Geometric parameters optimization & Analysis of packing robot arm using ANSYS

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***Abstract*—Robots are involved in several industrial applications right from the raw materials to pick and packaging of final products. The robot arms involved in applications such as packaging are to be of smooth surfaced and should be of lighter weight. Generally robot arms are fabricated using different grade steels. In present work a robot arm assembly models were designed using two types of cross-sections i.e. square-square, cylinder-cylinder and light weight alloys were assigned to the best performed cross-section type. Magnesium, aluminum and zinc were used as alternate materials for steel. Results of the analysis clearly showed square-square geometry is superior to cylinder-cylinder geometry and magnesium alloy displayed higher stress values with respect to the weight than that of steel.**

Key words: Robot Arm, Light weight alloys, Magnesium alloy.

I. INTRODUCTION

Generally robots are of two types; they are said to be service section robots and industrial section robots. The robots utilized in commercial places, offices, hotels and homes come under the service section while the robots industrial robots are utilized to reduce the human laborious work in industries. Industrial robots perform heavy and tedious works like mechanical processes like machining, casting and welding, heavy material handling. In the same way very repetitive works like inspection of goods and packing which are not manufacturing processes yet very important operation in industries are performed by robots. In this view, robots can be termed as an automated server and employee respectively.

According to the international federation of robots around 114000 robots are employed in several packaging operation of industries like liquid filling, drink processing, pharmacy and cosmetics all over the world by 2007 and the installing robots is being increased every year by 3-4% [2]. Only food and beverage industry has increased robot orders about 32%, about 4350 units which is almost 4% share of supply. In Europe only almost 58% of worldwide share sales of robots taken place in similar industries.[1]

A. Background of Magnesium alloy:

In past, magnesium was extensively used in World War I & II, for the applications in nuclear industry, military aircrafts etc.
Magnesium is lightest weighed metal among the metals used in manufacturing processes.
The necessity of weight reduction in products has initiated the development of interest on magnesium alloys.

The benefits of magnesium alloys are,

- Density is low
- Specific strength is high
- Cast-ability is good and suits of high pressure die casting applications

- Can be turned or milled at high speed.
- Easily available.
- Recyclable & has better mechanical properties than polymeric materials.

Some reasons why it is not used as a conventional metal are:

- Elastic modulus is low comparatively
- Shrinkage on solidification is high
- It is chemical reactive.[5]

The growth rate of magnesium alloys in applications of over the next 10years has been forecast to be 7% per annum [7]

While selecting a material for an arm of robot, the stiffness of material to its weight ratio denoted by 'P' plays a major role. Steels have a P value of 25.3 where as Mg alloys have almost nearly equal to the same value of 25 which indicates that these materials are compatible for robot arms. [1]

Magnesium alloy (AZ91A) material composition is as follows[11]:

Material	composition
Al	8.3-9.7%
Mn	0.13%
Zn	0.35-1.0%
Si	0.50%
Cu	0.10%
Ni	0.03%
Other	0.30%
Mg	90-91%

Properties of the AZ91A Mg Alloy:

Sl.No	Property	Value
1	Density	1.8 g/cm3
2	Poisson ratio	0.35
3	Young's modulus	45000MPa
4	Bulk modulus	50000MPa
5	Shear modulus	16667MPa
6	P-value	25

II. Literature Review

Huiyuan Liu and Han Huang; In their work, different prototype designs were made to examine the feasibility of the application of light alloys for robot arm, in comparison to conventional materials.[1]

Dr. Ahmed Abdul Hussain Ali, Dler Obed Ramadhan; In the beginning the program finds the optimum section in which the stress in the members not exceeds the allowable stress and estimates the best choices of the dimension for each section that gives the minimum weight and deflection.The dynamic behavior of the best chosen structure of industrial robot was studied to find the natural frequencies and mode shapes.[9]

B.L. Mordike, T. Ebert; The requirement to reduce the weight of car components as a result in part of the introduction of legislation limiting emission has triggered renewed interest in magnesium. The growth rate over the next 10 years has been forecast to be 7% per annum. A wider use of magnesium base alloys necessitates several parallel programs.[5]

III. Problem Definition

In the present work two types of robot arm cross sections are modeled and investigated for better cross section and different alloy materials were used such that the weight of robot reduces. This helps in increasing the load bearing capacity and speed of robot.

Robot speed is defined as the distance moved by it per unit time, usually specified at a specific load. Hence the speed of load is dependent on weight parameters.[3] The use of Mg alloys in the place of present alloy materials provides better results at affordable cost. In this work three materials are examined including Mg alloys. Finite Element Analysis is done using ANSYS software.

IV. Modeling Approach:

A .Geometry modeling:

For present work two cross sections of robot arm assembly are modeled in CATIA, they are shown in following figures.

The models are saved as .IGES file in CATIA and imported to ANSYS for FEA analysis.

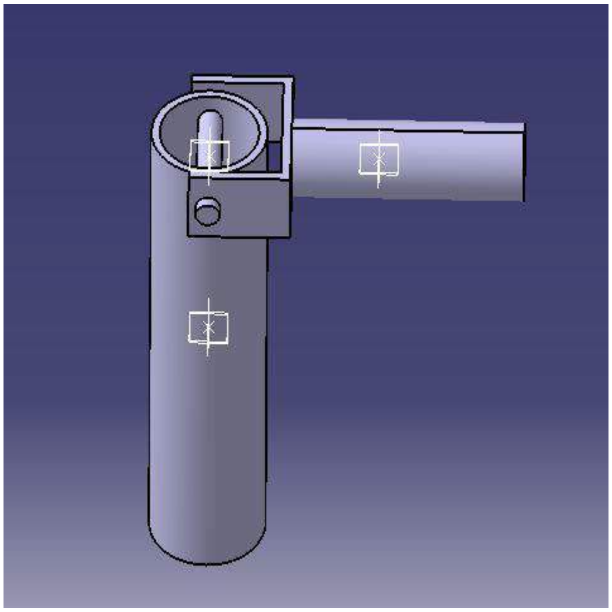


FIG: 1 Cylinder-cylinder cross sectional robot assembly

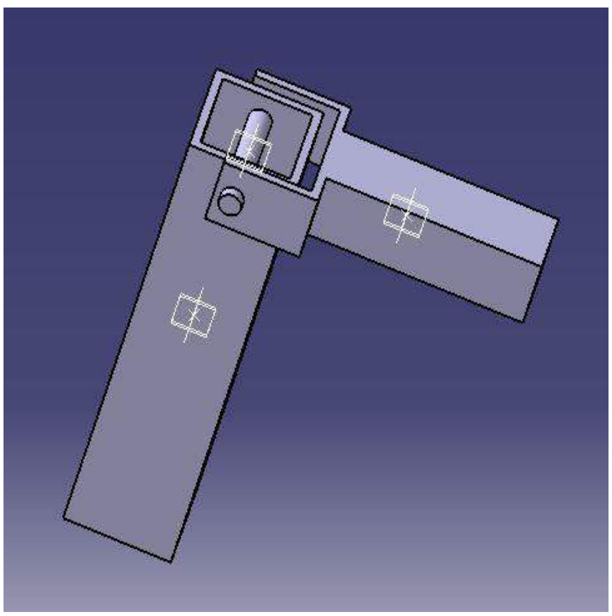


FIG: 2 Square-square cross sectional robot assembly

B. FEA Simulation:

The two models are individually imported and simulated for assessment of the better cross section. The long arm of the assembly is fixed and the load is applied on the other arm which is connected with a pin. Revolute link was assigned between two arms.

Meshing of the models was done using general fine mesh. Static structural analysis was done by applying a maximum load of 1e5 N on the smaller arm while the other arm is made to act as a fixed support.Then the equivalent stress and normal stress were studied with respect to the weight of the arm assembly.

The results observed from simulation of better cross section assessment shown in fig:3,4,5,6 while material feasibility results of Magnesium alloy are shown in fig:7,8.

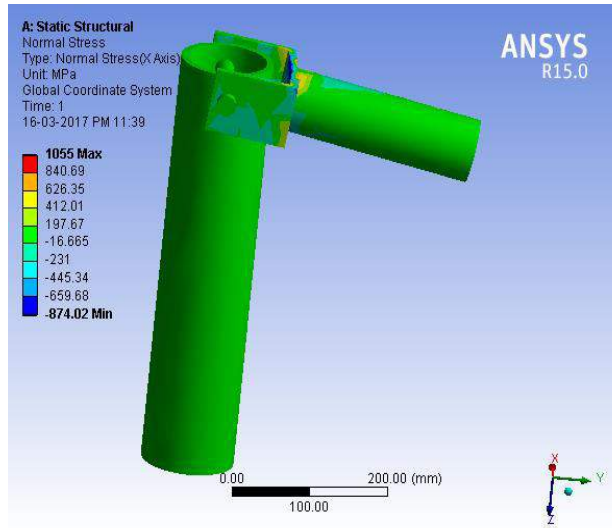


FIG.3 Normal stress of Cylinder crosses sectional robot assembly

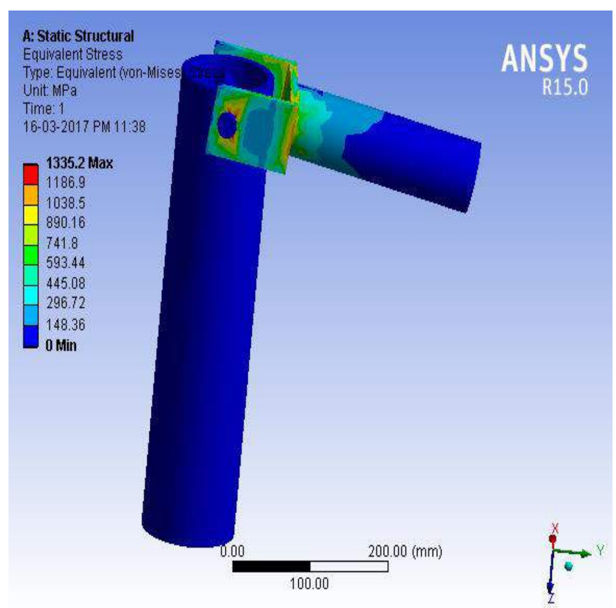


FIG.4 Normal stress of Cylinder crosses sectional robot assembly

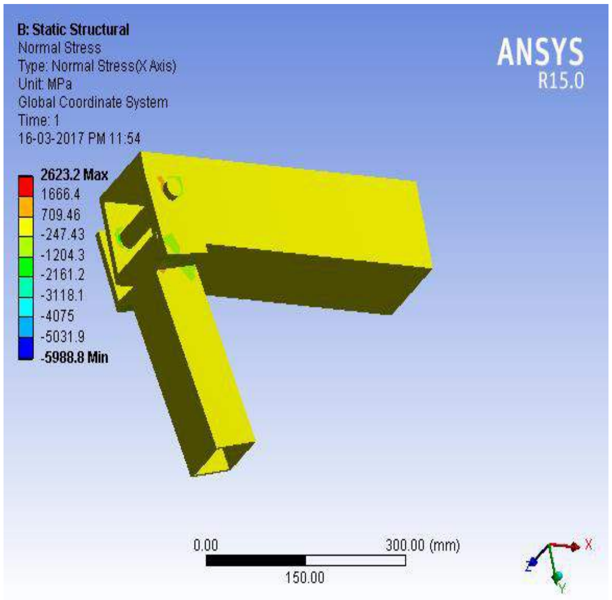


FIG.5 Normal stress of Square cross sectional robot assembly

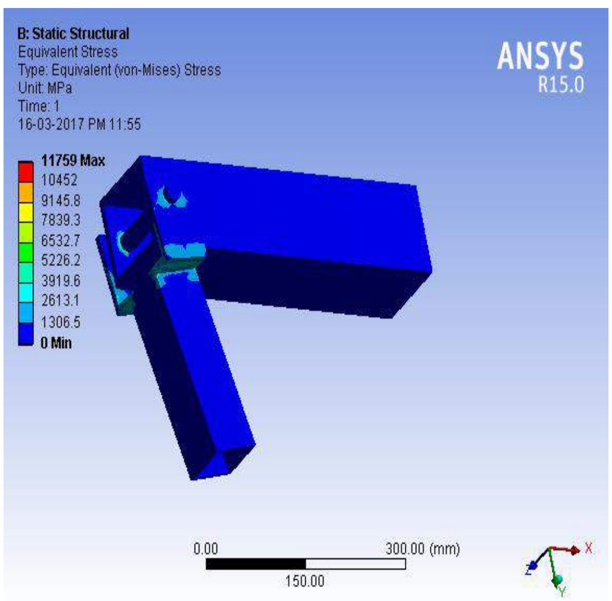


FIG.6 Normal stress of Square cross sectional robot assembly

Table: 3, Compariosn of cross section assessment results

S.no	Cross-Section	Equivalent stress (Mpa)	Normal stress(Mpa)
1	SQ-SQ	11759	2623
2	CR-CR	1335	1055

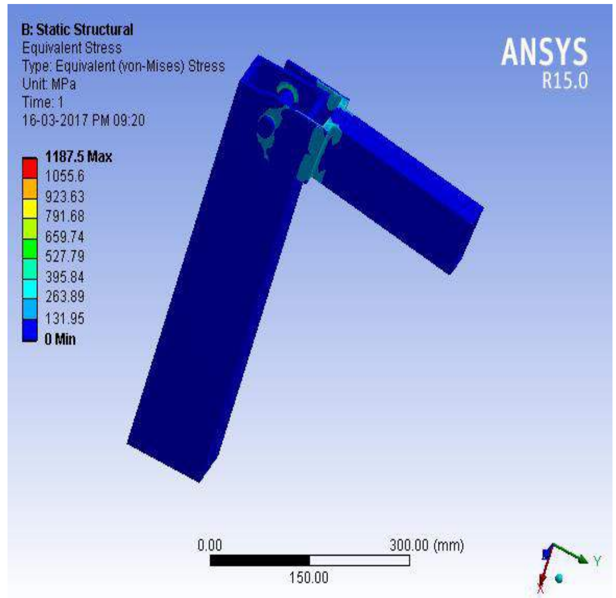


FIG.7 Equivalent stress

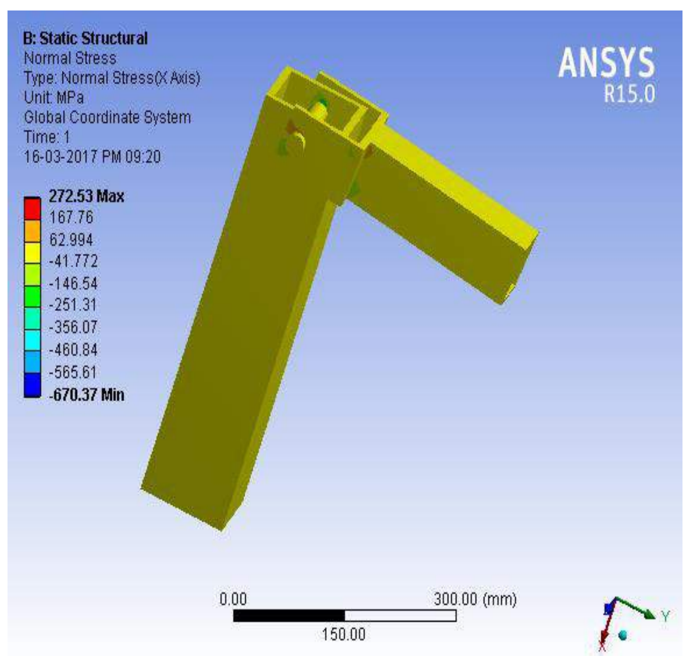
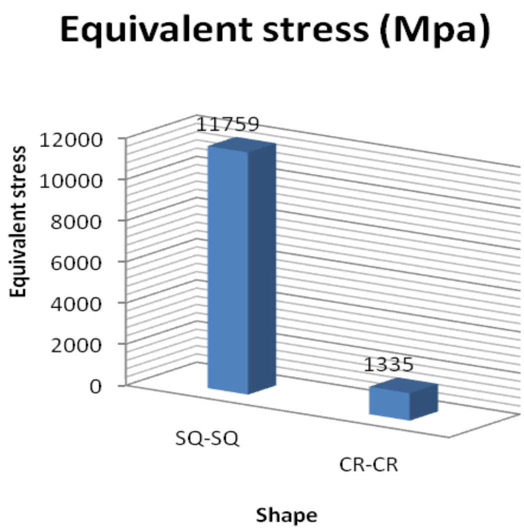


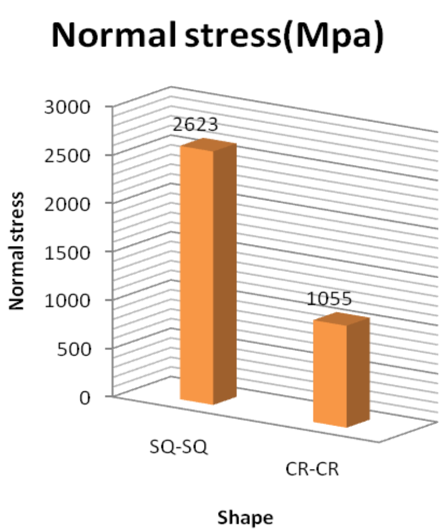
FIG.8 Normal stress

Table: 4,Comparision of Materials results of simulation

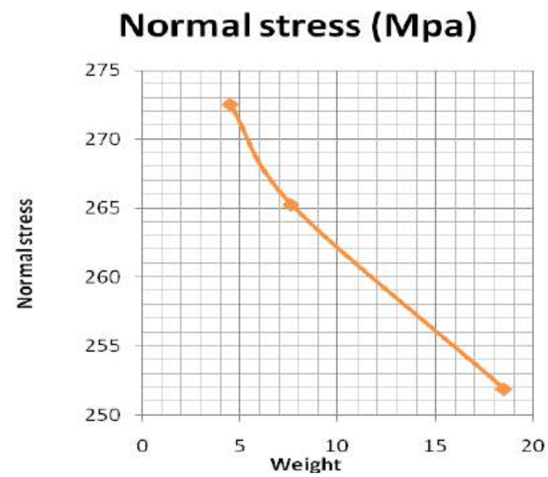
S.no	Material	Weight (Kg)	Equivale-nt stress (Mpa)	Normal stress (Mpa)
1	Magnesiu-m alloy	4.46	1187.5	272.53
2	Aluminiu-m alloy	7.59	1227.1	265.25
3	Zinc alloy	18.5	1388.3	251.86



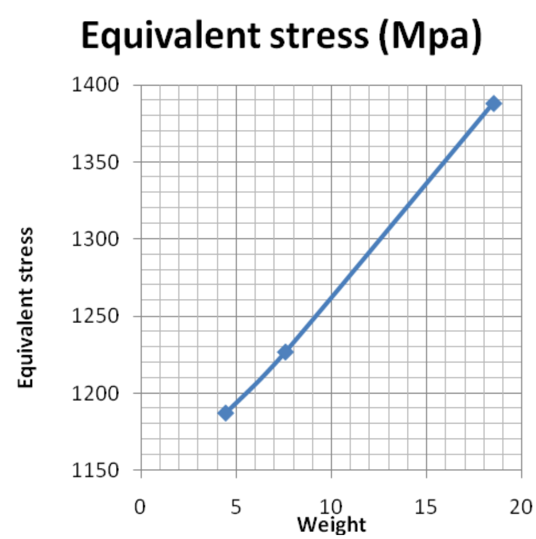
Graph: 1, Presents the variation in equivalent stress W.R.T Cross section of robot arm.



Graph: 2, Presents the variation in Normal stress W.R.T Cross section of robot arm.



Graph3, Presents the variation in normal stress W.R.T weight of each material robot arm.



Graph4, Presents the variation in normal stress W.R.T weight of each material robot arm

V. Results and Discussion

A.Robot arm cross section Vs maximum stress:

To demonstrate the effect of structural design, the cross section were compared based on the maximum stress experienced in the arm assembly, as shown in Figures 1-4.

Maximum stress that could be experienced by the robot arm was taken as half of the yield strength of that material, in other words half of the yield stress was taken as safety operational stress of the robot arm, above which the arm material might undergo plastic deformation which should never be allowed in any handling machineries.

By observing the Equivalent stress of 11759Mpa and Normal stress of 2623Mpa the square-square cross section had demonstrated clear domination over cylinder-cylinder cross section whose Equivalent stress is of 1335Mpa and Normal stress is of 1055Mpa.

B. Robot arm weight Vs maximum stress:

To demonstrate the effect of material properties of robot arm in self weight reduction and more stress bearing capacity, as shown in figure 5, 6 and graphs. We have used three types of alloys they are Magnesium alloy, Aluminium alloy and Zinc alloy.

Equivalent stress and Normal stress of different alloys were observed and came to a conclusion that Magnesium alloy demonstrated superiority to other alloys by having a weight of 4.46 kg, Equivalent stress of 1187.5 Mpa and Normal stress of 272.53 Mpa. Which were superior to Aluminium alloys weight of 7.59 kg, Equivalent stress of 1227.1 Mpa and Normal stress of 265.25 Mpa and Zinc alloys weight of 18.5 kg, Equivalent stress of 1388.3 Mpa and Normal stress of 251.86 Mpa.

CONCLUSION:

From the results it is concluded that square-square cross section is most suitable in designing of packing robots and Magnesium alloy is most suitable material in manufacturing of packing robots.

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