Design, Development and Kinematics Analysis of 4dof Scara Configuration

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***Abstract*- In this paper a Design, development and analysis of SCARA robot with 4 degrees of freedom in which 3 rotational and 1 prismatic movement (RRRP) to used in pick and sorting metallic parts. The structure of the robot is firstly presented. The kinematic model is then built, and the kinematic analysis is performed based on OCTAVE. Design of model is done in and analysis through software. A control interface is also control via to control the robot for achieving pick and sorting task. Sensor sense the object and electromagnet pick this object and sorted to desire location.**

Index Terms- SCARA, Kinematics, D-H matrix, Octave, Electromag- net, sensor (TCS3200)

I. INTRODUCTION

A. Introduction Robot:

A device with minimum of 4 degree of freedom designed to both manipulate and transport parts, tools or specialized manufacturing implements through variable programmed motions for performance of certain manufacturing task.

SCARA robot is a manipulator with 4 Degree of freedom. This type of robot has been developed to improve the speed and repeatability on pick and place tasks from one location to another location.

SCARA manipulator is primarily used where the operation required high accuracy and less operating time.

B. Introduction to our project:

This paper main aim is design, development and analysis of 4 DOF scara robot. In design we use SOLIDWORK software, in this software we design particular link in 3D and assembly of our project and also design wireframe model. We generate movement of scara robot in X Y and Z axis.

In our SCARA robot is fully automatic. This can be done by using a Colour sensors interfaced with Arduino UNO Controller Unit. Firstly robot sense the three colour object namely red, yellow and black. Colour sensor sense the 1 colour and electromagnet grasped the object and sorted to the preprogrammed place. Thereby eliminating the monotonous work done by human, achieving accuracy and speed in the work.

This robot involves colour sensors that senses the object's colour and sends the signal to the microcontroller. The microcontroller sends signal to circuit which drives the various motors of the robotic arm to grip the object and place it in the specified location. Based on the colour sense, the robotic link moves to the desire location, discharge the object and comes back to the rest position.

In SCARA we find DH matrix with the help of size of the link and angle of the robot and find equation of SCARA robot. This equation result's put in octave software and with the help of octave program generate graph. This graph indicates SCARA movement. And also we analysed SCARA robot in ansys. In ansys software we find load and stress de- formation of SCARA robot.

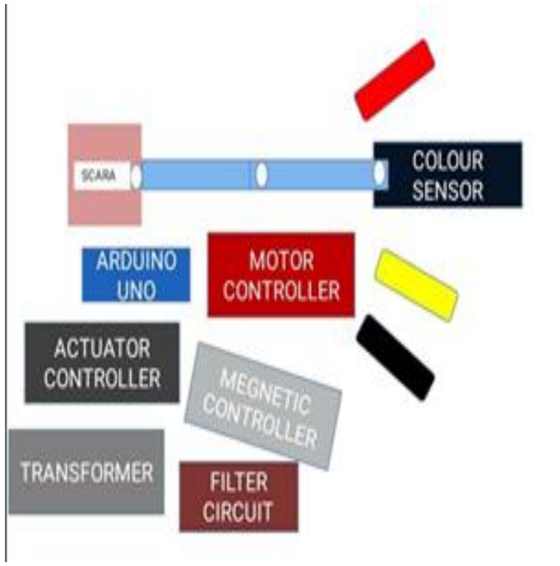


Fig. 1. Basic circuit diagram

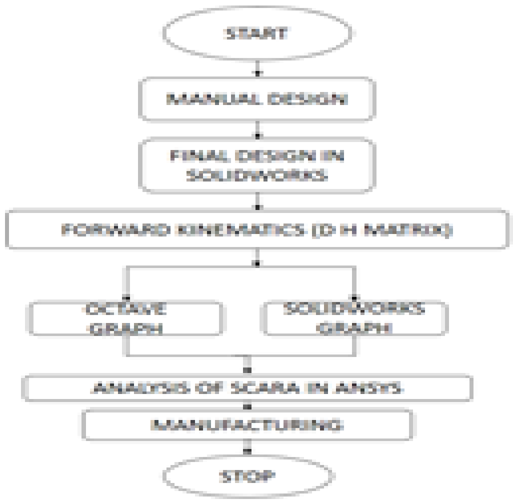


Fig. 2. WORK PLAN

III. SCARA KINAMTIC

Before any control theory can be developed, a consistent and systematic representation of the robot has to be developed. This involves assigning coordinate frames to the manipulator and assigning the Denavit Hartenberg link parameters. Applying the Denavit Hartenberg algorithm to the link chain results in the link coordinate diagram shown in fig. below. Determine DH parameters is first step to derive robot's kinematics. The coordinate system are attached to the robot according to DH convetion and show in the figure. The established DH table of scara is shown in table. Using this table kinematics of the will be obtained.

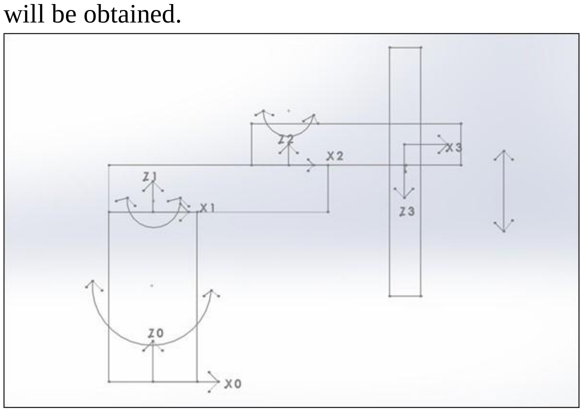


Fig. 3. Link Coordinate Diagram

A. D-H Matrix

Next, we calculate the arm matrix for the robot.

$T = {}^{0}T_{1}\, {}^{1}T_{2}\, {}^{2}T_{3}\, {}^{3}T_{4}$

TABLE I. DENAVIT-HARTENBERG TABLE

Axis	A	α	d	Θ
0-1	L1	0	t1/2	Θ1
1-2	L2	-180	t2/2	Θ2
2-3	L3	0	0	Θ3
3-4	0	0	0	d4

$$T1 = \begin{bmatrix} C_1 & -S_1 & 0 & L_1C_1 \\ S_1 & C_1 & 0 & L_1S_1 \\ 0 & 0 & 1 & t_1/2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T2 = \begin{bmatrix} C_2 & S_2 & 0 & L_2C_2 \\ S_2 & -C_2 & 0 & L_2S_2 \\ 0 & 0 & -1 & t_2/2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T3 = \begin{bmatrix} C_3 & -S_3 & 0 & L_3C_3 \\ S_3 & C_3 & 0 & L_3S_3 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T4 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & d_4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

After multiplication and simplification using trigonometric identities, we get the following arm matrix

$$\begin{bmatrix} C_{123} & S_{123} & 0 & L_1C_1 + L_2C_{12} + L_3C_{123} \\ S_{123} & -C_{123} & 0 & L_1S_1 + L2S_{12} + L_3S_{123} \\ 0 & 0 & -1 & -d_4 + 1/2(t_1 + t_2) \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 0.173 & -0.984 & 0 & 20.21 \\ -0.984 & -0.173 & 0 & -5.54 \\ 0 & 0 & -1 & 1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

TABLE II. NOMENCLATURE

SYMBOL	ABBREVIATIONS
C_{123}	COS(θ1+θ2-θ3)
S_{123}	SIN(θ1+θ2-θ3)
C_{12}	COS(θ1+θ2)
S_{12}	SIN(θ1+θ2)
L1	LENGTH OF LINK 1
L2	LENGTH OF LINK 2
L3	LENGTH OF LINK 3
d4	LENGTH OF LINEAR ACTUATOR
t1	THICKNESS OF LINK 2
t2	THICKNESS OF LINK 3

IV. MATERIAL

Sensor

Without the data supplied by the sense organs, the brain would be incapable of intelligence. In other words the controller of the robot cannot do any meaningful task, if the robot is not with a component analogous to the sense organs of the human body. Sensors are nothing but measuring instruments which measures quantities such as position, force, torque, proximity, temperature, etc.

B. Electromagnet:

Magnetic grippers can be configured by permanent magnets or electromagnets. Permanent magnets, don't need of an external supply for grasping, once an object is grasped there is an additional device called stripper push which separate the object from the gripper. In the other hand, there are the electromagnets, including a controller unit and a DC power which can grasp magnetic objects.

Fig. 4. Electromagnet

C. Actutor

Actuators are used in order to produce mechanical movement in robots. Actuators are the muscles of robots. There are many types of actuators available depending on the load involved.

1. Hydraulic Actuator
2. Pnumetic Actuator
3. Electric Actuator

A linear actuator is a mechanical device that converts energy to create motion in a straight line; contrasted with circular motion of a conventional electric motor.

D. Arduino UNO

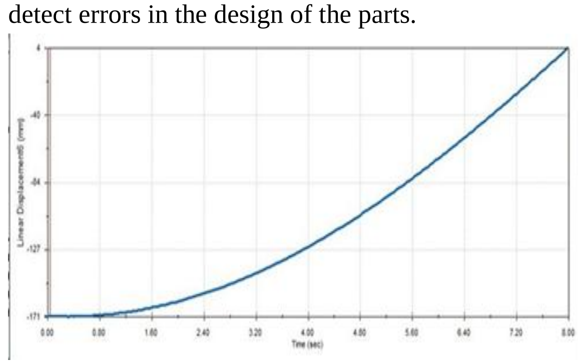
Arduino board is a micro-controller, which are able to read different inputs and turn them into outputs. Relevant specifications Instructions can be sent to the board using the Arduino programming language.

Fig. 5. ACTUATOR

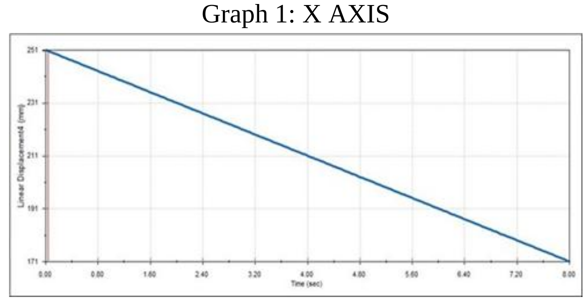
Fig. 6. ARDUINO UNO

V. RESULT AND DISCUSSION

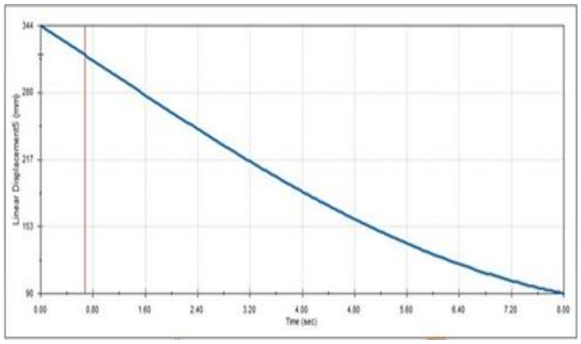
1. Solidworks motion which is a 3D CAD software was used to successfully design a Cartesian robot, articulated robot arms, conveyors and products that which are parts of an automated pick and place robotics system. The software enabled easy simulation of the system and was able to quickly detect errors in the design of the parts.



Graph 1: X AXIS

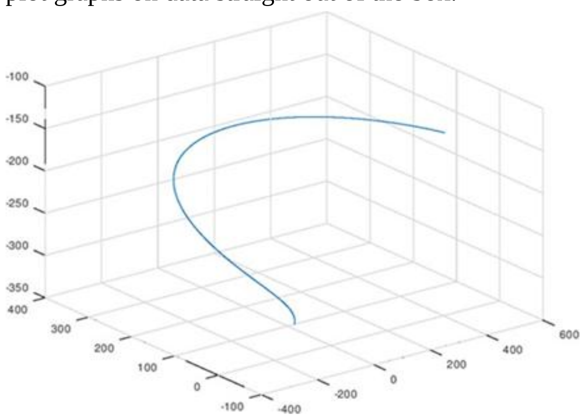


Graph 2: Y AXIS



Graph 3: Z AXIS

2.Octave is a high-level language, primarily intended for numerical computations. It provides a convenient numerical command line interface for solving linear and nonlinear problems numerically, and for performing other experiments using a language that is mostly compatible with MATLAB. It may also be used as a batch-oriented language. Octave makes it incredibly fast to implement idea's from many fields of math and data analysis. Octave is free compared to it's most popular opposition MATLAB. Ability to plot graphs on data straight out of the box.



Graph 4: SCARA movement in octave

3.Analysis in ANSYS

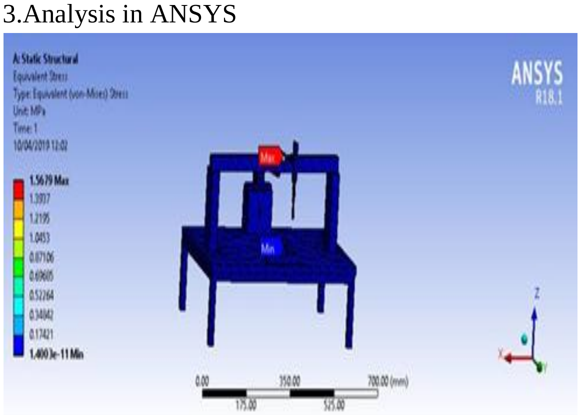


Fig. 7. ANALYSIS OF SCARA

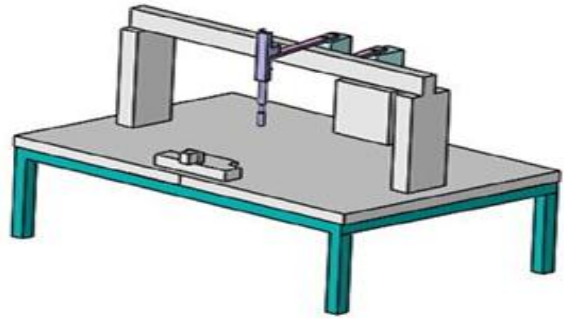


Fig. 8. FINAL DESIGN

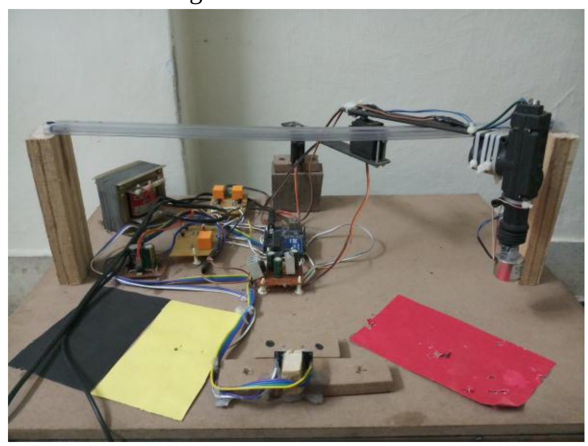


Fig. 9. FINAL MODEL

VI. SPECIFICATION

TABLE III. SCARA SPECIFICATION

MODAL	SCARA
PAYLOAD	300 GRAM
REACH	350
DOF	4
MOUNTING	TABLE
REPEATABILITY	9 SEC
ACTUATOR	ELECTRIC
END EFFECTOR	ELECTROMAGNETC
CONTROLLER	ARDUINO
SENSOR	TCS 3200 (COLOUR SENSOR)
APPLICATION	RYB COLOUR PICK AND SORTING
WEIGHT	3 KG (WITH STAND)
POWER REQUIREMENTS	12V

VII. CONCLUSION

The effective Design and Implementation of SCARA has been performed. The operation of various arm linkages and the robotic arm has been extensively tested and the required corrective measures were taken with the help of software. Hence the objective of designing and manufacturing of SCARA robot is to be manufactured at low cost. It's been proved that running cost of the robot is also very less by cost estimation. This will help to cut down labor and improve profits at very low initial investment. The proposed model is demonstrated through an application of example of real world. By considering the advantages and also by looking at various benefits, this project can be employed in the assembly industry.

BOOKS:

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