DESIGN AND ANALYSIS OF A THREE FINGERED ROBOTIC ARM

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ABSTRACT

In recent years robotics arm can be employed in many grasping applications. In that fingered robotic arm can be used widely in all applications especially in grasping. In practice, while preferring multi fingered robotic arm, to achieve the required grasping power. This facilitate increased total weight of robots and stress deformation in links. In present work, three fingered robotic arms can be analyzed with different materials (stainless steel, aluminium alloy, magnesium alloy and titanium alloy) under various load conditions. The stress analysis and deformation of links were analytically evaluated through ANSYS work bench with axial and vertical loading condition. Influence of various material on three fingered robotic arms was discussed.

Keywords: Grasping, Loading condition, Reaction moment, Stress analysis

I. INTRODUCTION

Robots have the potential to play a large role in our world. They can be widely used many industrial application especially in case of grasping. [1] The developed prosthetic hand like that of the human hand which perform similar to the human hand. The main disadvantage of the hand is the grasping capacity and manipulator capability, the each part designed separately. The spring used to retracts after taking force. [3] In this paper the human factor is determined with the largest component, in that major application point focused on the grasping force and DOF. It concludes that study of complex process of grasping. [5] The paper based on the design of actuated prosthetic hand with 5 fingered dexterous hand. It fabricated with low cost material in order to reduce the cost. According to this paper the future work can be done on the material selection and weight of the hand.

The main objective of the present study to investigate various material is used to design the three fingered robotic arm. The material can be chosen based on availability and cost factor. The fingered robotic arm can be designed with four links. Determination of stress and deformation of arms undervarious loading condition like axial and vertical load. From the results obtained the influence of various material properties under different loading condition were reported and discussed.

II.MODELLING OF ROBOTIC ARM

The three fingered robotic arm is modelling with the help of modelling software like SOLIDWORKS. It is a solid modeler, and utilizes a parametric feature-based approach to create models and assembles. Each part of arm can be designed separately through the software. The final assembly of robotic arm in 2D view can be shown in “fig.1”.

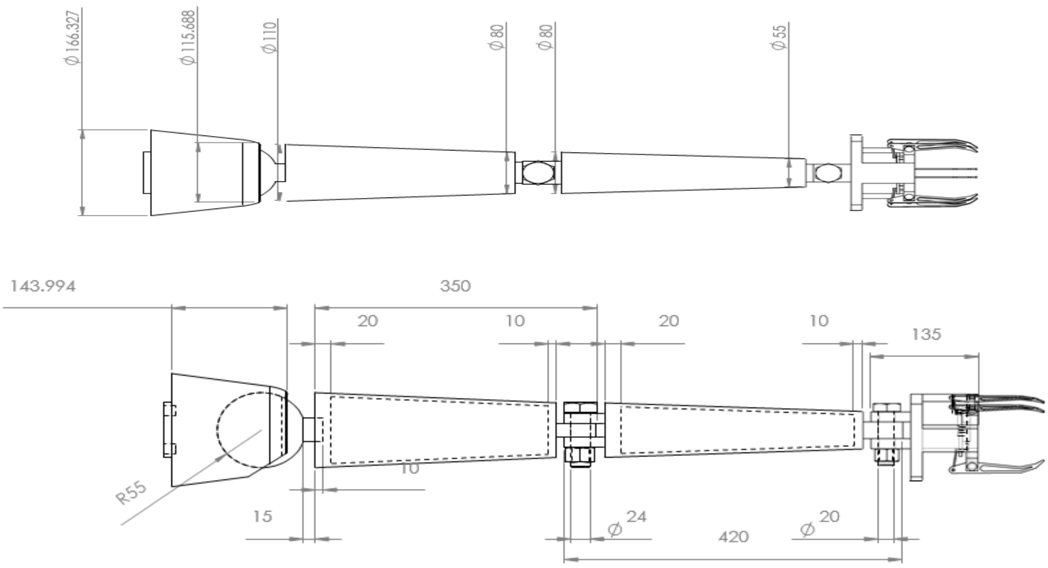

Figure 1: Overall 2D view of Robotic arm

III.ANALYSIS OF ROBOTIC ARM

The stress analysis and deformation of various links with different material under various loading condition can be analyzed with the help of analyzing platform ANSYS Workbench. This platform is the framework unifying our industry leading suite of advanced engineering simulation technology. Through the analysis platform we can analyze individual part of the robotic by applying load on the palm. Based on different loading condition stress analysis and deformation changes according to material property changes. The values of different materials under different loading condition were tabulated and plotted. The sample output of ANSYS Workbench for stainless steel shown in fig.2&3”.

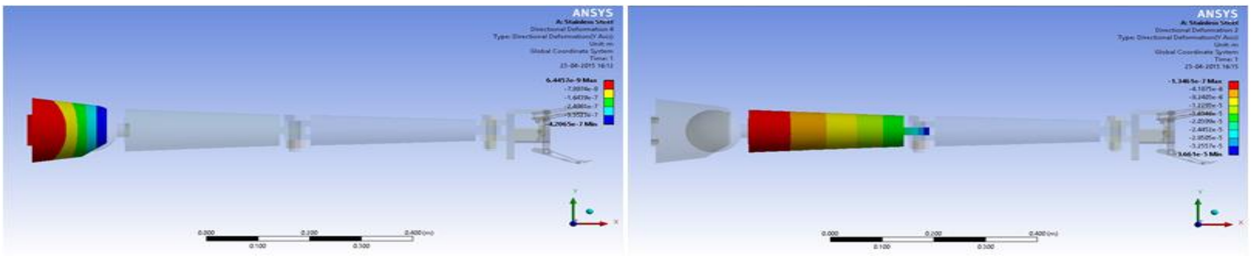

Figure 2: Stainless steel Deformation of link 1 and 2

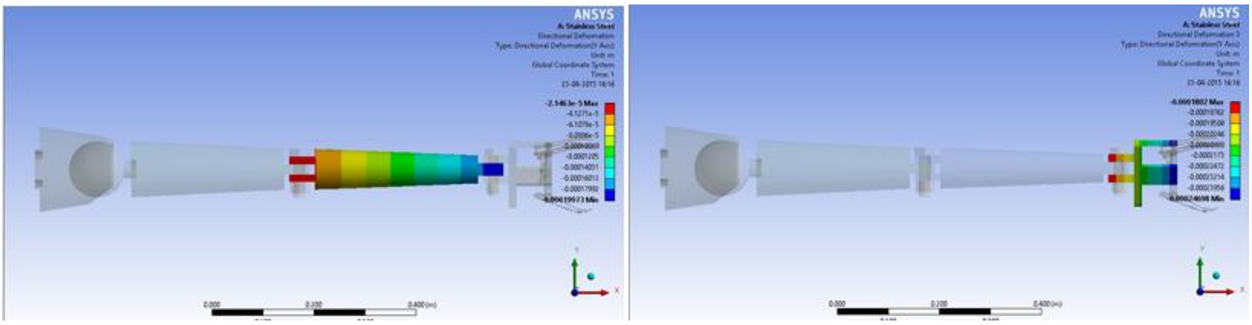

Figure 3: Stainless steel Deformation of link 3 and 4

IV.RESULTS AND DISCUSSION

For analyzing the three fingered robotic arm four different materials were chosen(Stainless steel, Aluminium alloy 6061 T6 , Magnesium alloy, Titanium alloy CP grade 01).There are certain loading conditions and cross sectional area are considered for the analyzing the robotic arm in "Fig.4" . The varying wall thickness for cross sectional areas of robotic arms are taken as 10mm, 15mm, 20mm and 25mm. The amount of load applying is 10kg, it is applied on the palm of the arm.

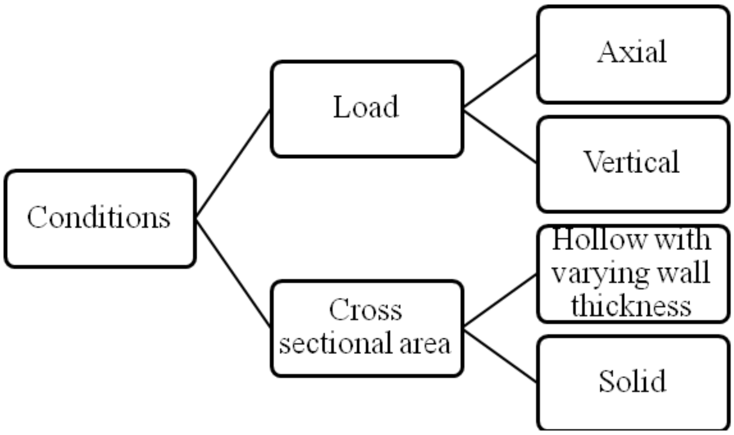

Figure 4: Conditions for Analyzing

Various material properties were involved to analysis the three fingered robotic arm deformation and stress. The properties of various list in the "TABLE 1".

Table 1: Material Properties

Material	Yield Strength (Mpa)	Density kg/mm^3
Stainless steel	215	7850
Aluminium Alloy - 6061 T6	241	2700
Magnesium Alloy	193	1800
Titanium Alloy- CP grade 1	221	4430

Under axial load condition the stress and deformation of various materials with different description(10mm,15mm,20mm,25mm and in solid section) can be obtained through analysis "TABLE 2". The graph can be plotted between obtained stress values for different materials and area of cross section under different description "fig.5"

International Journal of Advanced Technology in Engineering and Science
Vol. No.4, Issue No. 08, August 2016
www.ijates.com
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ISSN 2348 - 7550

Table 2: Stress and Deformation for Axial load conditions

Description	Stainless steel		Aluminium Alloy - 6061 T6		Magnesium Alloy		Titanium Alloy- CP grade 1	
	Deformation (m)	Stress (Mpa)	Deformation (m)	Stress (Mpa)	Deformation (m)	Stress (Mpa)	Deformation (m)	Stress (Mpa)
10 mm	0.0045584	10.102	0.001708	3.8073	0.03448	2.5633	0.004175	5.894
15 mm	0.0039402	8.5871	0.001605	3.1924	0.032682	2.1238	0.003796	4.9138
20 mm	0.0042291	9.2037	0.001564	3.4004	0.033123	2.2531	0.003932	5.2484
25 mm	0.0040672	8.9536	0.001506	3.3103	0.03271	2.1955	0.003839	5.1181
Solid	0.0039714	8.7533	0.0015717	3.3218	0.032623	2.1406	0.0037811	4.9927

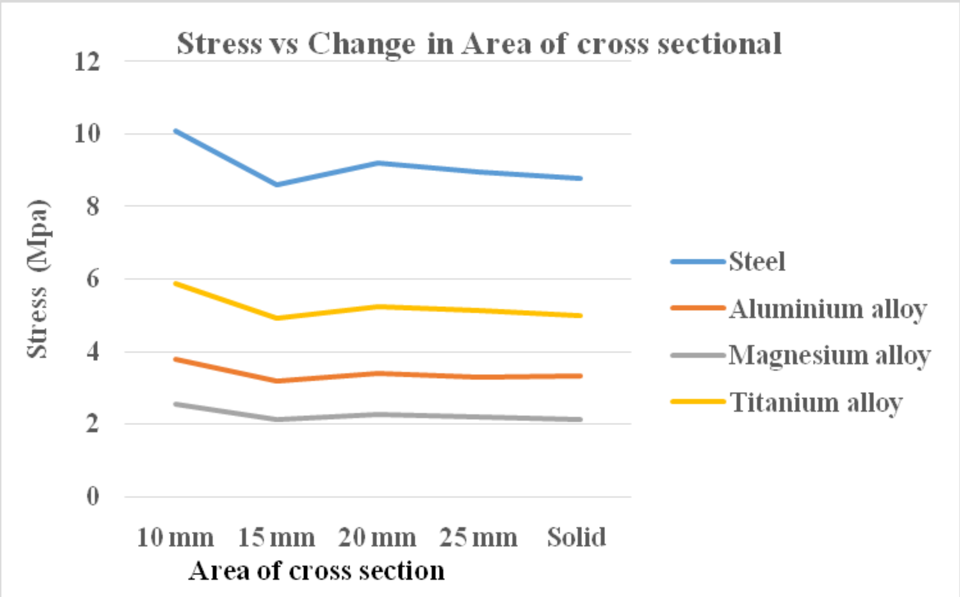

Figure 5: Stress vs Change in area of cross section (Axial load)

Under axial load condition the directional deformation of various links of various materials with different description (10mm, 15mm, 20mm, 25mm and in solid section) can be obtained through analysis "TABLE 3". The graph can be plotted between obtained directional deformation for different materials and area of cross section under different description "fig. 6 &7"

Table 3: Directional deformation under axial load condition

Description	Stainless steel				Aluminium Alloy - 6061 T6				Magnesium Alloy				Titanium Alloy- CP grade 1			
	L1	L2	L3	L4	L1	L2	L3	L4	L1	L2	L3	L4	L1	L2	L3	L4
10 mm	1.42	2.26	1.00	1.21	1.40	2.26	1.01	1.24	1.44	2.37	1.07	1.31	1.69	2.71	1.19	1.45
15 mm	2.13	1.94	0.87	1.05	2.07	1.92	0.87	1.06	2.13	1.99	0.91	1.11	2.52	2.29	1.02	1.24
20 mm	2.35	2.02	0.93	1.12	2.31	1.99	0.93	1.13	2.37	2.06	0.97	1.18	2.79	2.38	1.09	1.33
25 mm	2.41	1.82	0.89	1.08	2.35	1.80	0.89	1.08	2.41	1.87	0.92	1.13	2.85	2.17	1.05	1.28
Solid	2.61	1.81	0.81	1.06	2.55	1.79	0.87	1.06	2.61	1.86	0.90	1.11	3.09	2.15	1.03	1.25

*L- Links in m

International Journal of Advanced Technology in Engineering and Science
Vol. No.4, Issue No. 08, August 2016
www.ijates.com
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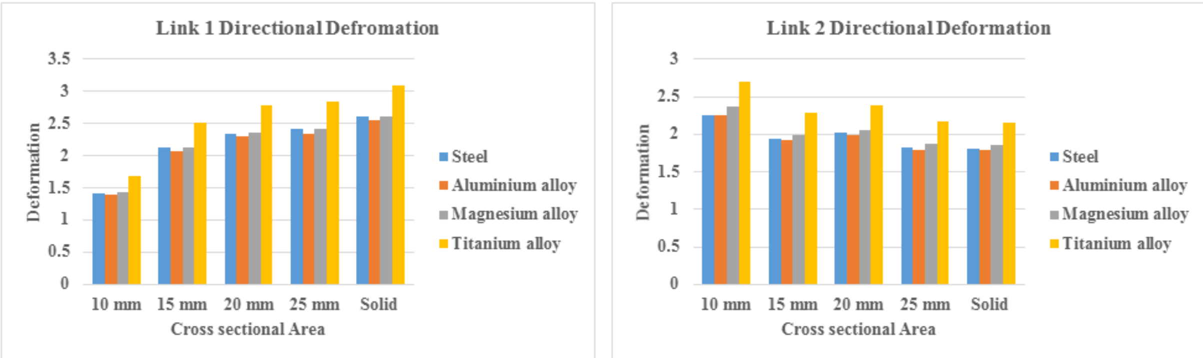

Figure 6: Directional deformation of link 1 & 2

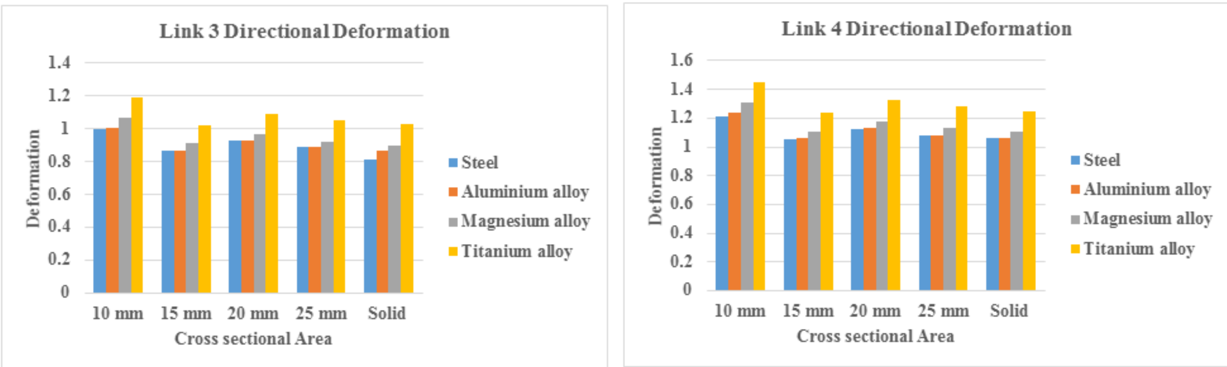

Figure 7: Directional deformation of link 3 & 4

Under vertical load condition the stress and deformation of various materials with different description(10mm,15mm,20mm,25mm and in solid section) can be obtained through analysis "TABLE 4". The graph can be plotted between obtained stress values for different materials and area of cross section under different description "fig. 8"

Table 4: Stress and Deformation for vertical load conditions

Description	**Stainless steel**		**Aluminium Alloy - 6061 T6**		**Magnesium Alloy**		**Titanium Alloy- CP grade 1**	
	Deformation (m)	Stress (Mpa)	Deformation (m)	Stress (Mpa)	Deformation (m)	Stress (Mpa)	Deformation (m)	Stress (Mpa)
10 mm	0.013258	31.287	0.010117	24.522	0.12885	22.789	0.01309	25.821
15 mm	0.009807	23.051	0.007147	17.306	0.097551	15.861	0.00973	18.454
20 mm	0.010127	23.695	0.007251	17.531	0.096597	16.004	0.00993	18.802
25 mm	0.009569	22.673	0.006804	16.696	0.091988	15.234	0.00945	17.976
Solid	0.0091773	21.839	0.006498	15.989	0.089373	14.555	0.00909	17.228

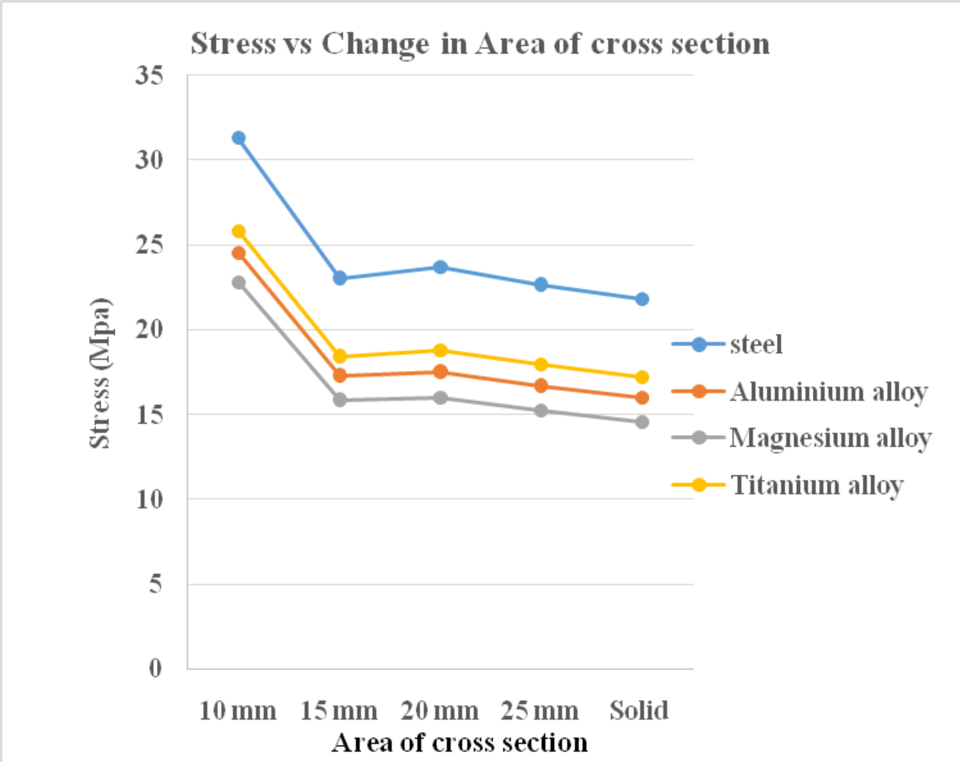

Figure 8: Stress vs Change in area of cross section (Vertical load)

Under vertical load condition the directional deformation of various links of various materials with different description (10mm, 15mm, 20mm, 25mm and in solid section) can be obtained through analysis "TABLE 5". The graph can be plotted between obtained directional deformation for different materials and area of cross section under different description "fig. 9 &10"

Table 5: Directional deformation under vertical load condition

Description	Stainless steel				Aluminium Alloy – 6061 T6				Magnesium Alloy				Titanium Alloy- CP grade 1			
	L1	L2	L3	L4	L1	L2	L3	L4	L1	L2	L3	L4	L1	L2	L3	L4
10 mm	3.01	5.98	2.91	3.57	5.69	12.3	6.15	7.60	8.16	18.15	9.10	11.25	4.82	10.07	4.94	6.08
15 mm	3.82	4.29	2.16	2.66	6.65	8.26	4.33	5.36	9.30	11.89	6.29	7.81	5.87	6.91	3.53	4.36
20 mm	4.03	4.28	2.21	2.72	6.83	8.09	4.38	5.42	9.47	11.58	6.34	7.87	6.11	6.82	3.59	4.44
25 mm	4.01	3.79	2.08	2.57	6.68	7.10	4.08	5.08	9.19	10.15	5.91	7.37	6.01	6.03	3.37	4.18
Solid	4.60	3.66	2.00	1.80	6.85	6.79	3.90	4.85	9.34	9.68	5.62	7.02	6.23	5.81	3.22	4.00

*L- Links in m

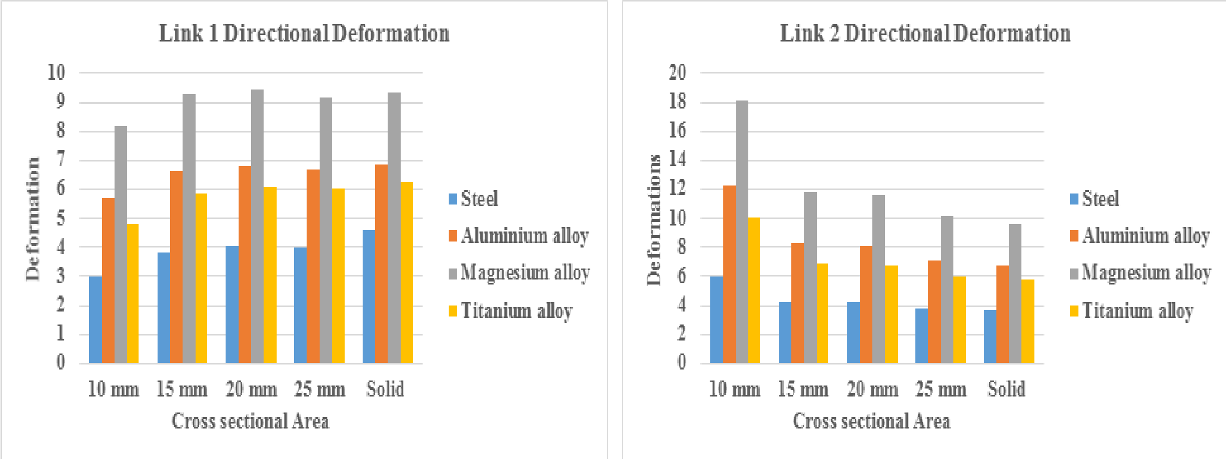

Figure 9: Directional deformation of link 1 & 2

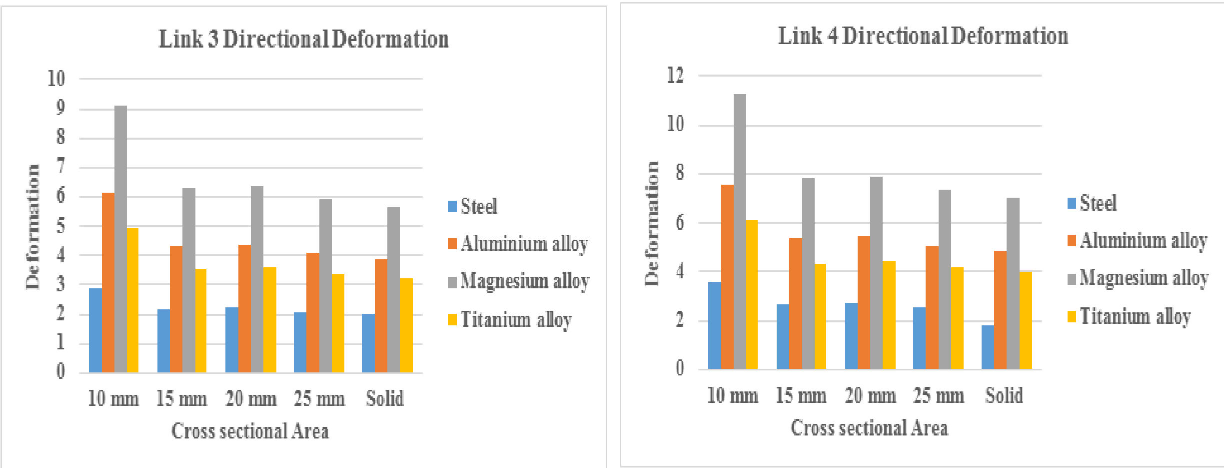

Figure 10: Directional deformation of link 3 & 4

V. CONCLUSION

Inference of above result are stress and deformation decreases with increasing area of cross section of the links. In case of axial load conditions Mg alloy shows less range of stress values varying from 2.560 to 2.14 Mpa. But in vertical load condition all four materials shows similar range of stress values. In directional deformation links, the link 1 have more deformation when compared to other links in axial load conditions. But link 4 shows higher deformation in vertical load conditions. According to various load condition, directional deformation of links Mg alloy shows better result when compared to other materials (Stainless steel, Aluminium alloy and Titanium alloy).

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