for cleaning using a dc pump to the front of the brush. The system thus allows for easy solar panel cleaning using wireless control.

Block Diagram

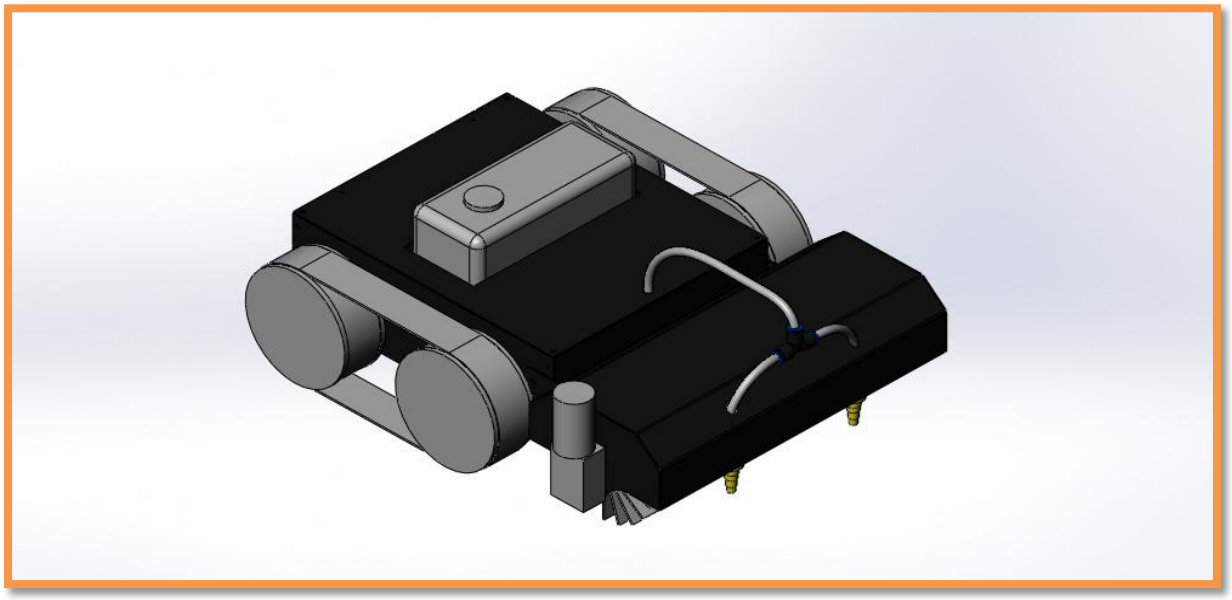

Figure 9.1 Schematic block diagram

Applications

- Large scale solar power producing plants
- Rooftop solar panels at homes and offices

Advantages

- Maintains efficiency of solar panels by keeping them clean.
- Remote and wireless operation ensures workers aren't put in danger
- Roller brush cleans all dust, dirt, grime, and debris.
- Equipped with water sprayer supplied with onboard water tank.
- Compact, portable, and user-friendly design.

Disadvantages

- Not entirely autonomous, requires human operators.

10. Solar Water Desalinator and Purifier Machine

Introduction

Only 3% of the water available on earth is fresh water. Two thirds of this fresh water is present in frozen glaciers. On an average over 1.1 billion people over the globe lack proper access to any fresh water reserves and over 2.7 billion people face scarcity of water at least once a month. But fortunately as we know 71% of earth's surface is water and 97% of that water is sea water.

So here we develop a portable solar powered se water desalination as well as water purifier to solve the water problem with a smart innovative concept. The solar portable desalinator serves the following key aspects

- Fast Water Desalination
- Instant Purification of desalinated water using RO system
- Added UV sterilization for virus bacteria sterilization
- Compact Design
- Portable Design Easy to Move
- Solar Powered – No External Power Needed
- Easy Maintenance System

The machine makes use of a 3 stage process to convert salty seawater to pure drinkable water. The system first allows user to pour salty water via a mesh based inlet where large waste like plastic granules or stones, weed etc gets separated. This water is then pumped into a large purification chamber having 3 layers of purifiers including sand and gravel for filtering weed, sand and large salt particles.

The output of this process is still salty water but without any particles. This water is then passed on to the second filtration where we use reverse osmosis to filter out salt from the water. Here we use 3 filtration membranes to filter out fresh water from salty water and trap the salt particles in membrane filters.

This water is now stored in a tank just above the system. The system tap when opened allows water to run from the tank to the tap where we detect the flow when on and turn on the UV light for stage 3 filtration to deactivate any remaining bacteria and virus in the water. This water is now in drinkable form using 3 stage process without the use of any chlorine.

Now the pumps used in the system are powered by a large battery. This battery is in turn charged by 2 x 50Watt solar panels due to large availability of solar power in sea areas. This makes it very portable to be used on any beach front or on long sea voyages for easy and instant sea water filtration.

Block Diagram

Figure 10.1 Schematic block diagram

Advantages

- Ability to Purify Seawater
- Solar Powered | No External Power Needed
- 3 Stage Purification
- 4 Wheel Portable Design
- Quiet Operation
- Easy To Use

Disadvantages

- Has limited filtering Capacity
- Seawater to be manually fed into the machine
- Requires timely Maintenance

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11. Foot press Pneumatic Lifter Jack

Introduction

Jacks have long been used for lifting vehicles for repairing. Screw mechanism and hydraulics are the 2 major mechanisms that have long been used in lifting jacks. However there are few problems involved in these lifting jack mechanisms:

- Screw mechanism lifting is very slow
- Screw mechanism requires high oiling and is at risk of getting stuck
- Hydraulic system requires hydraulic oil for working which is very costly

Well we hereby propose a mechanism that solves all these issues by making use of air pressure for pneumatic lifting. This makes the lifting process faster, as well as effortless using a pneumatic pump. User just needs to foot press the pup to achieve the lift. Additionally the jack doesn't has required any hydraulic oil to work, it uses compressed air to achieve the lift. To lower the vehicle the air is merely released using a switching air valve. This allows for easy lifting and lowering mechanism for objects up to 150kg.

The system makes use of a pneumatic piston with directional valve, pneumatic foot pump, piping and fittings to develop this system. To start the lifting user must place the jack under the object to be lifted. The direction valve is now to be switched to the lifting direction. This drives the pump air flow through the pipe connected to pushing end of pneumatic piston. As the user presses the foot pump compressed air builds up on the pushing end thus pushing the piston stroke outwards and lifting the object. To lower the object user needs to switch the valve to other side. This drains out the air pressure from the piston thus lowering the object. Thus the pneumatic jack allows for oil less, maintenance less lifting jack mechanism.

Mechanization is broadly defined as the replacement of manual effort by mechanical power. Pneumatic is an attractive medium for low Cost mechanization particularly for sequential (or) repetitive operations. Many factories and plants already have a compressed air system, which is capable of providing the power (or) energy requirements and control system (although equally pneumatic control systems may be economic and can be advantageously applied to other forms of power). The main advantages of an all pneumatic system are usually Economic and simplicity the latter reducing maintenance to a low level. It can have outstanding advantages in terms of safety. Pneumatic systems use pressurized gases to transmit and control power. Pneumatic systems typically use air as the fluid medium because air is safe, low cost and readily available.

Pneumatic Cylinder

Pneumatic cylinders impart a force by converting the potential energy of compressed gas into kinetic energy. This is achieved by the compressed gas being able to expand, without external energy input, which itself occurs due to the pressure gradient established by the compressed gas being at a greater pressure than the atmospheric pressure. This air expansion forces a piston to move in the desired direction.

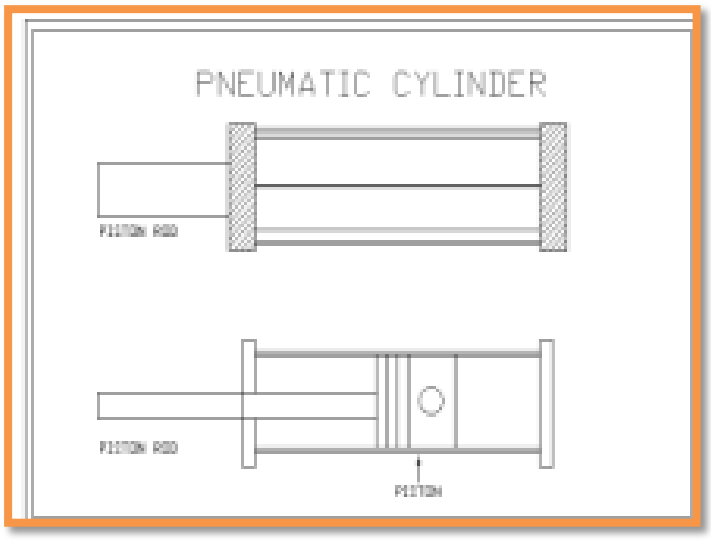

Figure 11.1 Pneumatic cylinder

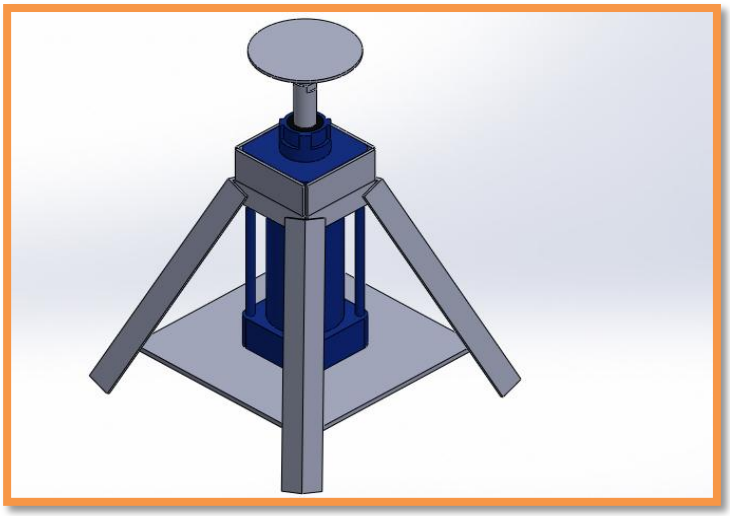

Figure 11.2 Schematic block diagram

Pressure Gauge

Pressure gauges are usually fitted with the regulators. So the air Pressure adjusted in the regulator is indicated in the pressure Gauge, is the line pressure of the air taken to the cylinder. 3.6. JACK a jack is a mechanical device used as a lifting device to lift heavy loads or apply great forces. Jacks employ a screw thread or hydraulic cylinder to apply very high linear forces.

A mechanical jack is a device which lifts heavy equipment. The most common form is a car jack, floor jack or garage jack which lifts vehicles so that maintenance can be performed. A pneumatic jack is a hydraulic jack that is actuated by compressed air - for example, air from a compressor - instead of human work. This eliminates the need for the user to actuate the hydraulic mechanism, saving effort and potentially increasing speed. Sometimes, such jacks are also able to be operated by the normal hydraulic actuation method, thereby retaining functionality, even if a source of compressed air is not available

Working Principle

The working medium adopted is compressed air. The compressed air is transmitted through tubes to pneumatic cylinder where power is converted into reciprocating motion. The reciprocating motion is obtained by using an electrically controlled solenoid valve. The input to the solenoid valve is given through the control unit. The reciprocating motion transmitted to the jack through the piston which moves on the cylinder. The jack is placed under the vehicle chassis, where the vehicle to be lifted. The vehicle can be lifted when the solenoid valve is switched. The vehicle over the jack gets the reciprocating motion through the piston which is connected to the jack. Thus using a pneumatic jack the vehicle can be lifted with ease in operation.

- Power can be easily transmission
- Less loss in transmission
- A single compressor can supply power to many pneumatic Jacky.
- Low cost
-] Easy to work and reduces the manual stress

Conclusions

The project carried out by us made an impressing task in the field of automobile and automobile workshops. It is very usefully for the workers to work in the automobile workshop are in the service station. This project has also reduced the cost involved in the concern. Project has been designed to perform the entire requirement task which has also been provided.

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12. Detecting and Recognizing Vehicle License Plate System

Introduction

Traffic control and vehicle owner identification have become a major problem in every country. Sometimes, it becomes difficult to identify vehicle owner who violates traffic rules and drives too fast. Therefore, it is not possible to catch and punish those kinds of people because the traffic personnel might not be able to retrieve the vehicle number from the moving vehicle because of the speed of the vehicle. Therefore, there is a need to develop the system as one of the solutions to this problem.

Working

This system will detect and recognize vehicle license plates from a user's uploaded file. The system can also detect vehicle number plates in real-time, by just clicking on the device's camera. The system will detect and recognize the license plate and if it's been detected, it will be displayed to the user. The front-end involves Html, CSS, and JavaScript and the back-end involves Python. The framework used is Django and the database is MySQL. We have implemented Open CV and Python-tesseract libraries. Python-tesseract is a wrapper for Google's Tesseract-OCR Engine.

Life Cycle

The waterfall model is a classical model used in the system development life cycle to create a system with a linear and sequential approach. It is termed a waterfall because the model develops systematically from one phase to another in a downward fashion. The waterfall approach does not define the process to go back to the previous phase to handle changes in requirements. The waterfall approach is the earliest approach that was used for software development.

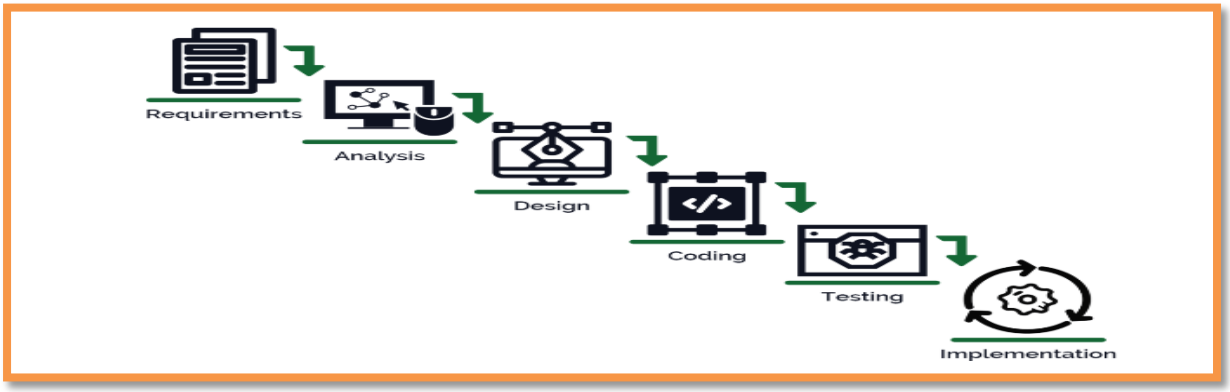

Figure 12.1 Schematic block diagram

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13. 360 Degree Rotating Fire Protection System

Introduction

Large factories, warehouses, and industrial production facilities always run the risk of fires breaking out. Lack of appropriate firefighting measures could result in disastrous consequences and along with financial losses and might even lead to massive loss of human life. Usual fire protection systems installed in buildings have the following disadvantage they spray small amounts of water from each sprinkler which may not be enough to put out the fire.

The sprinklers are not targeted and spray an entire floor or building ruining computers, furniture and paperwork. While this sprayer gun can spray water in desired qty only at fire outbreak point to stop fire without ruining complete office furniture and electronics. This demo version is made to be remote controlled from few meters but future version will operate remotely from fire dept.

Fire monitors and sprayers are an amiable and controllable high-capacity water jet used to deal with large fires. Unlike Fire extinguishers, Fire Monitors are permanently installed and cannot be moved. While traditional fire monitors systems need a human operator to change the direction of the water jet and aim it appropriately, this fire monitor has been equipped with RF control and an onboard camera. There by allowing the user to operate it from a safe distance.

The system makes use of 2 x Motors coupled with a powerful sprayer motor with piping system and onboard wireless streaming camera to run this system. The 2 motors are used to control the nozzle direction movement. The user may use a wireless remote to transmit movement commands. The receiver circuitry mounted on system receives users commands and operates the motors to achieve desired motion. Also the receiver operates the pump motor to start and stop the spray. The sprayer nozzle can also be adjusted to adjust the water spray outlet. The sprayer mechanism is built to operate in a 2 DOF operation to adjust position in x and Y directions and achieve a 360 Degree water spray coverage.

Components

- Pump Motor
- DC motors
- Controller Remote
- Receiver Circuitry
- Piping’s and Nozzle
- Pipe Joints and Fittings
- Bearings

- Rotating Frame
- Base Frame
- Supporting Frame
- Screws and Bolts

Block Diagram

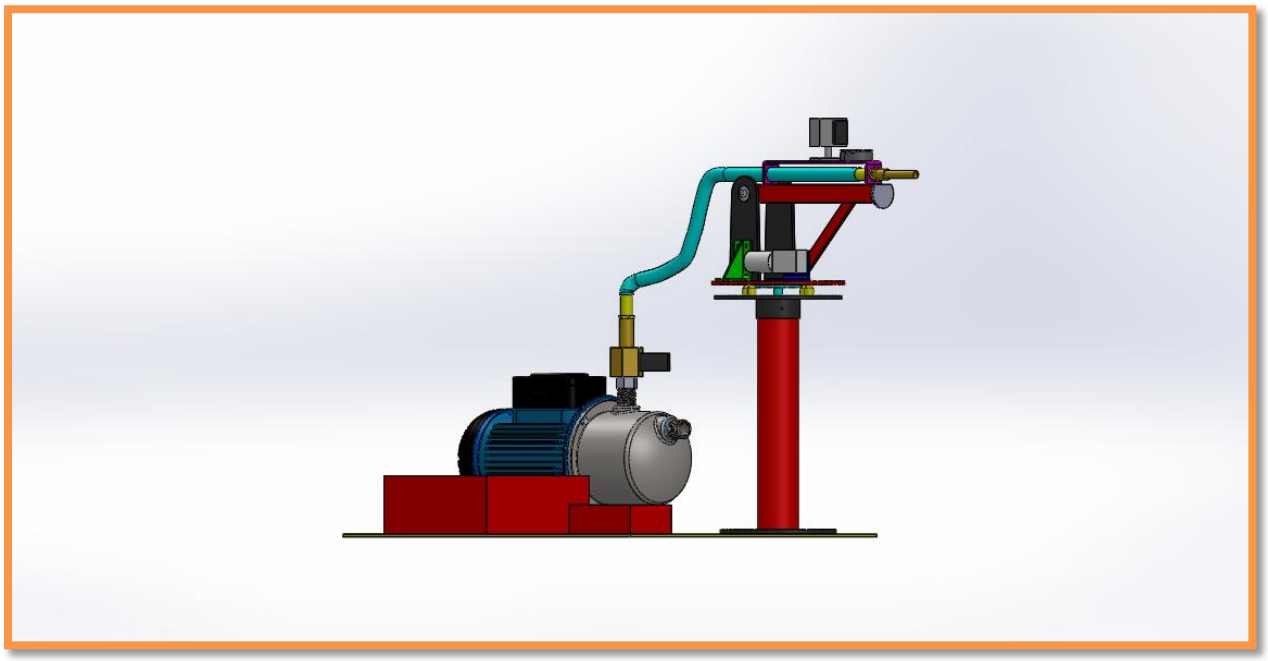

Figure 13.1 Schematic block diagram

Applications

- Useful for controlling indoor fires.
- Can provi**de a low cost fire protection system with limited centralized fire protection.**

Advantages

- Targeted water spraying to avoid water damage in office
- Remote controlled operation ensures operator remains safe
- Adjustable Nozzle for Spray Tuning
- Powerful Long Distance Water Spray

Miss. Archana R Gulli
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14. Ventilator Using Cam Shaft Mechanism

Introduction

COVID19 shocked humankind with a wave of unexpected health crisis in 2019 2020 and 2021 and still continues to plague humankind in some region or the other. As COVID family of viruses majorly affect the lungs while limiting lung capacity and causing breathing problems, ventilator development and research has gained particular importance. Human lungs use the reverse pressure generated by contraction motion of the diaphragm to suck in air for breathing. A contradictory motion is used by a ventilator to inflate the lungs by pumping type motion. A ventilator mechanism must be able to deliver in the range of 10 – 30 breaths per minute, with the ability to adjust rising increments in sets of 2. Along with this the ventilator must have the ability to adjust the air volume pushed into lungs in each breath. The last but now the least is the setting to adjust the time duration for inhalation to exhalation ratio. Apart from this the ventilator must be able to monitor the patient's blood oxygen level and exhaled lung pressure to avoid over/under air pressure simultaneously. The ventilator we here design and develop using a controller that encompasses all these requirements to develop a reliable yet affordable DIY ventilator to help in times of pandemic.

We here use a silicon ventilator bag coupled driven by Stepper motor with single side push mechanism to push the ventilator bag. For this we hereby make use of cam Shaft mechanism to achieve inflation and deflation. We make use of a stepper motor to drive the mechanism. We connect the stepper motor shaft to a cam in order to convert rotary motion into linear motion here. The cam is oval on shape designed to push one end of the pressing arm upwards. The pressing arm is mounted on top of the ventilator bag and connected to joint mechanism in between. This creates a seesaw like mechanism. Now as stepper motor rotates and pushes the arm upwards on one site, it presses against the bag on other end. Now the rate of inflation and deflation depends on the RPM of motor. As per settings provided we vary the motor RPM to achieve desired BPM rate. We use toggle switch for switching and a variable pot to adjust the breath length and the BPM value for the patient. Our system makes use of blood oxygen sensor along with sensitive pressure sensor to monitor the necessary vitals of the patient and display on a mini screen. Also an emergency buzzer alert is fitted in the system to sound an alert as soon as any anomaly is detected. The entire system is driven by a controller circuitry to achieve desired results and to assist patients in COVID pandemic and other emergency situations.

Components

- Stepper Motor
- Ventilator bag
- Valve and Fittings
- Press Arm
- Blood Oxygen Sensor
- Pressure Sensor
- Controller Circuitry
- Hinges
- Shaft and Bearings
- Support Rods
- Pipes and Joints
- Base Frame
- Supporting Frame
- Mounts and Joints
- Nuts and Bolts
- Screws and Connectors

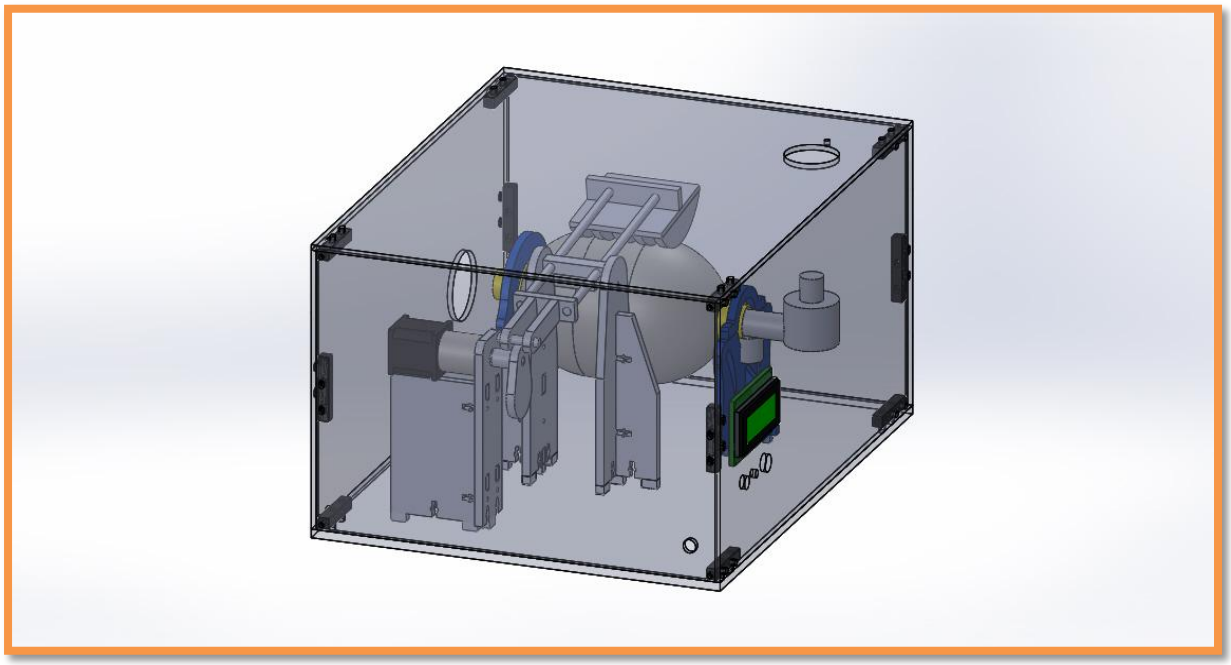

Figure 14.1 Schematic block diagram

15. FEA Analysis of Disc Brake Using ANSYS

Introduction

An automobile disc brake system is used to perform 3 basic functions, i.e. to reduce the speed of a vehicle, to maintain its speed when traveling downhill and to stop the vehicle completely. During these braking events, the disc brake may suffer from structural and wear issues. It is quite typically that the disc brake components fail structurally and/or having severe go down the pad. Thus, this project aims to see disc temperature and to look at stress concentration, structural deformation and make contact with pressure of brake disc and pads throughout one braking stop event by employing commercial finite-element software, ANSYS. We will take down the worth of friction contact power nodal displacement and buckle for various pressure conditions mistreatment analysis software system, depending on the value we can determine the best appropriate material for the disc brake with higher life distance. Temporary structural analysis of the rotor disc brakes concludes that grey cast iron materials is required which improve braking efficiency and provide greater stability to a vehicle.

Finite Element Analysis using ANSYS

Finite element method is a numerical method for solving any engineering problem. Because it is the mathematical representation of physical problems & it gives the approximate solution & also applicable even if physical prototype not available . ANSYS is FEA software developed by ANSYS. ANSYS involves three stages preprocessing, solution & post processing for solving problems. Preprocessing stage involves the preparation of FEM model, element type, real constant, material property & discretization. In Solutions stage ANSYS software automatically generates matrices that describe the behavior of each element, assemble them & computes the unknown values primary field variables such as displacement, temperature etc Procedure for

Finite Element Analysis

Any analysis to be performed by using finite element method can be divided into following steps:

- Discretization
- Choosing the solution approximation
- Forming the element matrixes and equation
- Assembling the matrixes
- Finding the unknown
- Interpreting the results

Meshing of the Disc

The elements used for the meshing of the full and ventilated disc are tetrahedral three dimensional elements with 10 nodes as shown in figure 15.1 .In this reproduction, the meshing was developed in the contact zone .This is important because in this zone the temperature varies considerably.

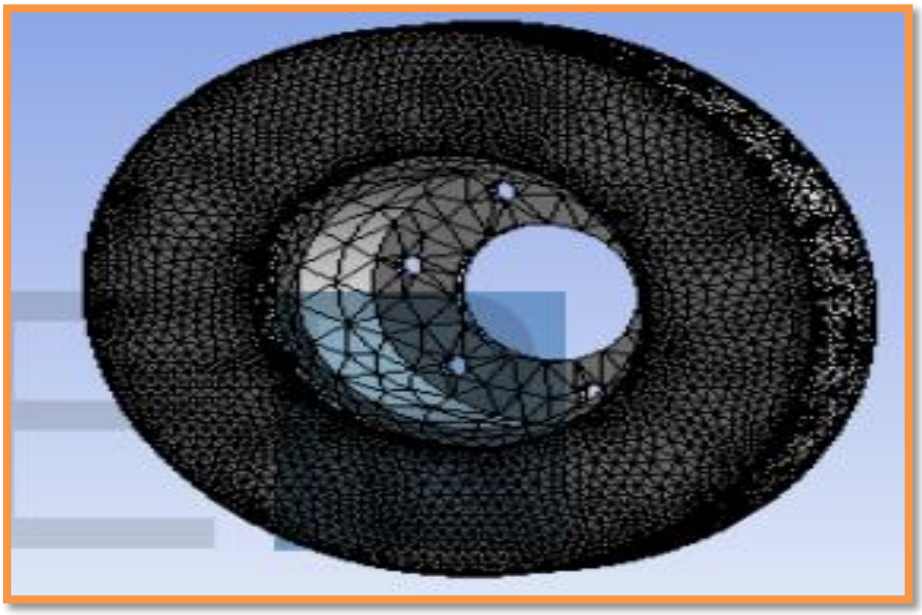

Figure 15.1Meshing of the disc

ANSYS Result

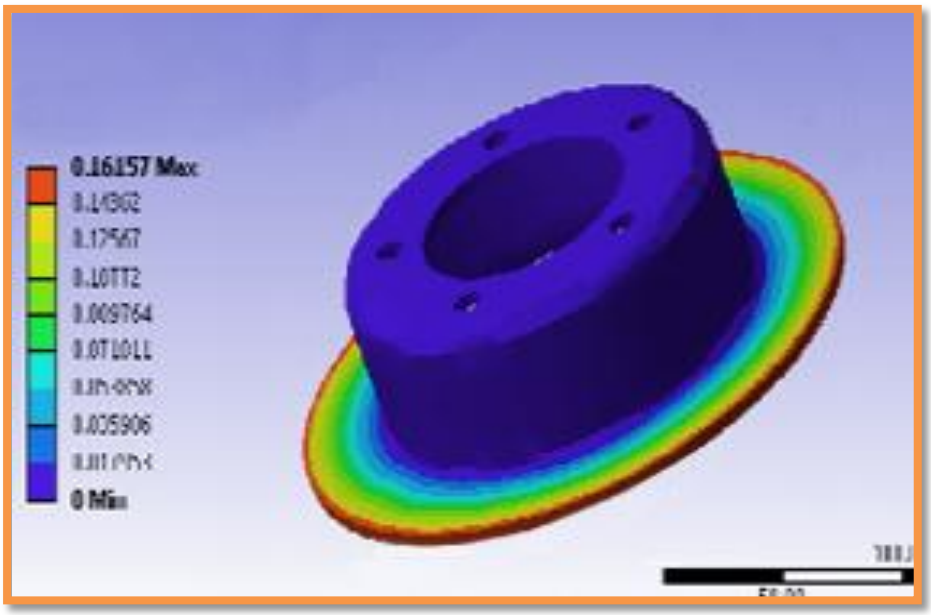

Figure 15.2 Analysis of disc brake

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16. Android Streaming Micro Quad copter with Obstacle Detection

Introduction

Quad copters come in all sizes, from heavy quad copters that spray crops to micro quad copters which can land on the palm of your hand. Here we develop a small micro quad copter with live android streaming and automatic obstacle detection feature. The drone makes use of a remote controller for flight controlling and a streaming camera that can be viewed on android device. Apart from that the drone encompasses obstacle detection and alerting feature to alert incase of obstacle in the front.

The drone receives commands from the user via a remote controller and then operates the motors via flight controller to achieve drone movement. The drone also has safety guards to protect the propellers from damage. We now have an ultrasonic sensor attached to an alerting circuitry for obstacle detection. On detecting any obstacles the ultrasonic sensor detects the object distance from the drone and sounds an alarm buzzer of the object is within a bumping range of the drone. This alerts the user and action can be taken by user to avoid it. Thus we develop an android streaming micro drone that integrates an ultrasonic sensor for obstacle detection and instant alerting.

Principle of Quad copter

The design of a quad copter enables it to move without any other moving parts except the rotors. The speed of the four motors determines all movements of the quad copter. It needs a control system and angular sensor data for continuous stabilization during flight. A quad copter is usually oriented in a plus- or X-configuration, the difference is the definition of forward movement see figure 2.3. This project use X-configuration because of practical reasons regarding the fastening of the smart phone device.

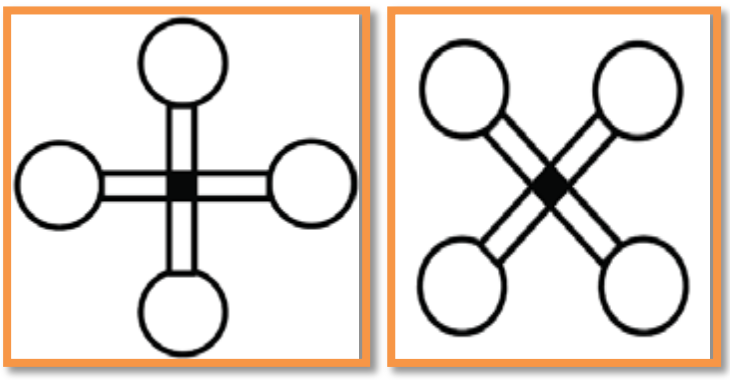

Figure 16.2 Quad copter, plus and X-configuration with the rotors numbered 1-4.

Each motor will add an upward thrust and a torque around its own axis. The motors next to each other have opposite rotational directions, to cancel the motor's rotational torque against each other. In order for the quad copter to hover, it is a necessary but not sufficient condition that all the motors thrusts cancel the gravitational pull.

Block Diagram

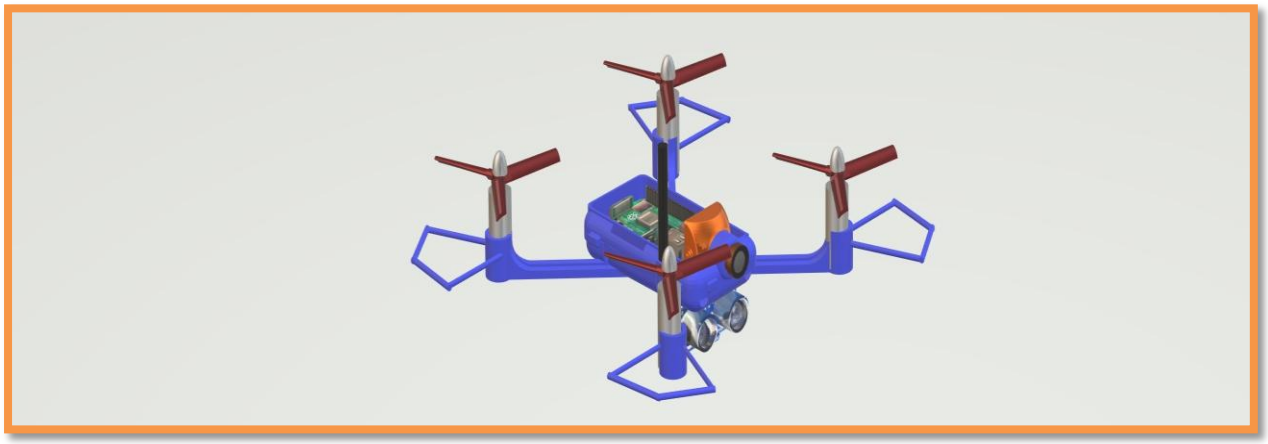

Figure 16.1 Schematic block diagram

Advantages

- Drone Safety
- Instant Alerts
- Live Footage Streaming

Future work

- Image processing. The camera in the smart phone used in this project can take about 16 frames per second at a resolution of 640x480. This is considered enough to do some minor image processing.
- Steer and stream images over a 3G network. It was shown in the report that the 3G network could be fast enough to provide the means to steer the quad copter when it is far away.
- Better hardware. If the frame vibrates a lot from the motors, it will disturb the sensor readings.
- Compensations for the magnetic field generated by the motors. Every motor create a magnetic field that is dependent on the angular velocity it has. This phenomenon disturbs the magnetometer estimation of the angle. However, as the relationship is deterministic, it is possible to compensate for it.

17. Portable Green Energy Mobile Laptop Charging Station

Introduction

People usually run out of phone and laptop charging while travelling. At such times there is literally no way of charging your phone laptop in an outdoor environment. Well we hereby solve this problem with a green energy system using a dual power generator solar plus wind energy charging system for mobile phones and laptop. The charging station is a portable charging station so that it can be easily moved with an anti-theft feature to prevent any theft or mischief with the charging station. The green energy charging station offers a wide variety of features including:

- Dual Power generation Solar plus Wind Energy
- Vertical Windmill for all direction wind generation
- 5V DC USB charging ports for Mobile phones
- 230V AC socket for all Laptop charging
- Inbuilt Inverter and charge controlling circuitry
- Select the type of device and charging duration to activate port for charging
- Automatic Charge Cut-off on Charging Completion
- Anti-Theft Feature – Alert Buzzer Alarm in case of Station Robbery/Damage Attempt

The system makes use of a battery to store the energy generated by both the power generators. This battery supply is now connected through the inverter for usage. The system provides 2 types of outputs. 4 USB outputs for 4 x 5V DC mobile charging ports and 1 x 230V AC port with current limitation for charging laptops only. The system is fitted with 4 wheels for ease of movement making it very portable. It can easily be used near bus stops, garden, historical monuments, zoo, college campus, corporate parks, footpaths, open parking and more. The system is further fitted with anti theft feature to prevent robbers from robbing or miscreants from damaging it. It instantly senses if it is being moved by unauthorized person or is trying to be damaged using impact sensors. In such cases the system instantly sounds a loud alarm sound to alert nearby people authorities without stopping. Thus the system provides efficient mobile and laptop charging outdoors with a whole lot of features.

Solar Wattage: 80 Watts

Windmill: 30 Watts

Block Diagram

Figure 17.1 Schematic block diagram

Applications

- Bus stops
- Garden
- Historical monuments
- College campus
- Corporate parks
- Footpaths

Advantages

- Dual Generation Solar Plus Wind
- Vertical Windmill for All Direction generation
- Laptop Plus Mobile Charging
- No External Power Supply Needed
- Inbuilt Inverter System
- Anti-Theft Feature

Disadvantages

- Needs Adequate Sunlight to Operate
- Requires timely Maintenance

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18. Water Float Solar Power Panels with Sun Position Tracing

Introduction

Solar power is the future of renewable power generation. The problem with solar panels is that they use up a lot of space on rooftops or open areas and are difficult to mount, maintain and clean regularly. Additionally the solar panels is moved as per sun position can generate upto 40% more solar power. We here by propose a new kind of solar panels that can be mounted on water bodies like lake pools so that they don't occupy any land space. Additionally we introduce an innovative sun tracker and panel movement system using hydraulic mechanism to move the solar panels as per sun position and generate more power.

The Floating solar panel power generator introduces following key aspects

- Does not occupy space on land
- Efficiently floats on water 24 Hours
- Sun Position Tracking throughout the day
- Automatically adjusts solar panel position using hydraulic system
- Reduces evaporation in water bodies by covering them and keeping them cool
- Water is in-turn used to keep the solar panels from overheating
- Easy to clean solar panels using Lake/pool Water

The system makes use of a solar sensing circuitry with a micro hydraulic power system. The circuitry senses the voltage and power efficiency at particular position. The hydraulic motor is then used to drive the fluid movement from one cylinder to another. As the liquid level moves between 2 cylinders, the pistons linked to each cylinder vary in height resulting in a change in the solar panel rotation. This allows for increased efficiency of solar panel while at the same time incurring a very negligible power usage required to adjust solar panel movement. Also it helps environment and save water by minimizing evaporation.

Solar Tracker

This creates a substantial diminution in the expenses and the preservation of the collectors. The knowledge of the movement of the sun throughout a season and different hours of the year is essential to enable maximum captivation of solar energy. The Sun chart for Hyderabad is shown below Through the use of the chart; it is possible to ascertain the position of the sun at different times and seasons so that the panel can be fixed for maximum output.

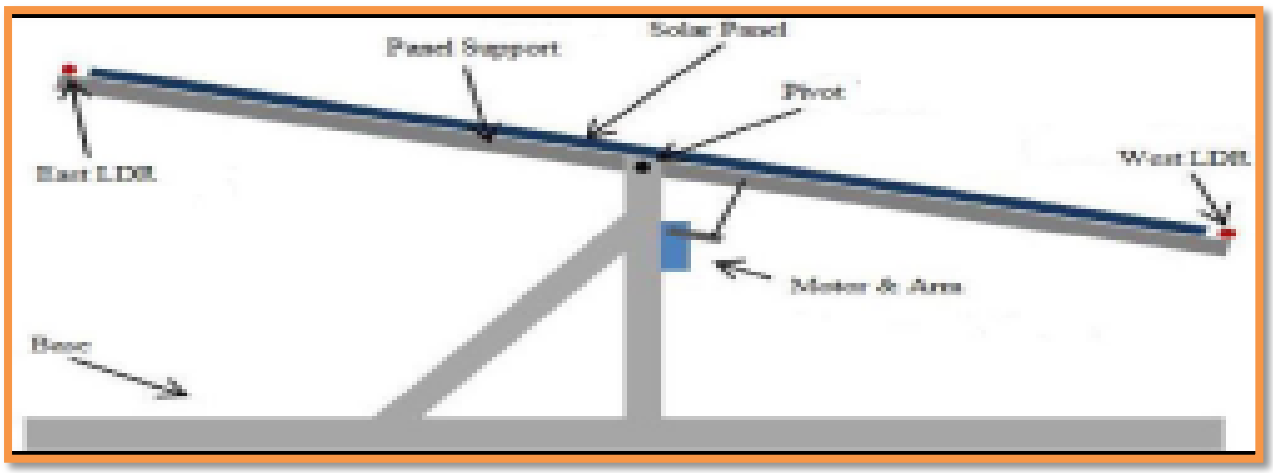

Figure 18.1 single axis trackers

Block Diagram

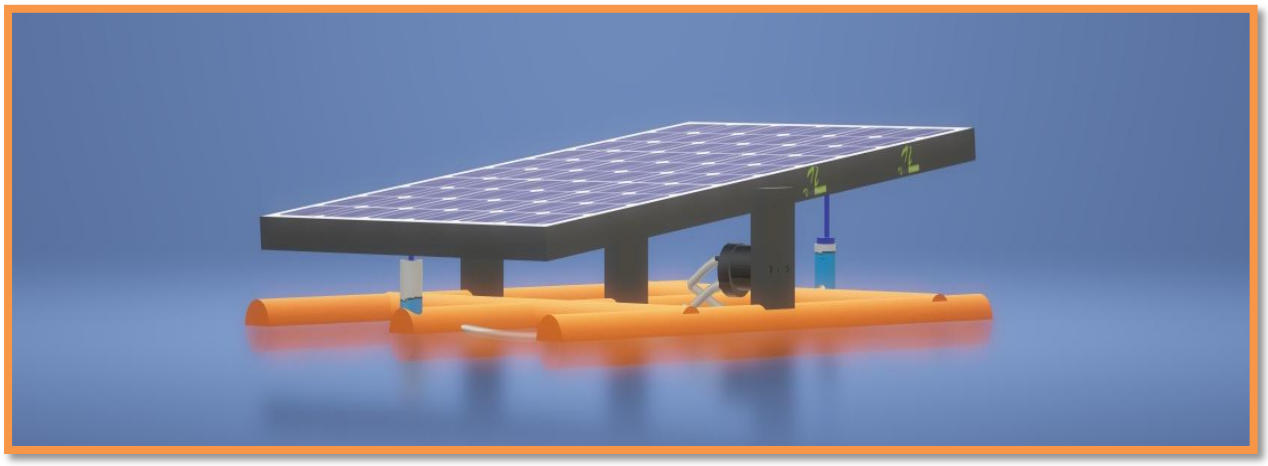

Figure 18.2 Schematic block diagram

Future Scope

In a decade, solar energy has gone a long way. In 2010, the worldwide market was limited and heavily reliant on government subsidies in countries like as Germany and Italy. This year, more than 115 gigatonnes (GW) of solar will be deployed worldwide, which is more than all other generating methods combined. It is also becoming increasingly affordable, particularly in sunny locations where it has already become the least expensive source of new power generation. In the next years, technological advancements will ensure that solar becomes even more affordable. Solar might become the most important source of energy for power production in a vast area of the planet by 2030. This will have a favorable effect as well With relation to the environment and climate change.

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19. Pneumatic Sugarcane Bud Cutter Machine

Introduction

The main objective of our Project is to perform job holding and cutting operations effectively with less human effort by incorporating a machine with pneumatic power. This also takes less time due to its quick action. This pneumatic Sugarcane bud-cutting machine aims to provide better and faster bud cutting operations with less human effort, thereby promoting agricultural activities of sugarcane cultivation. Nowadays, almost all manufacturing process is being atomized in order to deliver products at a faster rate. To achieve mass production, the automation of predefined tasks is necessary and is made mandatory in the current operating conditions of the industries.

One alternative to reduce the mass and improve the quality of seed cane would be to plant excised axillary buds of cane stalk, popularly known as bud chips. These bud chips are less bulky, easily transportable and more economical seed material. The bud chip technology holds great promise in the rapid multiplication of new cane varieties. The sowing of buds of grown Sugarcane ensures the growth of new Sugarcane, thereby increasing the production rate and decreasing the damaging rate of the Sugarcane. The left-over cane can be well utilized for preparing juice or sugar, or jiggery.

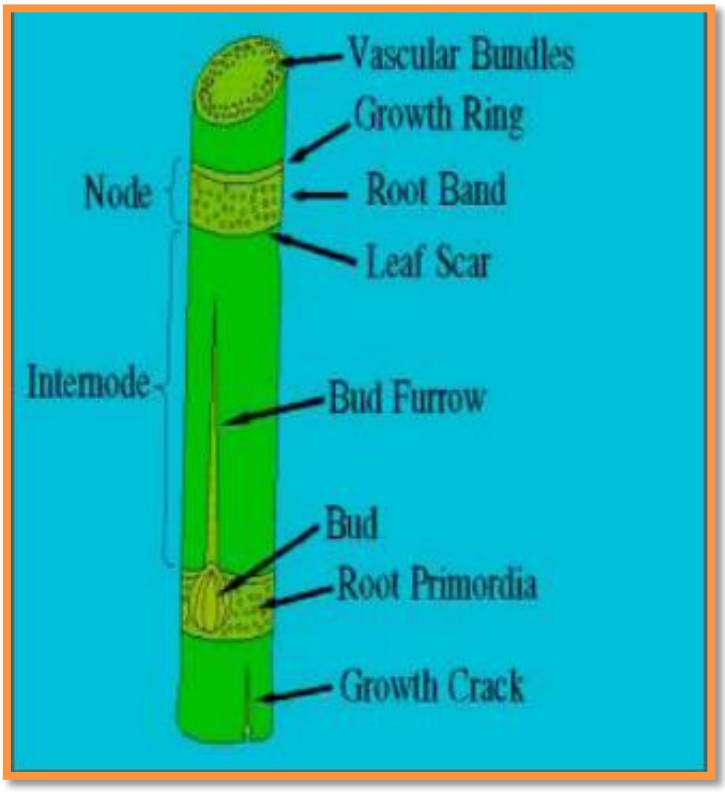

Figure 19.1 Representation of bud in Sugarcane

Design of Bud Cutting Machine

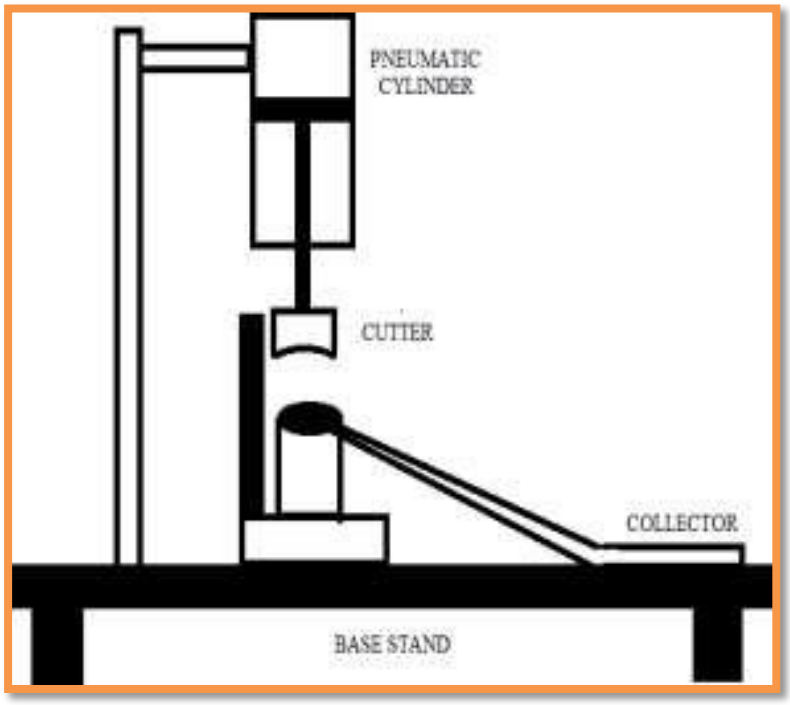

Figure 19.2 Design of Pneumatic sugarcane bud cutting machine

Working principle

The compressed air from the compressor is used as the force medium for this operation. The machine uses a pneumatic double-acting cylinder and foot valves. The arm from the compressor enters the flow control valve. The controlled air from the flow control valve enters the foot valve. The function of foot valves is to control the extension and retraction of air from the cylinder at the correct time interval. The 5/2 foot valve is used. In one position, air enters the cylinder and pushes the piston so that the cutting stroke is obtained. In the next position, air enters the other side of the cylinder and pushes the piston return back so that the releasing stroke is obtained. The speed of the cutting and releasing stroke is varied by the human foot position.

Conclusions

The Project carried out by us made an impressive task in the field of small-scale industries related to agricultural activities and automobile maintenance shops. It is very useful for workers to work in lathes and small-scale industries. This Project will reduce the cost involved in the concern. The speed of the cutting and releasing stroke is varied from human to human.

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Program Educational Objectives (PEOs)

The Graduates will be able to

PEO1: Acquire core competence in Applied Science, Mathematics and Mechanical Engineering fundamentals to excel in professional career and higher study

PEO2: Design, demonstrate and analyze the mechanical systems which are useful to society.

PEO3: Maintain professional & ethical values, employability skills, multidisciplinary approach & an ability to realize engineering issues to broader social context by engaging in lifelong learning.

Program Specific Outcomes (PSOs)

PSO1: Able to apply the basic principles of Mechanical Engineering in various practical fields to solve societal problems by engaging themselves in many state/national level projects.

PSO2: Able to analyze and design basic mechanical system using relevant tools and techniques.

PSO3: Able to resolve contemporary issues of industries through industry institute interaction and alumni social networks

Program Outcomes (POs)

PO1: **Engineering knowledge-** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: **Problem analysis-** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: **Design/development of solutions-** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: **Conduct investigations of complex problems-** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: **Modern tool usage-** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: **The engineer and society-** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: **Environment and sustainability-** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: **Ethics-** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: **Individual and team work-** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: **Communication-** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: **Project management and finance-** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12: **Life-long learning-** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

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