ISSN: 0971-1260
Vol-22-Issue-17-September-2019

Design, Analysis and Fabrication of Hydraulic Tilting Table For Go-Kart

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Abstract
This is an experimentalapproach to develop a hydraulic tilting table which can be used to lift the go-kart to a certain angle to check for any anomalies in the design and previous iterations of the tilting table made use of a pivot system where the tilt was achieved through a belt attached to one end and when the belt was pulled, the tilting table tilts the go-kart placed on its platform to a desirable elevation. The addition of a hydraulic system would eliminate any mechanical work input by humans and the tilting motion of the table can easily have achieved through the press of the buttons and also it is quite comfortable to stop the tilt at any angle in the range of the tilt and hydraulic system would not collapse as fluid is incompressible. This proves to be a major advantage compared to the previous design as some sort of stopping mechanism had to be fashioned in the design to stop the tilt at a desired angle.

1. Introduction

A hydraulic system is a fundamental to give the table a tilting function. Hydraulics is the science of using compressed fluids to do work [1]. A hydraulic system can be broken down to four parts; power device like a pump and motor, piping for fluid flow, control valves and fluid powered motor such as cylinders, fluid motors and actuators. As the actuator which is mounted between the plates of tilting machine moves with the help of a motor, lifting the machine to the required angle. The angle is measured using a stepper motor [2].

2. Literature Review

This study analyses the design of a tilting table for automobiles at mechanical workshops. The design of such system arises at the time of maintenance especially when the underbody of the automobile needs to be inspected and worked upon. Traditional techniques such as using manual labour to lift the automobile and using wooden bars and metal rods to hold the automobile in position often leads to human fatigue and also involves a great amount of risk to workplace safety of the worker. The study of selection and designing of the components were based on the type of application from machine design and fluid principals and basics laws [4]. This study analysis the Construction of tilt table with high loads a design for a tilt table has been presented. The construction is iterated to a working concept by help of CAD-software and calculation programs such as Ansys for structural mechanics and Hopsan for the hydraulic system. The construction has the capability to tilt 20 tonne sheets with the height and width of 600 mm and 1300mm respectively from 0_ to 55_ in 30 seconds using three hydraulic cylinders and a system pressure of 18 Mpa. Today there are no commercially available tilt table with this capacity [5]. Based on the study of the two research articles authors worked on the hydraulic tilting table for Go-Kart by keeping the main objectives are, to contribute design and analysis of mechanism of tilting machine. the analysis of load on tilting machine to make the machine safer and failure resistant, cost of production should be reduced to maximum level, the machine should be able to carry the load of 150kgs maximum. the use of angle measurement sensors to obtain the lifting angle of up to 50º. it should save time and human labour

3. Components used.

3.1 Hydraulic Power pack

The Hydraulic power pack consist of reservoir which can store the hydraulic fluid, regulator is used to control the amount of pressure can be supplied to the pressure control valve, Pressure relief valves for application line to actuate the actuators by energizing the motor and pump. The main function of the hydraulic pack gives multiple option of valve connection, and permitting operator to connect them to different control valves to actuate the verity of machines.

3.2 Hydraulic Reservoir

The hydraulic tank which quite simply as the name suggests holds the hydraulic fluid or oil that is cycled throughout the system. The size of hydraulic reservoirs varies in different sizes depending upon the Motor and pump capacity.

3.3 Regulator

The regulators keep the amount of pressure that the hydraulic power pack delivers

3.4 Motor

The motor in a hydraulic power pack is present to power the hydraulic pump.

3.5 Pump

The pump in a hydraulic power pack performs by converting mechanical energy to fluid energy by two actions, i.e. First, it creates a vacuum at the pump inlet port and through full of atmosphere pressure forces fluid from the reservoir into the inlet line and then to the pump. It then brings the fluid to the pump outlet and pumps it into the application line.

3.6 Directional Control Valve (DCV)

Direction Control Valve- It consist of a spool that is either operated mechanically or electrically. The situation of the spool allows or restricts the flow, thus controlling the flow of the fluid.

Solenoid operated DCV- Solenoid operated DCV work on the principle of electromagnetism, i.e. the solenoid uses electric current to generate a magnetic field. When the magnetic field is generated, it accelerates a cylindrical ball which is present in the solenoid valve to strike a plunger which is internally grooved according to the specification of the design. Depending upon the position of the plunger, the flow of fluid takes place in that particular direction.

In this project we are using a solenoid operated 4/3 Directional Control Valve and its maximum operating pressure is 250kgf/cm^2. The 3.1 shows the 4/3 DCV, first fig one P-T Connected to a crossly, second one Pump release to the tank and third one neutrally locked.

ISSN: 0971-1260
Vol-22-Issue-17-September-2019

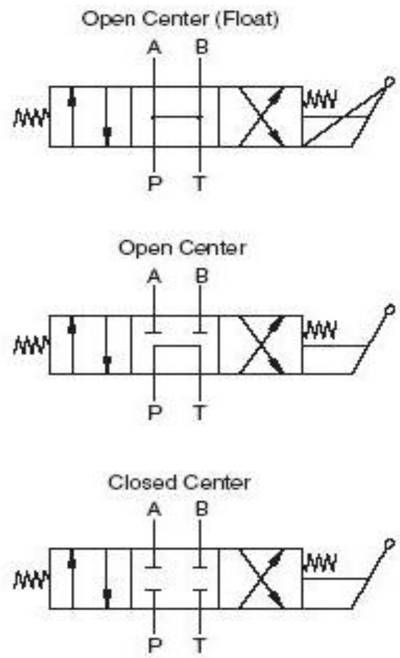

Fig.1. 4/3 Directional Control Valve [3]

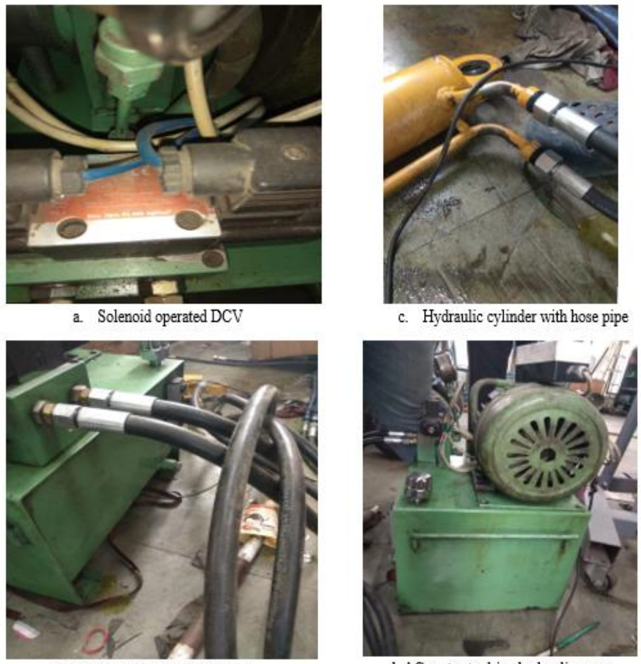
a. Solenoid operated DCV
c. Hydraulic cylinder with hose pipe
b. Single station manifold block
d. AC motor to drive hydraulic pump

Fig. 2. Hydraulic Power Pack assembly

3.7 Hydraulic Hose

A hydraulic flexible hoseisprecisely designed to carry hydraulic fluid to or between hydraulic components, valves, actuators and tools. The specification of the hose pipe that we used for the project is a 3/8-inch pipe having an operational capacity up to 330 bars. We also used hose pipe connectors of ¼ inch at pump end and ½ inch at cylinder end and adapters to make necessary adjustments to the hydraulic circuit.

3.8 Hydraulic Manifold Block

The manifold that controls fluid flow between the pumps and actuators and other components in a hydraulic system. Fig 3.22 shows the single station manifold block where pressure line and tank line.

4. Research Methodology

When we were assigned this project, we went through the basic terminology and the working knowledge, key terms and principles of working of the hardware that we need to use and the also made a list of the components that we need to procure.

We then made the necessary design calculations to help us determine the machinery and equipment that we need to use for the working of our project. To further help the project, we designed the prototype model of the tilting table in a CREO, which is a Computer Aided Design (CAD) software. In this process, we designed all the individual parts by drawing them to their individual specifications and then later assembled them into a single working part. Also, it was possible for us to conduct a force analysis on the designed part so as to analyse any structurally weak components or points. These components and points are then redesigned or repurposed to the best of its ability so that the tilting table performs its function in a proper manner [6].

After the approval of the prototype design, we then started the procurement of parts and components that we would be needing to build the tilting table. We went to the markets and analysed the various options available to us in terms of the quality, quantity and pricing. Carefully planning the number of components that we need to buy; we went through with the purchase.

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Vol-22-Issue-17-September-2019

Some components that were purchased are in their raw form and need to be processed and fabricated so as to be assembled on to the tilting table. The various process that were involved in this stage were cutting, grinding, welding etc. Along with these processes, the hydraulic components need to assembled, i.e. the inlet and outlet pipes need to be connected to their respective ports on the hydraulic power packs. We also checked the condition of the hydraulic components to check if any leakages were present.After the fabrication of the components, the hydraulic system was placed in to the frame of the tilting table and was secured in its position by using appropriate fasteners.

5. Design Calculations

-Cylinder bore= 45 mm, -Stroke= 230mm, -Forward. Stroke time = 21 s
-Reverse Stroke= 13 s, -Cycle time = 34 s, -Operating pressure = 250kgf/cm^2=245.16 bar
-Efficiency of the pump = 0.7

5.1 Volume of the cylinder

Volume of the cylinder=$\frac{\pi}{4} \times d^2 \times$ length of strok=3657992mm^3 = 3.65 litres (approx.)

5.2 Flow rate (Q) or Discharge

$$\mathbf{Q = \frac{Volume\ of\ cylinder}{time(in\ sec)} = \frac{3.65}{21/60}\ lit/min = 10.45\ lit/min}$$

5.3 Motor Power Rating

$$H.P = \frac{K.W}{0.745} = \frac{Q(LPM) \times P(bar)}{600 \times \eta} \quad = \quad H.P = \frac{10.45 \times 245.16}{600 \times 0.7} \times 0.745 = 4.54$$

Design Analysis

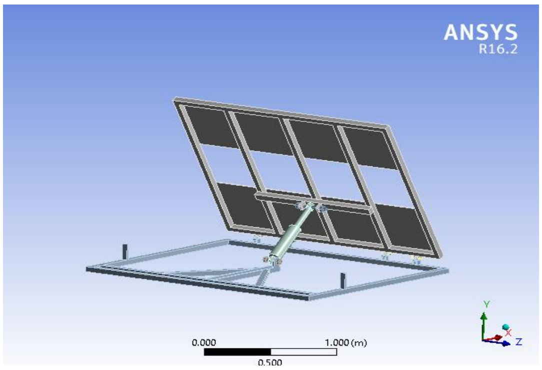
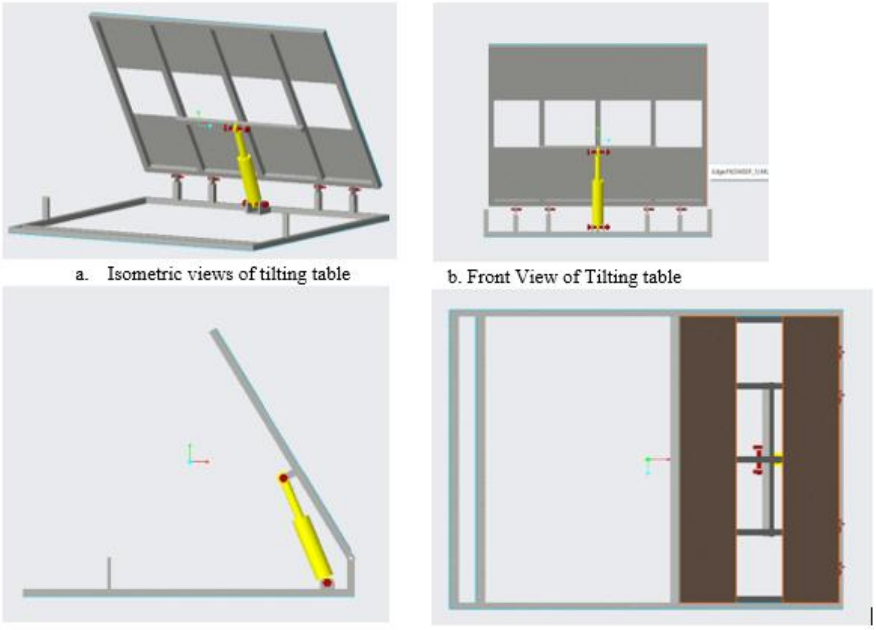


Fig. 3. 3D Model of Tilting table

Table. 1. Structural steel constants considered for the analysis

Density of Material	7850 kg m^-3
Coefficient of Thermal Expansion	1.2e-005 C^-1
Specific Heat	434 J kg^-1 C^-1
Thermal Conductivity	60.5 W m^-1 C^-1
Resistivity	1.7e-007 Ohm



a. Isometric views of tilting table

b. Front View of Tilting table

c. Side View of Tilting table

d. Top View of Tilting table

Fig. 4.Orthographic View of Tilting Table Model

6. Result and Discussion

Total Deformation Analysis:

As figure 5displays the deformation due to application of 150 kg load, the maximum deformation of 0.001107 meters occurred at the left edge of platform. This is due to existence of maximum bending torque generated at this edge on account of placing the net load over this surface.

Maximum Principal Elastic Strain Analysis

Maximum Principle Elastic strain of 0.0001040 occurs at the longitudinal box members of Platform as can be seen from figure 6 near supporting joint of Hydraulic piston. Strain is higher in these members could be possibly seen as because of the relatively higher concentration of stresses and the edges and since these members are hollow the are susceptible to change in dimensions upon loading.

Maximum principle stress

From figure 7 average Principle stress of 755 Pa was generated on entire Table and Maximum stress of 2352 Pa is located at the members near the pin joint of hydraulic and platform.

Maximum Shear Stress

Average shear stress of 1972 Pa is generated at pin joints with nut and bolt displayed in figure 8 as these could be generated due to transmission of lifting force on the table hinges results in higher shear stress at this point.

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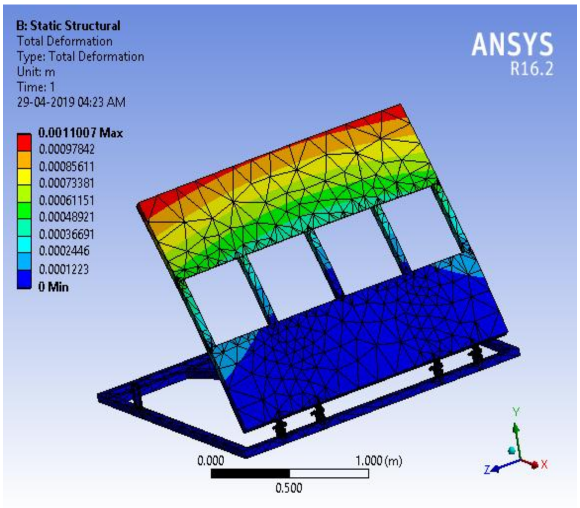

Fig. 5. Total deformation analysis

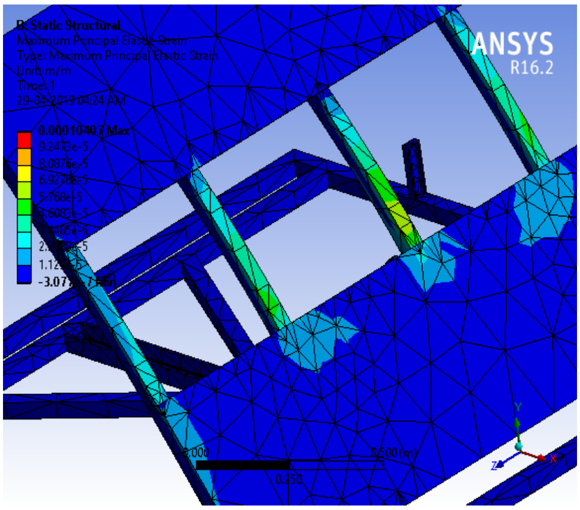

Fig. 6. Maximum Principle elastic strain analysis

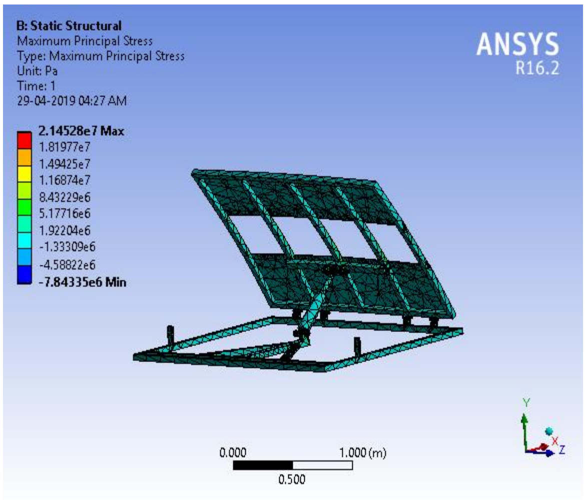

Fig. 7. Maximum principle stress analysis

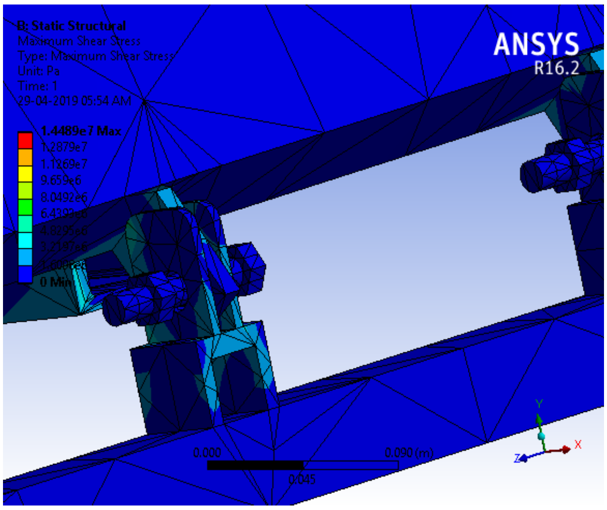

Fig.8. Maximum shear stress analysis.

7. Conclusion

In this experiment, we have automated the tilting table for the go-kart by adding a hydraulic system to the design and also used a microcontroller and sensors to measure the angle of the rotating part of the tilting table. In this experiment we also learnt the basics of the different hydraulic components used in the project and also understood the principle of working of those components. With the help of this hydraulic tilting table, the effort put in by a human is reduced and the safety of the workplace is also increased by a great deal. By the use of sensors and micro-controller, we have introduced the ability of automation to the project which has become the basic requirement of a machinery in this day and age to be used in industrial applications. Also, due to the exposure that we got from surveying the markets, we got to know the different variety of components and parts available for wide range of configurations to the hydraulic tilting table.

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