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DESIGN ANALYSIS OF PICK AND PLACE ROBOT WITH MECHANICAL GRIPPER

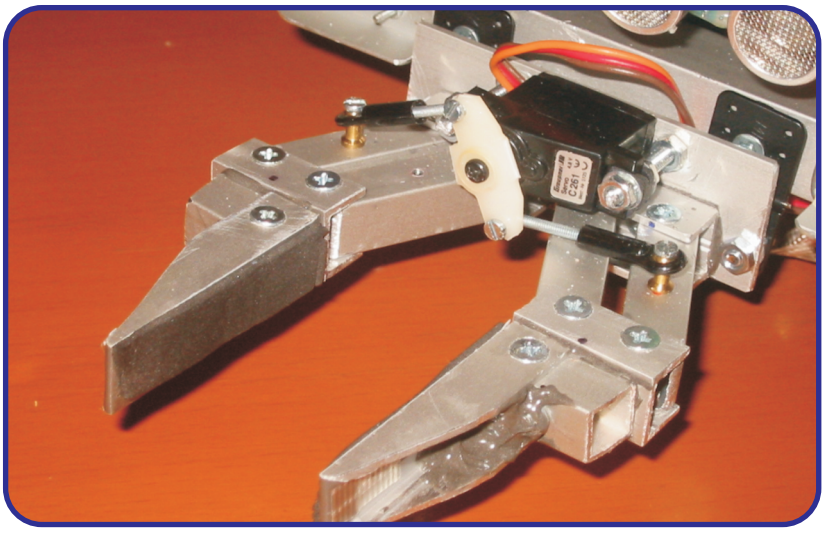
Vaibhav V Kulkarni
Shrimati Savitribai Phule Pune University,
MIT College of Engineering,Kothrud, Pune.

Vaibhav V Kulkarni

ABSTRACT

Mankind has always strived to give life like qualities to its artifacts in an attempt to find substitutes for himself to carry out his orders and also to work in a hostile environment. The popular concept of a pick and place robot with mechanical gripper whose arm looks and works like a human arm is one of those attempts. In this paper we have outlined the design procedure and analysis of prototype of pick and place robot with mechanical gripper. We have described a simple process to design pick and place robot using pulley mechanism to actuate its arm. Depending on requirement of weight to be lifted easy changes can be made to this robot using simple relations.

KEYWORDS : Design of arm, analysis, mechanical gripper.



I.INTRODUCTION :

In this highly developing society, time and man power are critical constraints for completion of task in large scales. Automation is playing an important role to save human efforts in most of the regular and frequently carried out tasks. One of the major and most commonly performed works is picking and placing of jobs from source to destination. In this age of competition to make our significance it is important to upgrade our way of working day by day. This paper describes the design and analysis of simple pick and place robot which can be made at low cost and can be used efficiently in small workshops and warehouses.

This robot is made such that it can concentrate on simple repetitive tasks, which tend not to require high precision. But with certain modifications in design the required precision can be achieved.

Our objective is to produce a simple pick and place robot model with wooden chassis, four wheels, electrical motors and wired remote control. The gripper is made of worm and worm gear

mechanism which would facilitate further upgrading and adaptation.

LITERATURE REVIEW

Engineers and inventors from ancient civilizations, including Ancient China, Ancient Greece and Egypt attempted to build self-operating machines, some resembling animals, birds and humans. This gives us an idea that from the time of ancient civilization there have been many accounts of user-configurable automated devices. The first digital and programmable robot was invented by George Devol in 1954 and was named the "Unimate". It was sold to General Motors in 1961 where it was used to lift pieces of hot metal from die casting machines at the Inland Fisher Guide Plant in West Trenton section of Ewing Township, New Jersey. It was the first robot installed in American industries.

Robotics has become the fastest growing segment of industrial machine market in few decades. Japanese firms are leading the development of robotics and many of their designs incorporate the new science of artificial intelligence which allows robots to learn and adapt their operations on their own.

1.1 SYSTEM DESCRIPTION

This section will describe the general working prototype of the robot and function of each component.

This prototype made is simple pick and place robot which consists of the base, arm, vertical support and end effector. This robot is a moving vehicle which can lift and place an object to the desired location. The arm of the robot works with help of pulley mechanism which is actuated by the motor. The end effector used here is a gripper with two fingers which works with the help of worm gear mechanism and is also actuated by the motor.

The wired remote control is used to actuate motors present on different components of robot. Switches are present on remote control to actuate these motors.

Fig. 1 shows the general diagram of prototype of pick and place robot.

Following are the components of the prototype of this robot whose functions and working are given in detail.

1.1.1 End Effector

The actual interference with the object is done by end effector of the robot. It may be any tool or gripper to perform desired task. It is similar to the hand of the humans which performs various tasks.

The end effector used in this prototype is two fingers gripper. This gripper is mounted on one side of arm. For working of this mechanical gripper we have used worm gears. The worm is fitted to the shaft of the motor and properly aligned with two worm gears so that on rotation of worm it transmits motion to worm gears. Two fingers are mounted on these gears which will perform holding and unholding action on actuation of motor which transmits motion to gears.

The gripper fingers can be of different sizes and shapes to lift various objects. The material of the gripper should be such that it avoids slippage of object.

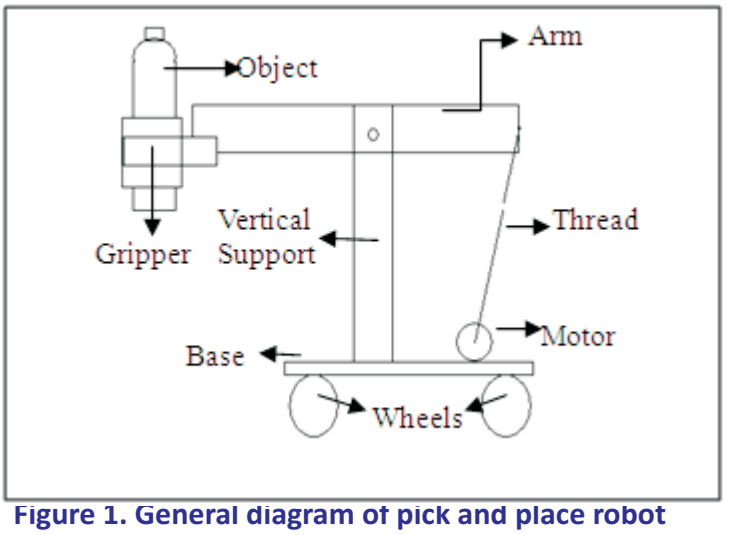


Figure 1. General diagram of pick and place robot

Fig. 2 shows model of gripper used for this prototype of pick and place robot.

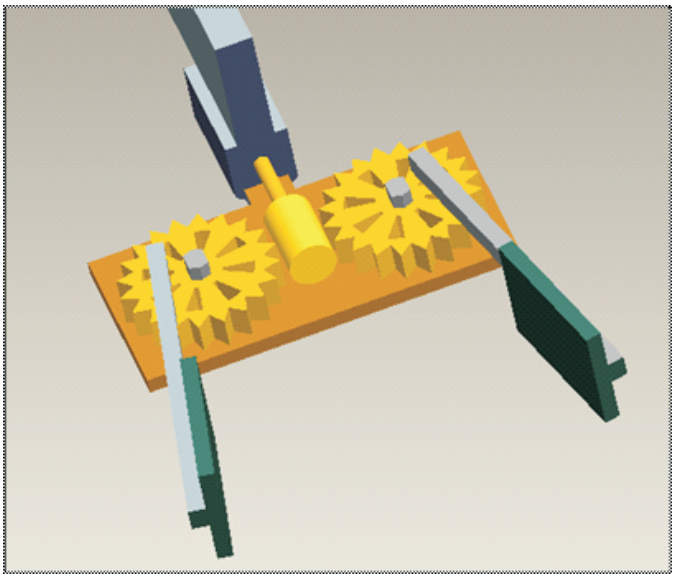


Figure 2. Gripper of robot

1.1.2 Base and Vertical support

Here the base is made of wood. Base material and dimensions should be selected such that it can carry load of all components mounted on it and components should be easily mounted with simple arrangements. In this prototype four motors are mounted for wheels and one for providing movement to arm.

The vertical support here may be called as shoulder of robot, as arm is pivoted on it. The support material is selected such that it has high strength and is light in weight. Here for this prototype vertical support is made of aluminium.

Fig. 3 shows model of base with vertical support and motors mounted on it.

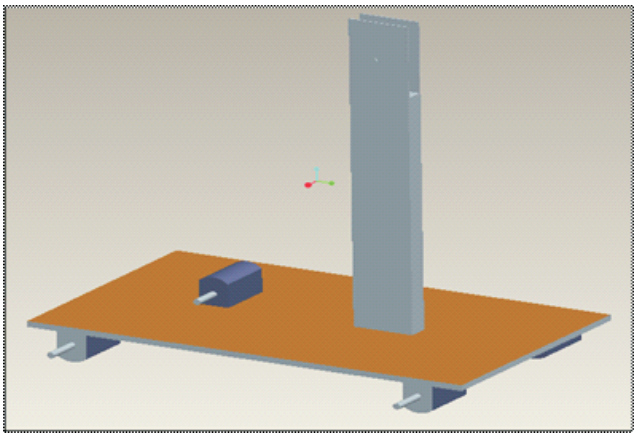


Figure 3. Base with vertical support and motors mounted on it

1.1.3 Arm

Arm is pivoted on vertical support and at proper distance. Arm of the robot works on basis of pulley mechanism. On one side of arm gripper mechanism is mounted while on other side nail is fitted to tie thread on it. Thread then is tied to shaft of motor such that when motor is actuated, thread gets wound on shaft which pulls arm resulting in upward movement at gripper side and opposite action takes place in opposite direction of rotation of shaft. Fig. 4 shows assembled model of prototype of robot with all components.

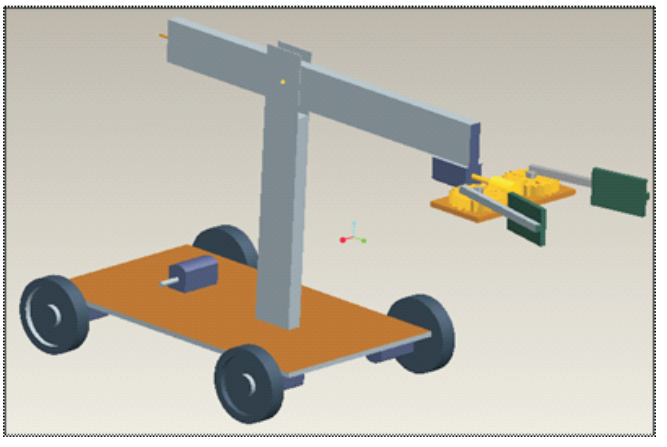


Figure 4. Assembled model of robot

1.1.4 Motors

In this Prototype electrical actuators intead of hydraulic or pneumatic are used because they are light in weight and also cheap. Table.1 below shows the motors with different speeds used for different components of robot.

Table 1. Motors used for various components of robot

Components	Quantity	Speed in RPM
Wheels	4	200
Arm pulley mechanism	1	100
Gripper	1	60

1.1.5 Wired remote control and power supply

It is simple remote control with four switches used to operate different components with help of motors. Wires are connected from different components to remote control. Power supply of 5 A and 12 V is required so voltage regulator is used to convert 240 volt ac supply to 12 volt dc supply.

2.1 DESIGN ANALYSIS

2.1.1 Design consideration

Following were taken into consideration during design process.

- The materials which will be used for the design will be light in weight so as to reduce the weight concentration on the base and the shoulder.
- Hollow rectangular bars instead of blocks are chosen for the links because of their light weight and stability and to reduce the weight of the arm.
- Correct holding position should be set or else while movement of the mechanical arm it may drop the object.
- The mechanical arm should be interfaced properly to the motor with high strength thread.
- Load carrying capacity should be maintained as it should be always more than the default load which is to be lifted.
- The mechanical arm should be designed such that it does not damage any other components mounted nearby or the object while holding it in its gripper.

2.1.2 Design analysis of arm

Here the maximum load that can be carried by at the one end of arm is calculated. Fig. 5 shows diagram of the load calculation of arm.

From motor specifications we get,
Torque = 2 kg-cm = 20 kg-mm
Radius of shaft of motor = 2.5 mm
Therefore, Torque = Force × Radius of shaft

$$T = F \times R \qquad (1)$$

Therefore force generated by motor can be calculated by equation (1)
Therefore, $F = (20 / 2.5) \times g = 8g$ kg
Taking moment at point B, MB
$MB = m.g \times 220 = 8 \times g \times \cos 20 \times 145$
Therefore, m = 4.95 kg

Hence the maximum load calculated is 4.95 kg. The actual load will be less than the calculated value because the weight of the material used in constructing the arm was light and also weight of

gripper mechanism was not taken into consideration.

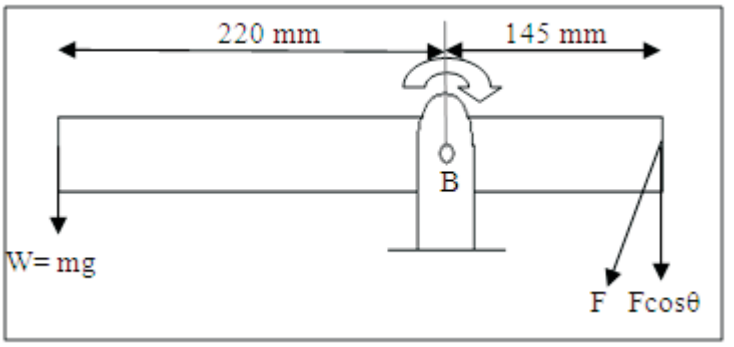


Figure 5. Diagram showing load calculations of arm

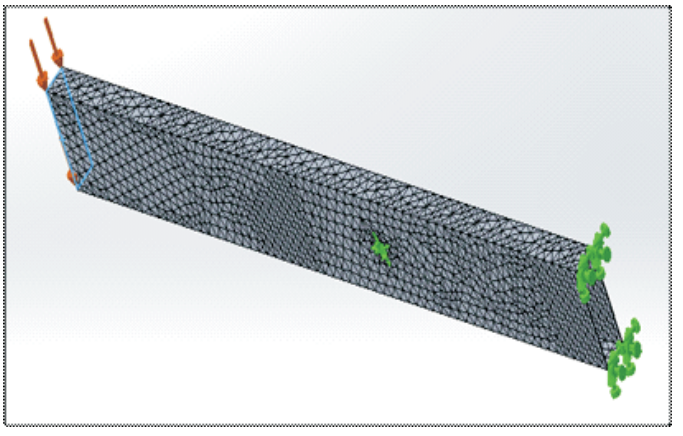
On basis of above calculation, arm is mounted on base at proper location such that during linear motion with object hold in gripper the load should be balanced and in case on imbalance dead weight can be placed on base to balance structure during motion.

2.1.3 Finite Element Analysis of Arm

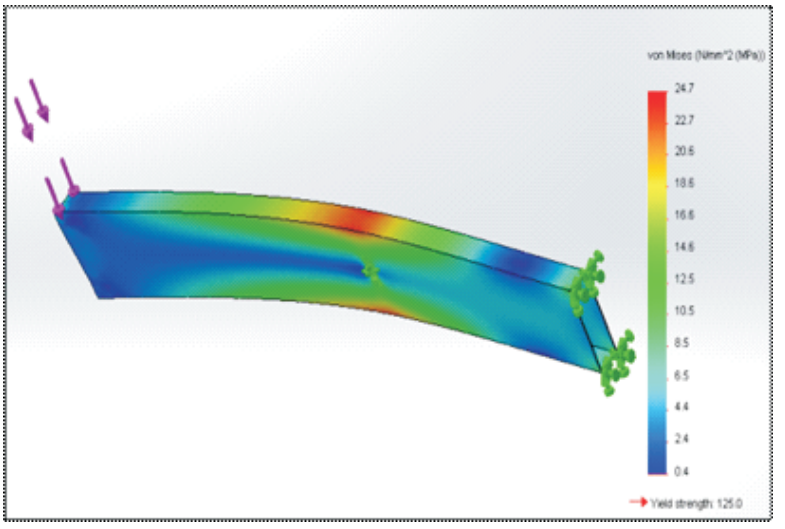
In this paper the stress analysis of the robot armwas performed using Solidworks'12 software. The FEA was performed to check whether the arm is safe or not when force is applied. Stress analysis was performed by keeping one end of the arm fixed, the pin was given a fixed hinge constraint and 50N load was applied on the other end.

Results

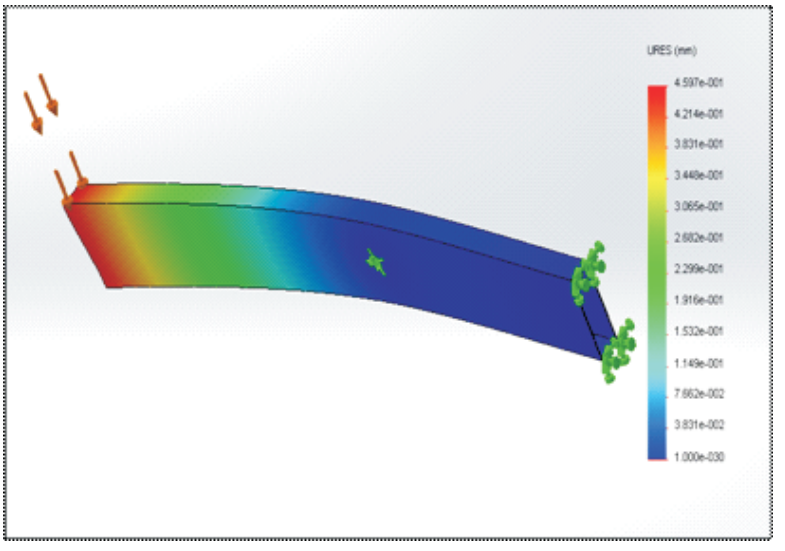
1.Tetra Mesh



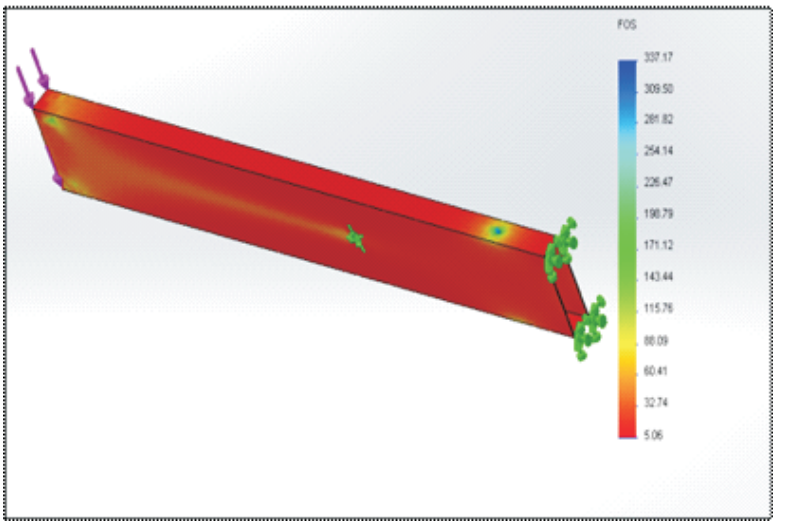
2. Von-Mises plot: Max value= 24.7 MPa
Yield Strength= 125 Mpa



3. Displacement Plot: Max Deflection = 0.459mm



4. Factor of Safety Plot : FOS = 5.1



2.1.4 Gripper force analysis

The minimum static force that must be applied to the stationary object is given by following equation (2). Fig.6 shows free body diagram of object in gripper.

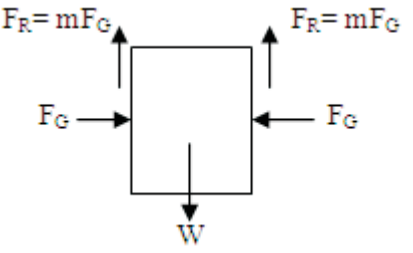


Figure 6. Free body diagram of object in gripper

$$FG = W / \mu.n$$
$$FG = m.g / \mu.n \qquad (2)$$

Where,

FG : Gripping force [N]
μ : Co-efficient of friction
n : Number of fingers of gripper
m : Mass of the object [kg]
g : Gravitational acceleration [m/s^2]

If object is lifted with acceleration then equation (2) can be written as follows

$$F_G = m.(a + g) / \mu.n \qquad (3)$$

Where,

a : Acceleration with which object is lifted [m/s^2]

Figure 7. Prototype of pick and place robot with pulley mechanism

CONCLUSION

The design of simple pick and place robot with pulley mechanism has been completed. The prototype of this robot was built and confirmed functional along with stress analysis. This robot with pulley mechanism can be used at small workshops for less precision jobs. With some modification and study of electrical circuit it can be made with wireless remote control with extensive scope in the future. There is a lot of scope of improvement in this robot by using various technologies and increasing it precision of work and also making it available at low cost.The design was found to be safe according to the FEA results.

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