Original Article: Effects of Additional Mechanisms on The Performance of Workshop Crane

Pourya Bazyar[1,*] | Andreas Baumgart[2]

[1]*Department of Agricultural Machinery Engineering, Faculty of Agricultural Engineering and Technology, University of Tehran, Karaj, Iran*
[2]*Department of Mechanical Engineering and Production Management, Berliner Tor 21, 20099, Hamburg university of applied science, Hamburg, Germany*

Use yor device to scan and read the article online

Citation P. Bazyar*, A. Baumgart, **Effects of Additional Mechanisms on The Performance of Workshop Crane.** *J. Eng. Indu. Res.*, 2022, 3(2), 87-98.

https://doi.org/10.22034/JEIRES.2022.2.1

Article info:
Received: 02 September 2021
Accepted: 05 October 2021
Available Online: 20 October 2021
ID: JEIRES-2110-1060
Checked for Plagiarism: Yes
Peer Reviewers Approved by:
Dr. Amir Samimi
Editor who Approved Publication:
Professor Dr. Mohammad Haghighi

Keywords:
workshop crane, mobile machine shop-cranes

ABSTRACT

Typically, mobile machine shop-cranes are used in applications where a lifting solution is needed for operation in a small area or within a large industrial facility that has limited space available. Workshop cranes are able to benefit mechanical advantage to raise weighty gadgets. The profile, i.e. the tall vertical a part of a crane, is held via a big, hefty base, which aims to offset the weight the crane grips at superior heights. Workshop crane is an overhead crane gadget which turns ponderous elevating within the workshops. Workshop cranes apportions the load of your objects over a machine, which includes a bridge and two parallel runways. Motion and navigation of weights over than 2000 kilos becomes convenient in order to distribute the weight. In this research, some changes were made on a mobile machine shop-crane. Then, they were designed in CATIA and analyzed in ANSYS. After that, they were compared with each other. It was designed with 120 and 140 millimeters profiles. The chosen maximum weight was 750 kilograms. Moreover, the results of analysis showed that the changed model had the best performance than primary model.

Introduction

The cranes have a crucial importance in up-to-the-minute fabricating industries [1]. A crane is a sort of device usually comprising of a hoist, wire, ropes or chains and shears. All of these components are used to raise and decrease substances and to move them horizontally. It is typically used for raising leaden hundreds and forwarding them from one point to another. It makes use of one or more primitive devices to create mechanical benefit and for this reason it is important in the normal human physical elevating functionality [2,3,4]. Also, it is better to use finite element analysis before constructing special machine like harvesters [5,6]. In this section, some patents will be considered.

Spitsbergen (2008) designed a system related to a small transportable lifting package. It causes moving slight weights in low distances. Small masses are hundreds that cannot effortlessly be raised by using one or individuals [7]. Fei, *et al*. (2015) invented a

***Corresponding Author:** *Pourya Bazyar (pourya.bazyar@ut.ac.ir)*

crane that provides a swing arm tower crane assists hoist mechanism, including fix supporting platform, the hoisting accessory on the body of the tower, hoist engine and rope guide device. The hoist engine is installed supporting platform, and passes through rope guide device with hoisting accessory connects [8]. Woods (1998) constructed an engine hoist, which includes an inclined boom. The boom contains a lengthwise extendable load lifting end with a guide pulley. Furthermore, the hoist and stand assembly of the instant invention comprise of some of the general structural features of a conventional engine hoist [9]. Anthony and Cresci (1963) manufactured a vehicle for transporting loads, collection of the weight, or dismantling with parallel fluctuation of weight assisting or including elements. One of the objects of the invention is the provision of a fluid operated high-lift mechanism for moving the load carrying body vertically. Another object of the invention is to provide supporting means for an overhead trolley [10]. Rujin, *et al*. (2102) fabricated a model related to the travelling crane for transporting production in workshops. A travelling track constitutes a ring shape together with I-steel fixed at the top end of the upright post. Additionally, the travelling track is provided with an electric hoist that runs circularly along the track. The travelling crane has a simple structure, it does not need for secondary manual carrying, labor force consumption is lowered, vehicle transport cost is not required, and production cost is saved [11]. Donghua, and Zheng (2016) invented a workshop traveling crane. A hanging bracket is arranged at the top end of an inner workshop, and a hanging beam is fixed to the lower end of the hanging bracket., The mentioned traveling crane ran synchronously, saved costs, and improved efficiency [12]. Jinglei, *et al*. (2014) disclosed a special lifting arrangement structure for feeding and discharging of an aluminum strip annealing material coil in a high rack warehouse. The special lifting arrangement structure comprises a high rack warehouse, an annealing straddle and an annealing furnace arranged inside the annealing straddle. The high rack warehouse is arranged adjacent to the lateral wall of the annealing straddle. A channel through which a special material base of the high rack warehouse passes is arranged on the lateral wall of the annealing straddle [13]. Hongtao (2014) invented a bridge type electromagnetic crane. The bridge type electromagnetic crane mainly comprises an operation room, a bridge frame, a trolley, a steel wire rope, an electromagnetic sucking cup and a camera. The operation room is fixed below the left part of the bridge frame. Moreover, a trolley runs on the bridge frame. Additionally, the steel wire rope falls down from the trolley. Ultimately, electromagnetic sucking cup is suspended at the lower end of the steel wire rope [14].

This study aimed at adding some mechanism to improve the strength of the primary crane against damages during the lifting process.

Material and Method

In this part, some parameters including design descriptions, analyzing parameters, design limitation, and methods of evaluation were checked. In this research, the disadvantages of the mentioned mobile machine shop-cranes were evaluated. After concentrating on this crane, we found that there was not a distribution of force in of the section AB. The goal of this study was to increase the strength of the AB section by adding some surplus mechanisms. Some changes were made including: a) Perpendicular to the angle of the jack; b) adding truss on the number 2 Horizontal profile (fig. 1); c) decrease the size of number one Horizontal profile (fig. 1); and d) adding another connection hole to the second Horizontal profile (number 2).

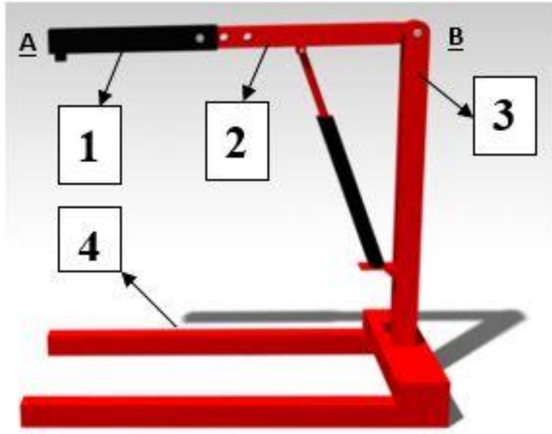

Figure 1: Render of the primary model

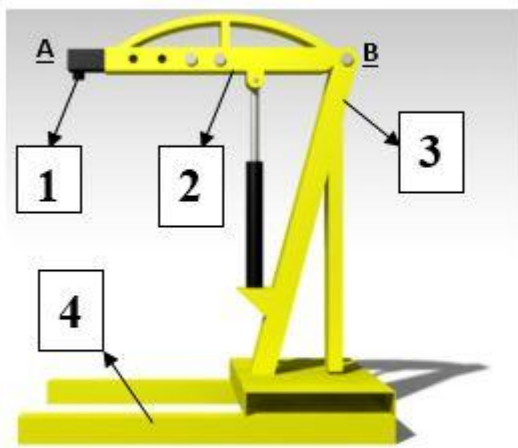

Figure 2: Render of the changed model

Type of material

The primary evaluations conducted in choosing materials for the workshop crane elements entailed powerfulness, machinability, firmness, flexibility, etc., for each element of the crane.

a) Material for vertical profile

The vertical profile was in danger of a condensed stress, and the material for the profile was a cast Iron. Cast Iron has little cost, desirable casting, and high condensed stress. It is initially produced by carbon and iron with carbon constituents of 1.7% to 4.5%.

b) Material for the horizontal profile

Regarding the high load on AB section of the crane, the chosen material of this section was firm and strict. So, the appropriate material was Carbon above 1.5% with a high resistance and intensity.

c) Material for Bolt

Bolts endured stretched and shearing stress. So, mild steel is the best choice to oppose these stresses.

d) Material of Pins

The pins endured stretched and shearing, and materials, which could suffer stresses. Mild steel was selected for pins material.

Design aspects

The following factors were considered: a) It should conduct the task for that it is designed; b) it has to be statically and dynamically durable; c) it has to be stable; and d) it has to gain its life time (i.e. at least 10 years).

Design specification

Two models were designed in CATIA, named primary model (before adding additional mechanism) and changed model (after adding some mechanisms). The chosen material for both models was steel. 120 and 140 millimeters profiles were selected. Furthermore, the height of crane was 2 meters. Other design descriptions are demonstrated in table 1 and 2.

Table 1: Parameters of primary model

Primary mode				
Dimension of number 1 in fig.1	Dimension of number 2 in fig.1	Dimension of number 3 in fig.1	Angle of the jack	Dimension of number 4 in fig.1
140×140×750 mm	120×120×1500 mm	140×140×2000 cm	30 degrees	140×140×2250 cm

Table 2: Parameters of changed model

Changed mode				
Dimension of number 1 in fig.2	Dimension of number 2 in fig.2	Dimension of number 3 in fig.2	Angle of the jack	Dimension of number 4 in fig.2
120×120×750 mm	140×140×1500 mm	140×140×2000 cm	90 degrees	140×140×2250 cm with an angle of 30 degrees

Designing calculations

A. profile formulas

In fig 3., the sectional view of the profile is demonstrated.

(1) $Ax = FL \cos\theta$

But,

(2) $\sigma = F/A$ [15]

The profile's thickness is 8mm.

Therefore,

(3) L= A/4 XThickness(mm)

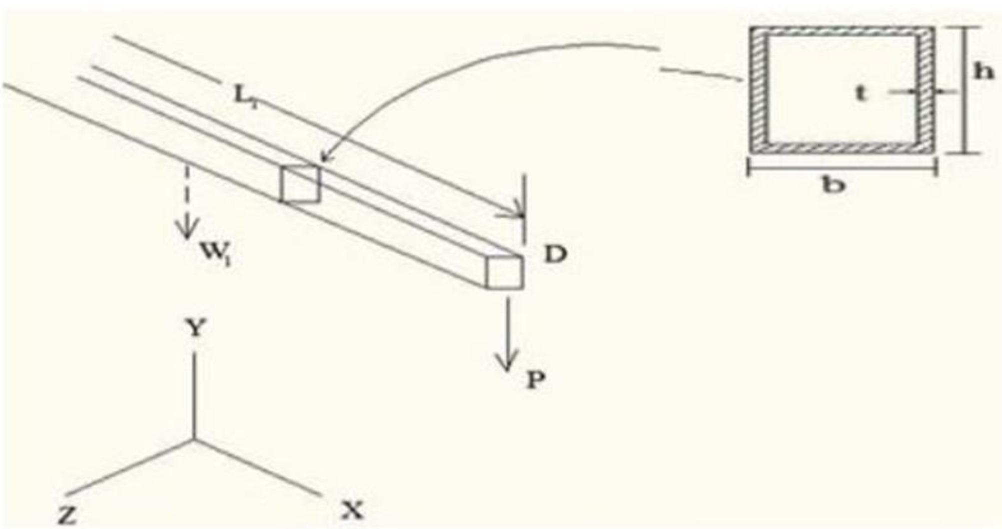

Figure 3: partial view of profile

B. flexural torque and Shear Force on the horizontal profile.

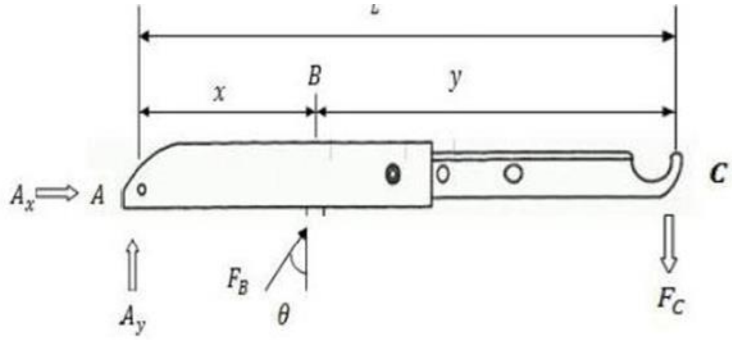

Figure 4: Diagram of horizontal profile's sustained loads

Calculation of the torque of point A

$$+\sum M_A = 0$$

so,

(4)

$$(F_B Cos\theta \times x) - (F_C \times L) = 0$$
$$F_C = \frac{F_B Cos\theta \times x}{L} = \frac{xF_B Cos\theta}{L}$$

C. counteraction of point A

(5)

$$\uparrow + \sum F_y = 0$$
$$\therefore A_y + F_B Cos\theta - 0F_C = 0$$
$$A_y = F_C - F_B Cos\theta$$

Shear Force at Point A

(6)

$$\rightarrow + \sum F_x = 0$$
$$\therefore A_x + F_B Sin\theta = 0$$
$$A_x = -F_B Sin\theta$$

D. Shear force at point B

(7)

$$F_{BX} = F_B Sin\theta$$

E. Stretching torque at point B

(8)

$$+\sum M_B = 0$$
$$\therefore (A_y \times x) + M_B = 0$$
$$M_B = -xA_y$$

F. Stretching torque at C

(9)

$$+\sum M_C = 0$$
$$\therefore (A_y \times L_{1)} - (F_B Cos\theta \times y) + M_C = 0$$
$$M_C = yF_B Cos\theta - A_y L$$

G. Gathered stress at the corrugation

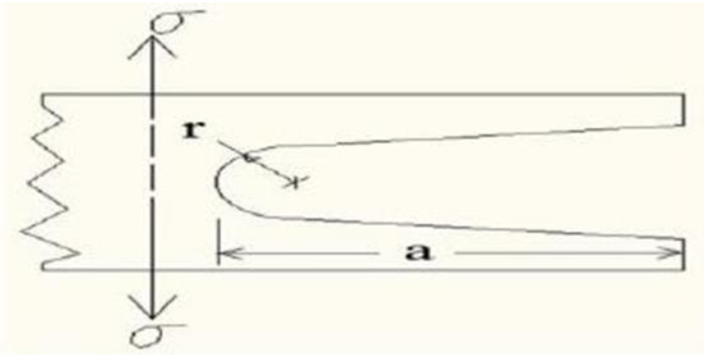

Figure 5: Right view of the flute

$$\sigma_{max} = \sigma\left(1+\frac{2a}{r}\right) N/M^2$$ [15].

Σ MZ = 0 at B

$$FL_1 + \frac{1}{2}W_1L_1 + \frac{1}{2}W_3L_3 + \frac{1}{2}W_3L_3 + \frac{1}{4}W_CL_3 = 2R_AL_3 + F_L(Sin60)\frac{L_1}{2} \quad (1)$$

$$R_A = \frac{1}{2}F\frac{L_1}{L_3} + \frac{W_1L_1}{4L_3} + \frac{W_3}{2} + \frac{W_C}{8} - F_L(Sin60)\frac{L_1}{4L_3} \quad (2)$$

$$R_B = F + W_1 + W_2 + W_3 + W_3 + W_C - 2R_A - F_L(Sin60)$$

Σ Fy, to the sustained loads diagram and force equals to zero and with a numerator WC to avoid turning over [16].

These equations were used for evaluating primary and changed model.

Analysis setting

Fixed support:

In the designs of both models, the base of the models was fixed.

Force:

F=m×g× confidence coefficient = 750 (kg) ×10 (N/kg) × 1.1 = 8250 *N*

Result and discussion

According to design descriptions and initial information, the results of research were explained.

Results of Ansys analysis

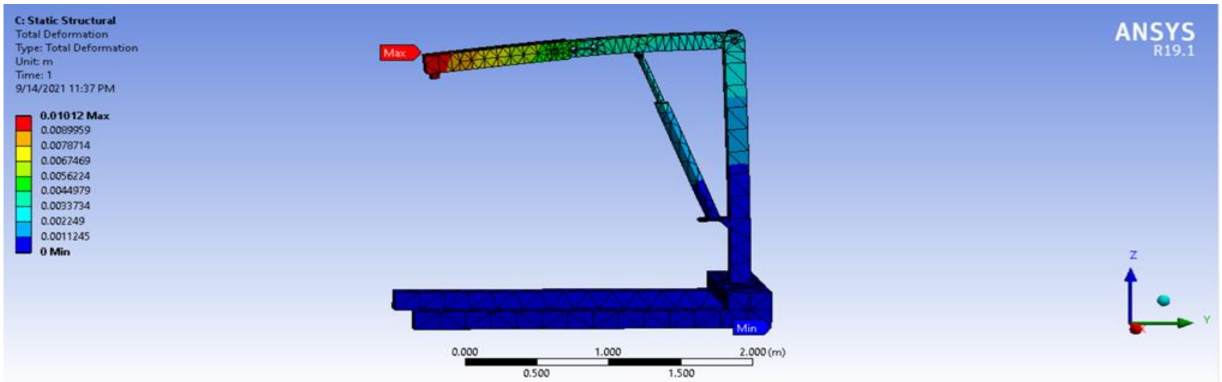

Figure 6: Deformation of primary model

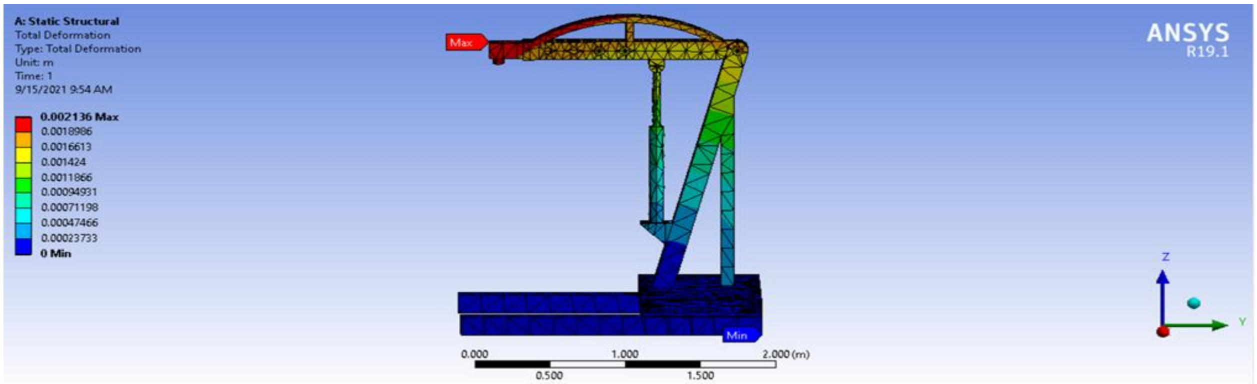

Figure 7: Deformation of changed model

Table 3: Deformation (m)

Primary model		Changed model	
Maximum	0.01012	**Maximum**	0.002136
Minimum	0	**Minimum**	0

With reference to Figures 6 and 7, section AB of both models was deformed more than other sections of both models. The maximum deformation of changed model decreased slightly by about 0.0080 (table 3).

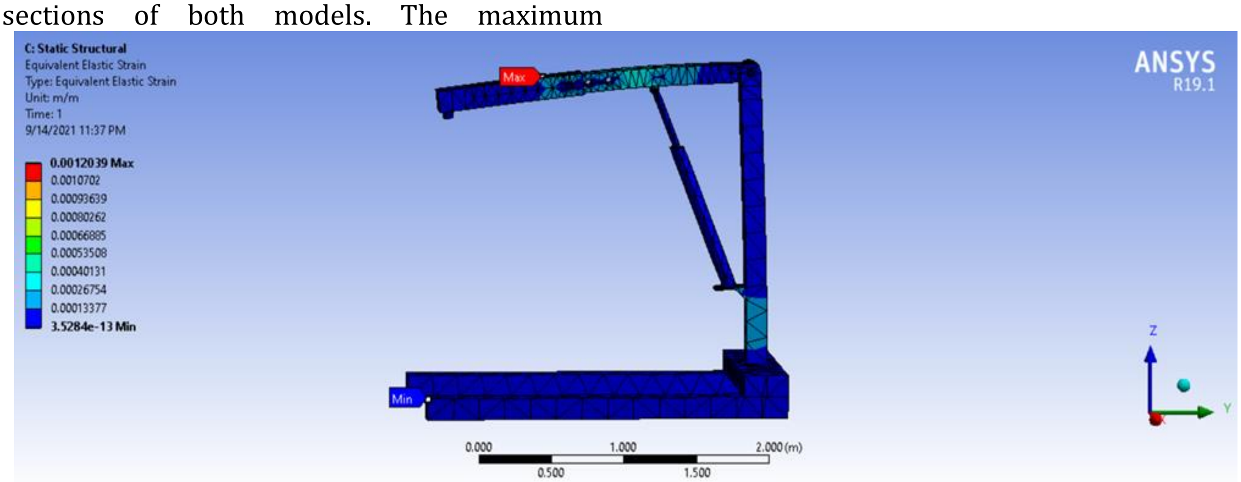

Figure 8: Strain of primary model

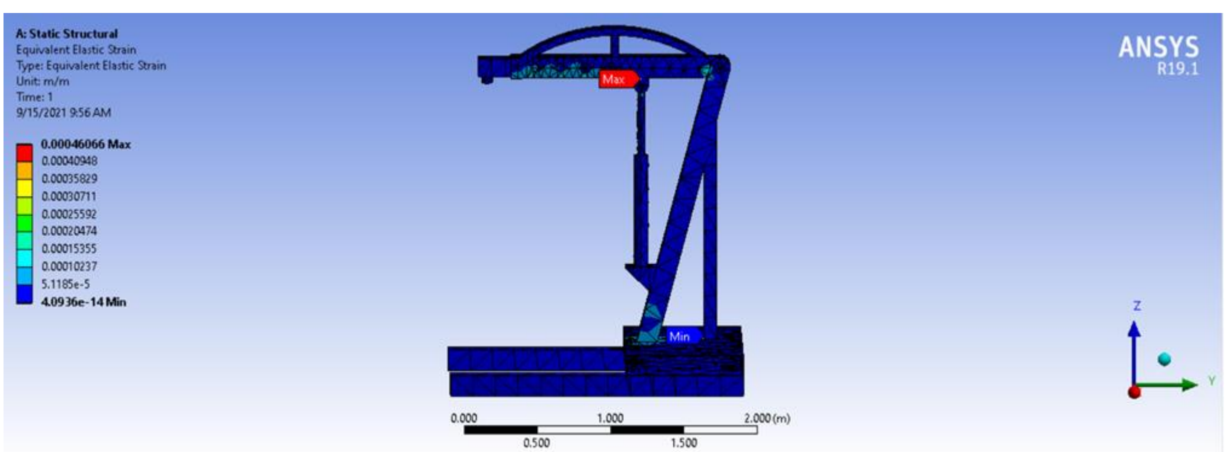

Figure 9: Strain of changed model

Table 4: Strain (m/m)

Primary model		Changed model	
Maximum	0.0012039	**Maximum**	0.00046066
Minimum	3.5284 e -13	**Minimum**	4.0936 e -14

As shown in Figures 8 and 9, the maximum strain was sustained by the connection pin between jack and horizontal profile in both models. The maximum strain experienced a mild fall about 0.00074 mm/mm. However, the minimum strain dipped significantly about 31.19 e-14 (table4).

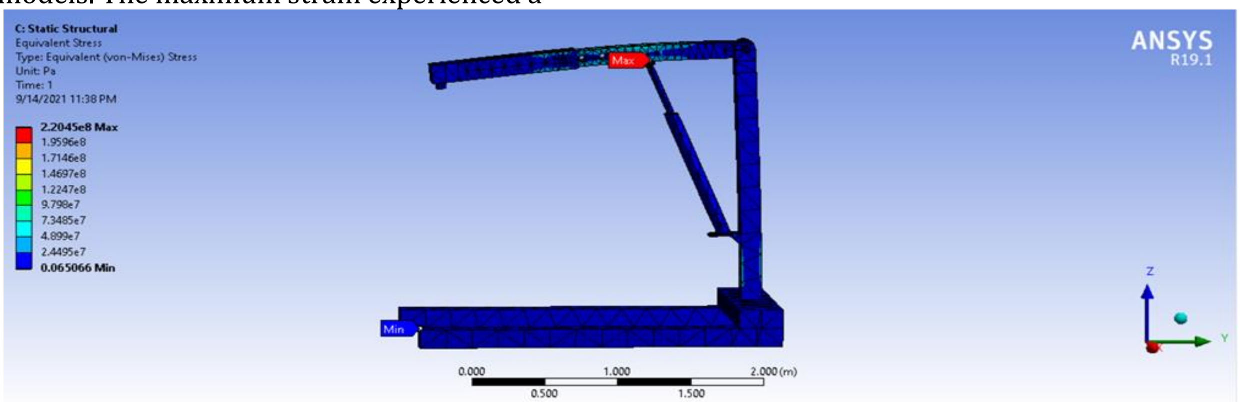

Figure 10: Stress of primary model

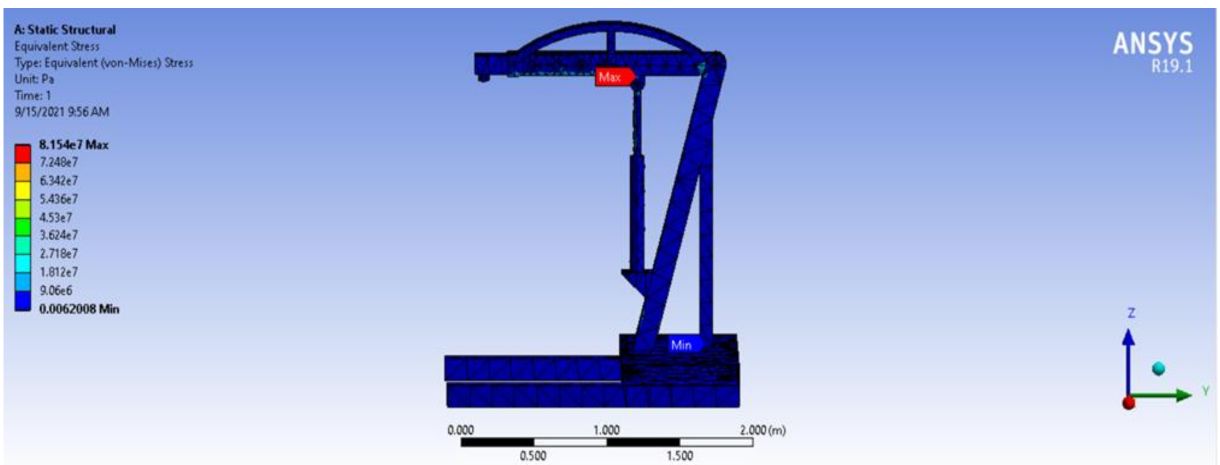

Figure 11: Stress of changed model

Table 5: Stress (Pa)

Primary model		Changed model	
Maximum	2.20458 e8	**Maximum**	8.154 e7
Minimum	0.065066	**Minimum**	0.0062008

According to Figures 10 and 11, the maximum stress was sustained by the connection pin between jack and horizontal profile. The maximum and minimum stress declined slowly by about 1.39 e8 (pa) and 0.0588 (pa), respectively (table 5).

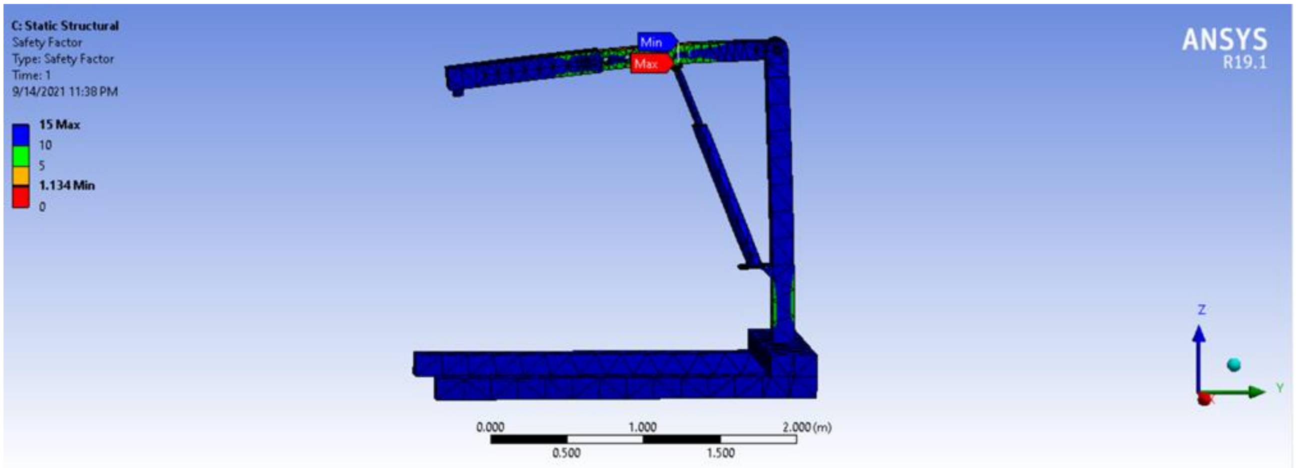

Figure 12: Safety factor of primary model

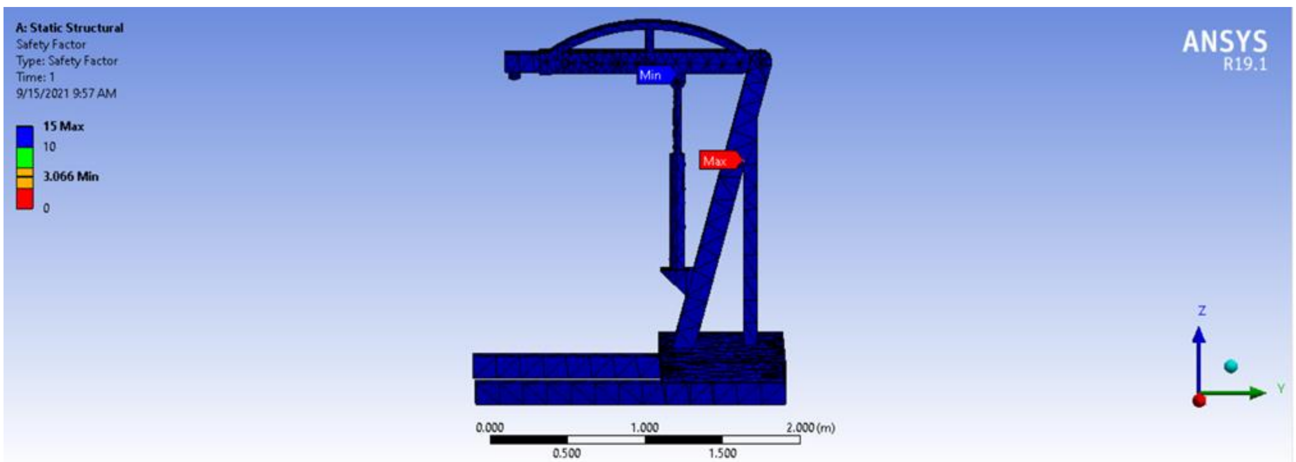

Figure 13: Safety factor of changed model

Table 6: Safety factor

Primary model		Changed model	
Maximum	15	**Maximum**	15
Minimum	0	**Minimum**	0

As it is demonstrated in Figure 12, the safety of section AB of primary model was less than section AB of changed model. The maximum safety factor was 15 in both models (table 6).

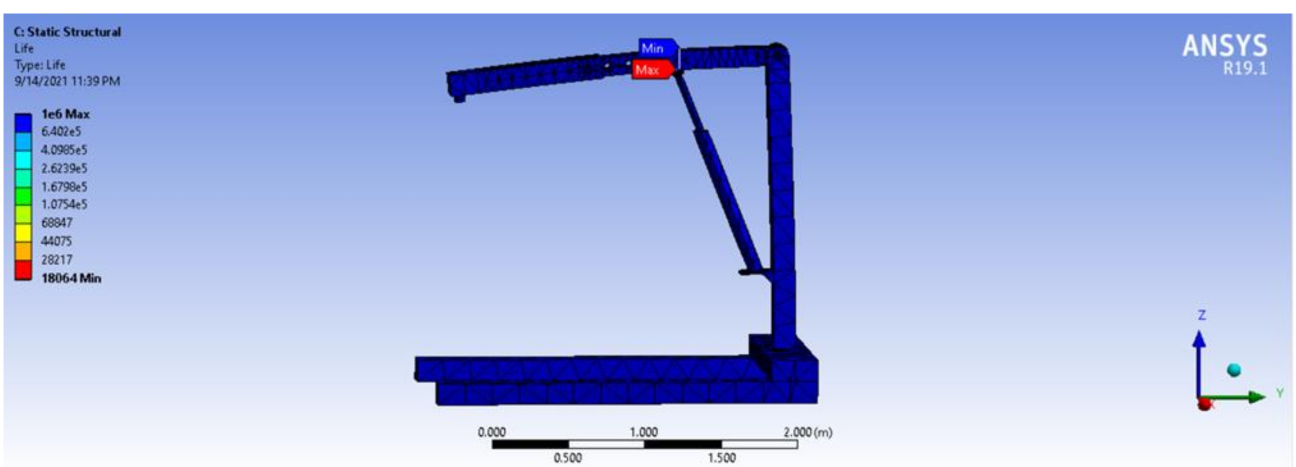

Figure 14: Life cycle of primary model

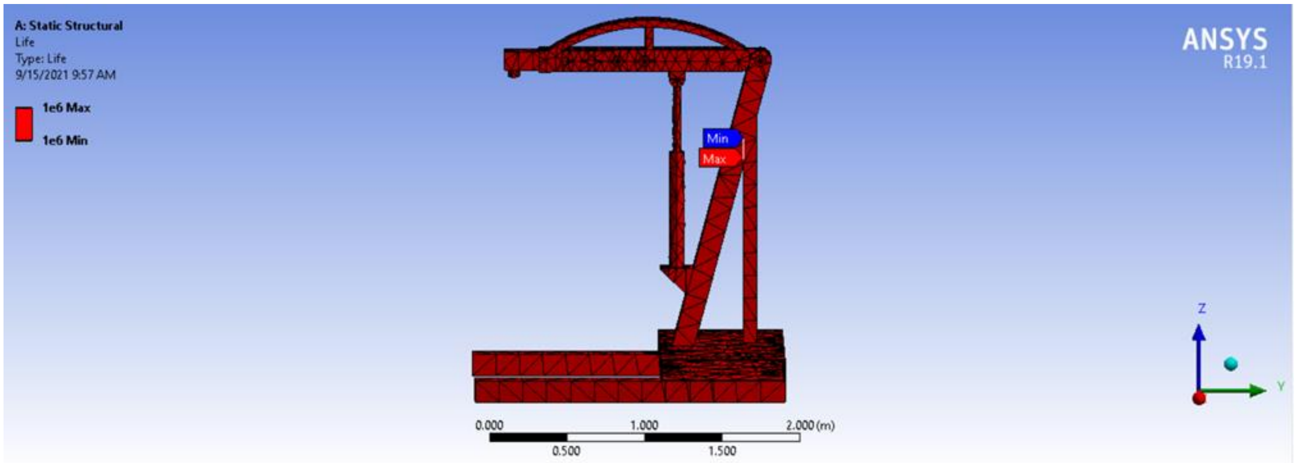

Figure 15: Life cycle of changed model

Table 7: Life cycle

Primary model		Changed model	
Maximum	1e6	**Maximum**	1e6
Minimum	18064	**Minimum**	1e6

The life cycle of all parts of changed model was 1 million cycles (Fig. 14), whereas, the life cycle of primary model was about 1800 cycles. It is clear that primary model was supposed to be damaged soon (table 7).

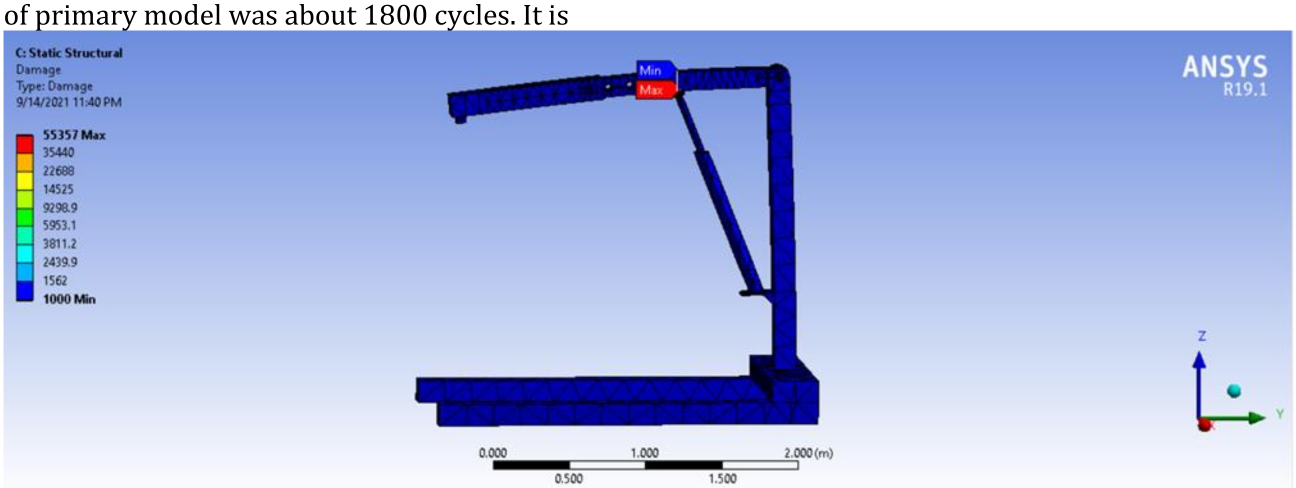

Figure 16: Damage of primary model

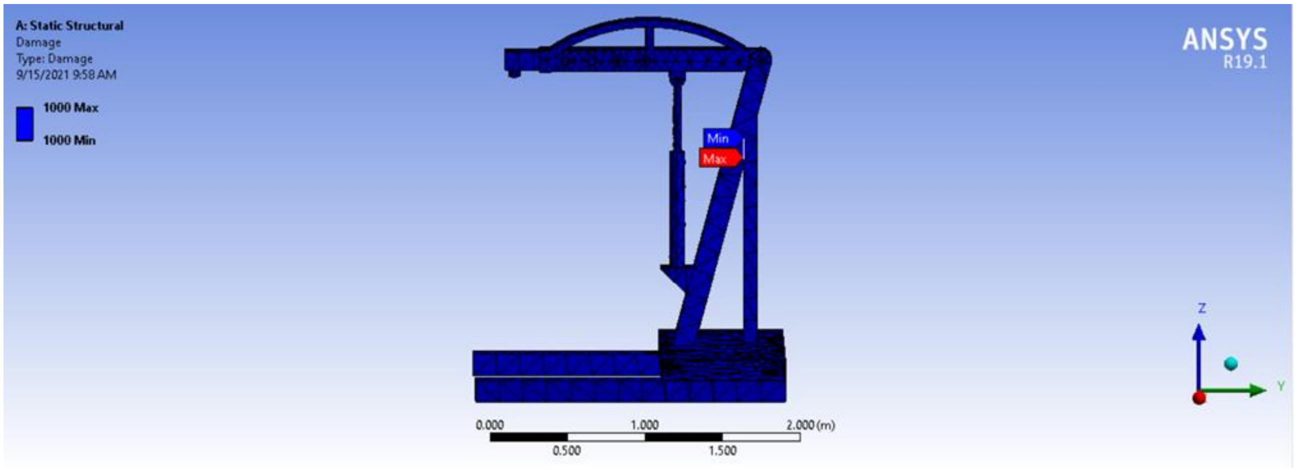

Figure 17: Damage of changed model

Table 8: Damage

Primary model		**Changed model**	
Maximum	55357	**Maximum**	1000
Minimum	1000	**Minimum**	1000

The maximum damage of primary and changed model was in the connection point between jack and horizontal profile (Fig. 16), and supporting profile respectively (number 1 in Fig. 17). It is obvious that the primary model was in danger of damage more than the changed model.

Conclusion

In this research, there was not a distribution of force in the section AB. Moreover, the connection point between jack and horizontal profile was in danger of damage. The calculations revealed that the primary model required some surplus mechanisms for swelling its strength. Some changes were made like for instance perpendicular to the angle of the jack, adding truss on the horizontal profile (connected to vertical profile), decreasing the size of horizontal profile (connected to load), and adding another connection hole to the horizontal profile (connected to load). After analyzing the changed model, it was obvious that the amount of deformation and stress were reduced and it was safer than the primary model. It is suggested to make some changes including approach Jack to the maximum load when lifting, using a hydraulic jack with a vertical angle to take advantage of its maximum power, adding a motor for moving easily, using a weight proportional to maximum load, and adding fixture to reduce its movement when lifting the load (table 8).

Acknowledgments

Dr. Usbeck from university of applied science in Hamburg and Iran tractor manufacturing company are appreciated to help carry out this project.

Orcid

Pourya Bazyar: https://orcid.org/0000-0003-1882-8941

References

[1] Chisholm, Hugh, ed. "Cranes". Encyclopædia Britannica. 7 (11th ed.). Cambridge University Press. **1911**, 368–372. **[Google Scholar], [Publisher]**

[2] Tadasse, M., & Meshesha, T. **2017**. Design and Development of Portable Crane in Production Workshop: Case Study in Bishoptu Automotive Industry, Ethiopia. *American Journal of Mechanical Engineering*, *5*(2), 41-50. **[Google Scholar], [Link]**

[3] S.A. Paipetis, M. Ceccarelli, Proceedings of an International Conference held at Syracuse, Italy, June 8–10, 2010. Springer

Science & Business Media. **2010**, 416. **[Google Scholar], [Publisher]**
[4] Chondros, T. G. 2010. Archimedes life works and machines. *Mechanism and Machine Theory*, *45*(11), 1766-1775. **[crossref], [Publisher]**
[5] P. Bazyar, A. Jafari, R. Alimardani, V. Mohammadi, *Small-scale head of combine for harvesting sesame. Agricultural Engineering, 22(4), 02* **[crossref], [Google Scholar], [Publisher]**.
[6] P. Bazyar, A. Jafari, R. Alimardani, V. Mohammadi, J. Grichar, *Finite Element Analysis of Small-scale Head of Combine Harvester for Harvesting Fine-Grain Products. International Journal of Advanced Biological and Biomedical Research, 8(4), 340-358.* **[crossref], [Google Scholar], [Publisher]**
[7] M. Spitsbergen, Portable hoist assembly mounting systems and methods (patent). Application number: US20080217277A1. **2008**, 1-2. **[Google Scholar], [Publisher]**
[8] T. Fei, L. Yi, L. Peng, Z. Yupin, Swing arm tower crane assists hoist mechanism (patent). Application number: US20080217277A1. **2015**, 1-2. **[Publisher]**
[9] T.W. Woods, Mobile engine hoist and rebuild stand assembly (patent). Application number: US4770304A. **1988**, 1-2. **[crossref], [Google Scholar], [Publisher]**
[10] A. Cresci, P. Cresci, Load carrying vehicle (patent). Application number: US3103291A. 1963, 1-2. **[Publisher]**
Link:
[11] R. Skjaerpe, A travelling crane (patent). Application number: WO2006062414A1. **2006**, 1-2. **[Publisher]**
[12] Y. Donghua, C. Zheng, Workshop traveling crane (patent). Application number: CN202481924U. **2012**, 1-2. **[Publisher]**
[13] Z. Jinglei, W. Shuangsuo, S. Xiaoxin, Z. Manyou, L. Yanbin, Special lifting arrangement structure for feeding and discharging of aluminum strip annealing material coil in high rack warehouse (patent). Application number: CN203474838U. **2014**, 1-2. **[Link]**
[14] P. Hongtao, Bridge type electromagnetic crane (patent). Application number: CN203411248U. **2014**, 1-2. **[Google Scholar]**
[15] R. Khurmi, J. Gupta, Theory of machines, simple mechanisms. (14th Revised edition). S.Chand and Company Limited, **2009**. **[Publisher]**
[16] R.K. Rajput, Strength of Materials (mechanics of solids); S. Chand and Company Limited, **2010**. **[Publisher]**