Cylindrical Robotic Arm for Multipurpose Operation

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ABSTRACT

Mankind has always strived to give life like qualities to its artefacts in an attempt to find substitutes for himself to carry out his orders and also to work in a hostile environment. The popular conception of a automaton is of a machine that appears and works sort of a creature.
One style of automation ordinarily employed in business could be a robotic manipulator or just a robotic arm. It is an open or closed kinematic chain of rigid links interconnected by movable joints.
We have to develop a mechanism for performing operation in cylindrical volume. So a cylindrical robot is developed where the tool can cover a cylindrical volume for working. The input to the robot is given through a stepper motor whose shaft is connected to the pinion. The gear meshed to the pinion holds the vertical assembly with screw. A carrier plate supports the horizontal assembly having a screw, DC motor and a stepper motor. The DC motor holds the tool of operation through a motor coupling.
The cylindrical robotic arm was performing operations with desired specifications. Finally we were able to develop the mechanism which was able to perform operations in required space

Keyword: *Kinematic chain, automation, Mechanism, Cylindrical volume, Vertical assembly, horizontal assembly.*

1. INTRODUCTION

Robotics is an science which is a combination of machine tool, electrical, electronics and computer science. It includes such seemingly diverse fields as machine design, control theory, micro-electronics, computer programming, artificial intelligence, human factors, and production theory. For robots
• Motors are the muscles
• Computer the human brain
• Robotic vision is the eye

1.1 Coordinate Systems/Frames

Three major coordinate systems used in the study of robotics are:

- Cartesian
- Cylindrical
- Spherical

1.2 Cylindrical coordinate frame:

A three dimensional point “A” in a cylindrical co-ordinate frame is considered to be located on a cylinder of a radius “R” with a height “Z”. The third piece of information required to define the point comes from an angle θ on the XY plane.

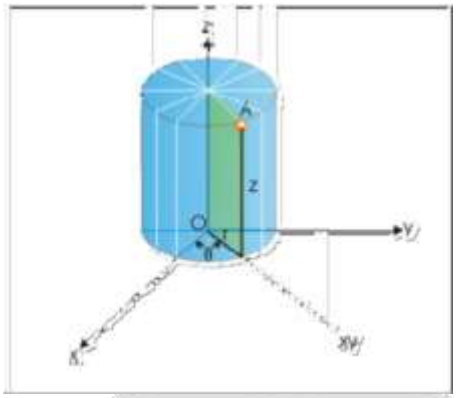

Fig. 1.1 Cylindrical coordinate frame

1.3 Problem Statement

The various operation required multiple manpower to perform it on single production line which is time consuming and may decrease the production rate. We have to perform various operation on single job which require tools to perform it. So a system performing multipurpose operations like drilling, fitting, grinding, etc. needs to be developed.

1.4 Objective

By selecting the cylindrical shape for robot we can perform various operation on production line buy using its 360 deg motion and vertical motion which can hold multiple tools to perform the operation. The robot just don't show performance on single line but it can also perform on another line which saves the lot of time and increase the production rate.

A shortage of skilled workers and an increase production have made it necessary to automate the assembly of segments. A number of different types of automatic segment assembly system have been developed, including hex-head bolt, both-nut bolt, medium-diameter, and large-diameter assembly systems. The objective is to automate the bolt tightening process in fixtures in the mechanical industry especially in the assembly units. Also it should serve purpose of adjusting different tools on it for multipurpose. The bolt tightening robot consists of bolt tightened that tighten bolts using DC servo motors, and a positioner that uses servos.

1.5 Methodology

This study/project would be consisting of following chronological step of working:

1. Design stage
2. Manufacturing Stage and fabrication of assembly
3. Electronic components
4. Working
5. Conclusion

2. DESIGN STAGE

2.1 Calculation Data of Screw:

- This power screw is designed to raise or drop the load of 200 N, its own weight & miscellaneous load i.e. 50 N considered.
- The Power selected for this application is a mild steel screw, M10 (P=1.5 mm), which is a standard material

available in market. To prove that our selected is material is safe we are going to measure the factor of safety available for our application.

1. Mean Diameter (d_m) = 9.25 mm
2. Helix Angle (α) = 3.312^o
3. Friction Angle (φ) = 11.3^o
4. Effort Required to Raise the Load against Thread Friction (P_r) = 52.14 N.mm
5. Torque Required to Raise the Load against Friction (T_{tr}) = 241.15 N.mm
6. Torque Required to Overcome Collar Friction (T_c) = 461.25 N.mm
7. Torque Required to raise the load (T_r) = 0.702Nm
8. Hence a motor of torque rating 1Nm and 100rpm is used for the above application.

2.2 Calculation data of shafts:

Mild steel shaft is used due to it's mechanical properties.

By assumption,

Length of vertical pillar = 700mm,

Length of horizontal arm = 600mm.

Stresses produced in the arms are majorly bending stresses and they are maximum at extreme position of arm.

We need to calculate the mass carried by the arms at the end of horizontal arm.

Assume total mass of actuator and accessories at the end of arm = 1 kg

So, m= 1 kg = 10N (approx.)

d=2mm

which is very less as per the design,

but in actual practice we may use rods of any diameter as per the practical concern.

2.3 Calculation data of Gear Pair:

Gear and pinion are of same material(mild steel) so we design the pinion

We have constant thickness of mild steel plate. Hence we have to take wear strength criteria of gear pair instead of beam strength of pinion to design the gear pair.

- No. of teeth on pinion = 18
- No. of teeth on gear = 27
- Circular pitch = 23mm
- Centre Distance = 136mm
- PCD of pinion = 110mm

- PCD of gear = 164mm
- Thickness of tooth = 11mm
- Length of tooth = 11mm
- Face width of tooth = 4mm

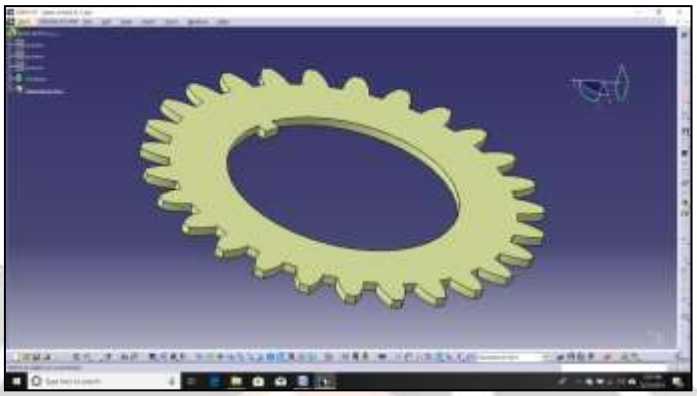

Fig 2.1 Gear

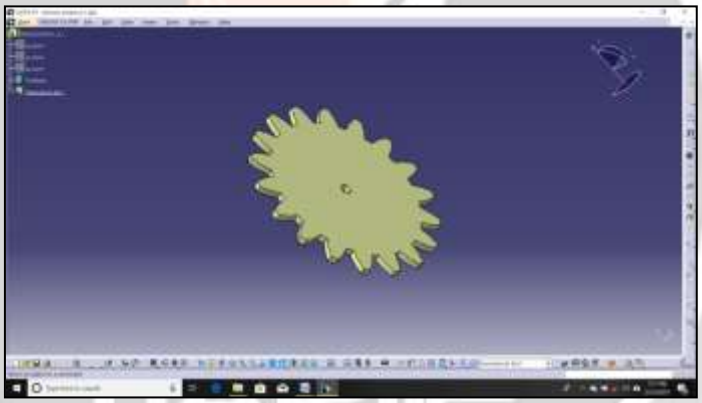

Fig 2.2 Pinion

3. MANUFACTURING STAGE AND FABRICATION OF ASSEMBLY

3.1 Gear and Pinion: The pinion is mounted on shaft of stepper motor. It drives the gear which further drives the shafts on vertical assembly.

Material of pinion: Mild steel

Material of gear: Mild steel

No. of teeth on pinion: 18

No: of teeth on gear: 27

Process of manufacturing: Laser cutting

3.2 Fixed Collar: It is bolted to the fixed plate through allen bolts. It holds the bearing which further holds the moving collar.

Material: Mild Steel

Process of manufacturing: Turning on lathe

Fig 3.1 Fixed collar on base plate

3.3 Moving Collar: Holds the gear at proper position.

Material: Mild Steel

Process of Manufacturing: Turning

Fig 3.2 Moving Collar

3.4 Base Plate: Supports the entire structure

Material: Mild Steel

Thickness: 4mm

Process of manufacturing:. The mild steel plate is cut to required dimension by laser cutting machine. Further with the help of bending machine the base plate is bent in required profile hence satisfying its functional requirement

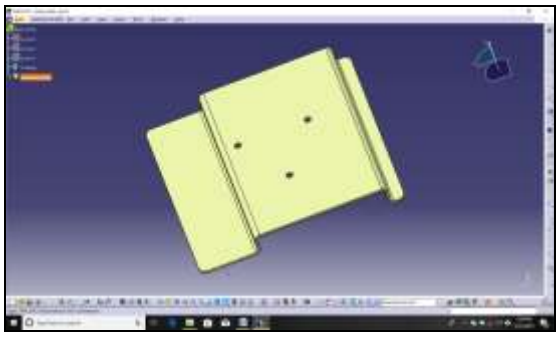

Fig 3.3 Base plate

3.5 Middle sliding plate: It forms part of both vertical as well as horizontal assembly. Two screws are passed through two holes at it's centre.

Fig. 3.4 Moving Plate

Material: Mild Steel

Process of manufacturing: Mild steel plate of thickness 4mm was laser cut and then bent to required form by bending machine.

3.6 Fabrication of assembly:

Step 1: Arrangement of base

Step 2: Installation of fixed collar and moving collar.

Step 3: Mounting of gear and pinion

Step 4: Fabricating of vertical assembly

Step 5: Fabricating horizontal assembly

Step 6: Installation of 3 stepper motors and 1 DC motor.

Step 6: Lubrication of required parts.

Fig 3.5 Assembly of robotic arm

4. ELECTRONIC COMPONENTS

The control of robot is through microcontroller and other electronic components.

Following are the components used in the arrangement for required working of mechanism.

1. SMPS: Switched mode power supply. It converts AC supply from mains To DC

2. Motor drivers: They act current amplifiers as they take low current and supply high current signal. Also they provide fractional steps to motors.

3. Stepper motors: They provide motion in steps by converting digital pulses into mechanical motion. They provide motion to two screws in steps.

4. DC motor: They convert DC electrical power to mechanical power. Here the tool is installed at DC motor shaft through a motor coupling.

5. Arduino Uno: It is the micro-controller which acts as the controlling element of the system. The program installed in it governs the movement of motors.

5. WORKING

When the supply through arduino is given, firstly the stepper motor attached to pinion moves in a small step. Hence a circular motion is given to the assembly. Now the stepper motor attached to horizontal screw moves in given angle thus moving the screw in horizontal direction. Further the stepper motor attached to vertical screw moves giving the system a vertical motion. In this way the DC motor attached on horizontal assembly is given the required position in space. This DC motor have the work tool for performing required operation (here bolt tightening). Again the motors move and the work tool is retracted from it's position and the work continues. It covers a cylindrical volume where working is possible.

6. CONCLUSIONS

The system was able to perform the work with required specifications. Following major conclusions were made:

1. The robot was evenly tightening the bolt on work piece through the bolt tightening tool attached on DC motor shaft.

2. The system was also able to perform other operations when the tool was changed.

3. This mechanism was performing functions in a cylindrical volume around it.

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