IJASRM

International Journal of Advanced Scientific Research and Management, Vol. 2 Issue 5, May 2017.

www.ijasrm.com

ISSN 2455-6378

Design and Analysis of Spring Loaded Lift Table for Industrial Application Using FEA

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Abstract

In many industries, irrespective of the working height of the loading or unloading of the goods may cause of the product losses and also increases the worker's injury. In this paper, it is shown how a Computer Aided Engineering (CAE) analysis of a lift table is being done and deformation of parts of lift table is determined when loading and unloading take place. This includes analytical design, and further development of computational models of components, their analysis, assembly of components and analysis of the complete assembly. The solid models are created in Creo5.0 and the stress analysis has been carried out in ANSYS 14.5. The lift table is a leveller and the load is directly supported on the springs. The scissors legs are not lifting the load, but merely functioning as an equalizer to keep the platform square and level to the base.

Keywords: *Computer Aided Engineering (CAE), Lift Table, Computational model, Creo5.0, ANSYS14.5*

1. Introduction

Machine design is creation of plans for machine to perform the desired functions. The machine may be entirely new in concept performing new types of work or it may perform more economically the work that can be done by existing machine. Design can be taken to mean all the processes of conception, invention, visualization, calculation, refinement and specification of details that determine the form of a product. Design generally begins with either a need or requirement or alternatively, an idea. It ends with a set of drawings or computer representations and other information that enables a product to be manufactured and utilized.

The work in this thesis is being done with the visit of the Crompton greaves. During the visit of the Crompton greaves, the management of the assembly department need something which automatically keep work piece or still age load at an optimum working height when loading or unloading of goods. Crompton greaves assemble the fans which are used in a train. So, they need something which maintains 500mm height with a load of 668N (total weight of the 50 nos. of fan cover)

- Computer aided engineering (CAE) analysis of a lift table is being done and deformation of parts of lift table is determined when loading and unloading take place.
- This includes analytical design, and further development of computational models of components, their analysis, assembly of components and analysis of the complete assembly.
- The solid models are created in Creo5.0 and the stress analysis has been carried out in ANSYS 14.5.

2. Problems in Industries

- In many industries the employees of the assembly department complain about the back pains and muscular pains, for manual handling of the goods.

- The effect of manual material handling represent the biggest single contribution to worker injury in India and the application of good ergonomic program can reduce those incidences and the worker will be more productive and that productivity contributes to profit.
- In many industries irrespective of the working height of the loading or unloading of the goods may cause of the product losses and also increases the workers injury.
- Lifting of goods, Stretching, Reaching, Buckling, Stooping and Walking with goods, are some unnecessary worker activities can result ergonomics problems.
- Further the main problems arises when assembling the parts because in lift table, the parts are having motion between them, to increase the problems constraints are present which if gets wrong can change the direction of analysis. So, proper constraints have to be applied in the system.
- Experimental parameters is to be matched with simulation results but the problem is up to which level environmental conditions present actually matches with conditions available in the software.

Fig. 1Typical problem in industries

3. Design calculation of the lift table

The lifting table is being designed for lifting 50 number of fan covers each weighing 1.19 kg. Hence it is being designed for a total load of 584N. Fig. 2shows three dimensional view of the lifting table listing various components of the lifting table. Further in this chapter design procedure and calculations of each of the components is reported.

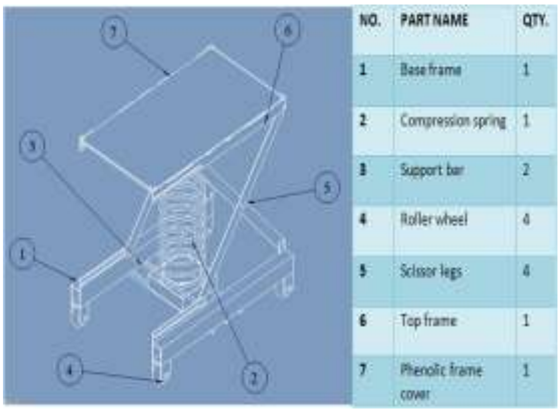

Fig. 2 Various component of the lifting table

3.1 Top deck frame

The main function of the Top deck frame is to bear the load of the fan covers and to hold the compressive spring. It appears in a rectangular shape and the top surface is flat and fabricated with different frames. And all the four corners of the top frame are clamped with the scissor legs. Initially, rectangular plate is use but the weight of the plate is too bulky and the material waste is taking place so in place of rectangular plate use top deck frame.

The material “ASTM A36” has been considered for it. A36 is the most commonly used mild and hot-rolled steel. It has excellent welding properties and is suitable for grinding, punching, tapping, drilling and machining processes. The mechanical and chemical properties of ASTM A36 material are as follows:

Table 1: Mechanical and Chemical properties of ASTM A36 mild steel

Mehanical Properties		Chemical Properties	
Density	7800 kg/m3	Carbon, C	0.25 - 0.29%
Young's Modulus	200 Gpa	Copper, Cu	0.20%
Poisson's Ratio	0.32	Iron, Fe	98.00%
Shear Modulus	75 Gpa	Manganese, Mn	1.03%
Yield Strength	250 Mpa	Phosphorous, P	0.04%
Ultimate Strength	400 - 550 Mpa	Silicon, Si	0.28%
Elongation at break	200mm	Sulphur, S	0.05%

For longer side of the frame as shown in Fig. 3, the two rectangular beams are loaded with a load i.e.

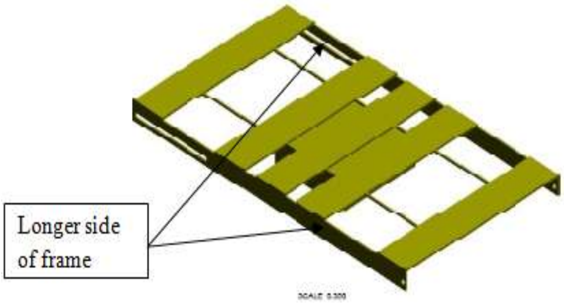

Fig. 3 Longer side of frame

$W_1 = 584/2$ N = 292 N

For convenience, a concentrated load is considered on the centre of the beam and design and the bending stress are found out as shown in Fig. 4.

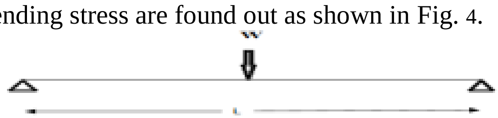

Fig. 4 Load on longer side of frame

Let, L = 750 mm, d = 40 mm, b = 4 mm, σ_{yp} = 250 N/mm^2, FOS = 4 (Mahadevan, 2012)

$$s_d = \frac{\sigma_{yp}}{FOS} = 63 \text{ N/mm}^2$$

Now using bending equation,

$$\sigma_b = \frac{M}{Z},\ M = \frac{W * L}{4},\ Z = \frac{I}{y_{max}},\ I = \frac{bd^3}{12},\ y_{max} = \frac{d}{2}$$

$$s_{b1} = 51.33 \text{ N/mm}^2$$

For shorter side of the frame as shown in Fig 5, the three rectangular beams are loaded at a single interval of time with a load i.e.

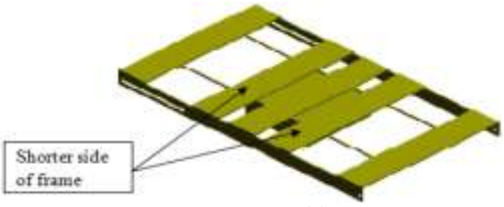

Fig 5 Shorter side of frame

$$W_2 = \frac{584}{3} = 195 \text{ N}$$

Let, L = 420mm, d = 5mm, b = 80mm

$$s_{b2} = \frac{M}{Z} = 61.46 \text{ N/mm}^2$$

Then, the total weight of the top deck frame are given below,

W = (total mass of shorter side of frame + total mass of the longer side of frame + mass of hollow cylinder + total mass of support frame) * 9.81

= (0.94*2 + 1.32*5 + 0.69 + 0.11) * 9.81

= 91 N

3.2 Base frame

The function of the base frame is to hold the compressive spring and clamped with all the four scissors legs. And its four edges are attached with the ground with the help of roller wheel as shown in Fig 6.The material of the base frame is same as used in the top deck frame.

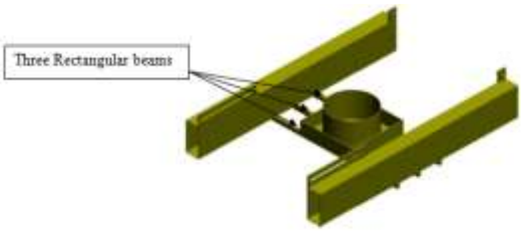

Fig 6 Three rectangular beams of base frame

The three rectangular beams as shown in Fig 7are loaded with a load of 670N. For convenient we take a concentrated load applied on the centre of the beam. Now finding the bending stress of a beam is as follows:

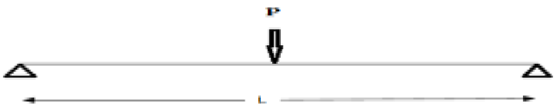

Fig 7 Load on three rectangular beams

$P = \frac{670}{3}$ = 224 N, L = 420mm, s_d = 63 N/mm^2, b = 10mm, d = 16mm

$$\sigma = \frac{(224 * 420 * 16 * 12)}{(4 * 2 * 10 * 16^3)} = 55.13 \text{ N/mm}^2$$

3.3 Rugged scissor legs

The main function of the scissor legs are to clamped both the top frame and the base frame and position the material at the proper work height. The scissors legs are not lifting the load, but merely functioning as an equalizer to keep the platform square and level to the base.

The rugged scissor legs are designed with a load of 584N and a weight of top deck frame as shown in Fig 8. Then the total load is divided into four parts and each parts is loaded as follows,

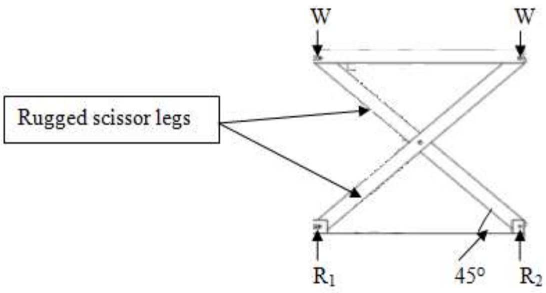

Fig 8 Rugged scissor legs

$$W = \frac{584 + 91}{4} = 169 \text{ N}$$

The frame is in symmetry condition. So the reaction forces are, $R_1 = R_2 = 169$ N and the compressive and tensile forces are 239 N and 169 N respectably. Similarly the entire frame members are act at the same load as given. So, now we find out the parameters of the frame by the help of the bending stress equation,

L = 750mm, d = 40mm, b = 3mm, $\sigma_d = 63$ N/mm^2

$$\sigma_c = \frac{239}{750 * 40} = 7.97*10^{-3} \text{ N/mm}^2$$

$$\sigma_c = \frac{169 * 750 * 6}{4 * 3 * 40^2} = 39.61 \text{ N/mm}^2$$

3.4 Support bar

The main function of the support bar is to hold the pair of the scissor legs. And the support bars are sliding under the slot provided in the top deck frame and base frame. The support bar as shown in Fig 9is being design with two point load of 168 N. Then the bending stress of the support bar is as follows:

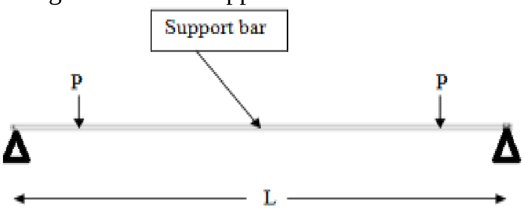

Fig 9 Support bar are placed as a simply supported beam

L = 400 mm, M = 3380 Nmm , P = 168 N, d = 9mm, $\sigma_d = 63$ N/mm^2

$$\sigma = \frac{(3380 * 9 * 64)}{(2 * P * 9^4)} = 47.23 \text{ N/mm}^2$$

3.5 Helical compression spring

The main function of the compression spring is to store the energy when the top deck frame is fully compressed under the loading condition. And when the load is lifted off in a controlled manner then this stored energy is released. The mechanical spring is used for low loading condition and for high loading condition use hydraulic and pneumatic pump.

The material "Oil Tempered (ASTM A229)" is use for designing of the helical spring. High-carbon spring steels are the most commonly used of all springs materials. Try to use these materials in preference to others because that is least expensive, readily available, easily worked, and most popular. These materials are not satisfactory for high or low temperatures or for shock or impact loading (Mahadevan and Reddy 2012). The properties of the material are as follows:

Table 2: Physical properties of oil tempered ASTM A229

Properties	Oil Tempered ASTM A229
Nominal Chemistry	C 0.55 – 0.75 % Mn 0.60 – 0.90% Si 0.10 – 0.35% S 0.04% Cu 0.15% P 0.04%
Ultimate Tensile Strength (Mpa*10^3)	1360 – 1510
E – Modulus of Elasticity (Mpa*10^3)	205
Design Stress % Ultimate Tensile	50
G - Modulus in rigidity (Mpa*10^3)	81.3
Maximum Operating Temperature, ^{0}C	121
Density g/cc	7.85
Method of Manufacture	Cold drawn and heat treated before fabrication

As the total load is applied on the spring are the sum of the weight of the top deck frame and the weight of the stocks of the fan cover. The helical compression spring which is compressed under the action of the load applied. So the total load is as follows,

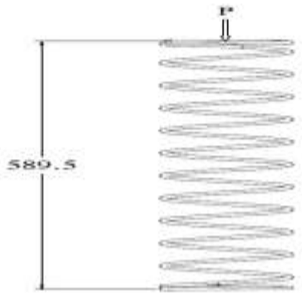

Fig 10 Helical compression spring

P = 68.3*9.81 = 670N

The total deflection of spring is up to, δ = 500mm and spring index, C = 17.5. And the stiffness of the spring is,

$$k = \frac{P}{\delta} = 1.34 \text{ N/mm}$$

Table 3: Spring design with different wire diameter

d (mm)	6	6.3	6.5	7	7.5	8
τ_d (N/mm2)	700	700	680	680	680	645
τ (N/mm2)	896.18	812.86	763.61	658	573.5	504.1
D (mm)	105	110.25	113.75	122.5	131.25	140
Nt	11	11	12	12	13	14
C	17.5	17.5	17.5	17.5	17.5	17.5
F.L. (mm)	571	574.3	583.5	589.5	603.5	618.5
F.L./D	5.43	5.2	5.12	4.8	4.6	4.42

The general constraints are 3 < N< 15, $\tau_d > \tau$ and F.L. /D > 2.6 guide is necessary are satisfied. We see that the diameters satisfy the given constraints as shown in Table 3. The 7mm diameter wire is the closest to satisfying all requirements. Then, the figure of merit decides and the decision is the design with 7mm diameter.

4. Modeling using Creo5.0

In this project work Creo5.0 has been used for modeling purpose of the spring loaded lift table. Here, the design of each component has been carried out through analytical calculation. Further, the components designed in this way are developed in CAD environment and then assembled. The individual components as well as assembled model are then imported into ANSYS workbench for the stress analysis. Creo5.0 software has the capability of transferring its modelled data into other CAD software's in different format like IGES.

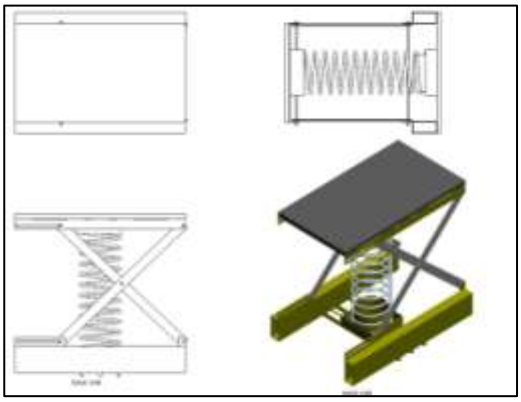

Fig 11Spring loaded lift table

5. FEA analysis in ANSYS

Motion analysis of the assembled model has been carried out in "Rigid Dynamics" module of ANSYS Workbench to find out total deformation of the lift table.

Pre-processing consist of numbers of steps include import the file, assign material and properties, create meshing of each component, create load collector and load step and finally select the desired output. The IGES file format are imported in the geometry module from Creo5.0 to ANSYS 14.5. Create 2D auto mesh on each component having element size default medium. Create connection between all the components of rigid elements. Apply load on the top of the plate form. Select desired output for analysis (total deformation, directional deformation, stress).

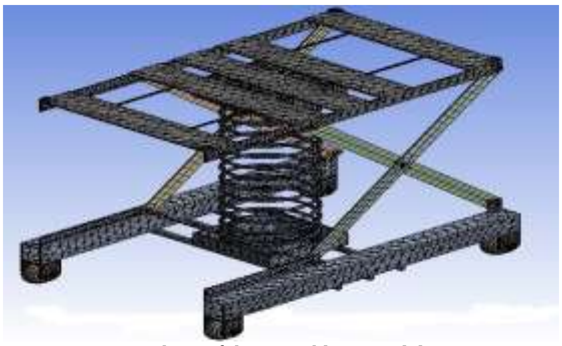

Fig 12 Meshing of the assembly in rigid dynamics

IJASRM

International Journal of Advanced Scientific Research and Management, Vol. 2 Issue 5, May 2017.

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ISSN 2455-6378

6. Results and Discussion

The finite element analysis of various components of the lift table has been done. It may be noted that the analytical approach of designing components has the limitation that the intricate and complex details cannot be included in the design process. This limitation is overcome in finite element modelling and analysis.

Stress of each component is found out in static structural analysis of ANSYS Workbench and an attempt is made to correlate the results with closed form solution. The details of components e.g. geometry, material, load applied etc has not been reproduced. All these details and dimensions of each component with boundary conditions and load applied can be seen above.

Simulation view of helical compression spring is shown in Fig 14, the total deformation comes out under the required limit.

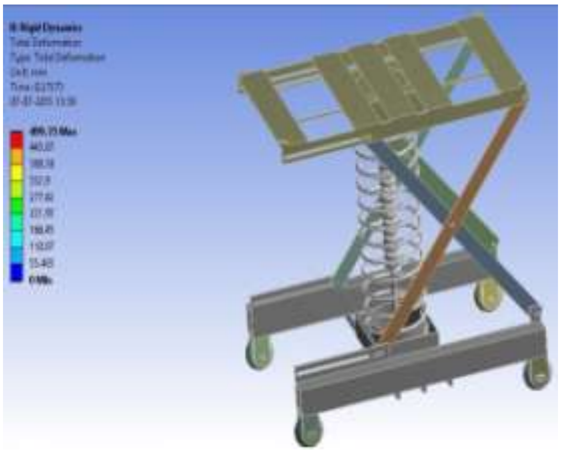

Fig 13 Total deformation of the assembly

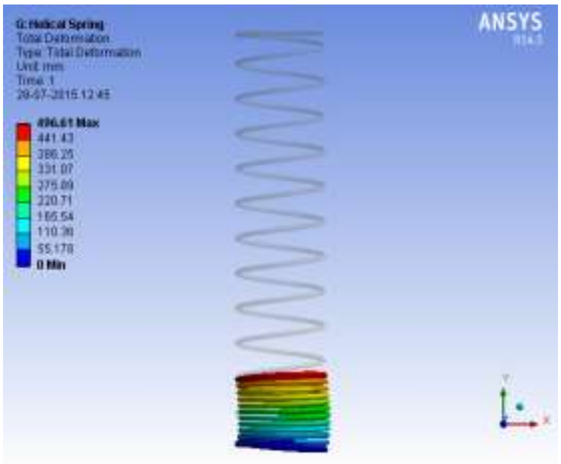

Fig 14 Simulation view of deformation of helical spring

7. Comparison of results obtained from analysis and analytical

The results of analytical calculation and numerical analysis obtained for the different parts of the lift table are compared and have been reported in **Error! Not a valid bookmark self-reference.**.The table shows that the numerical results match closely with analytical results. It may be noted that while carrying out analysis in software all the intricate details have been modelled, which were simplified in analytical calculations. Therefore, this may be attributed to any deviation, if there is, in the results.

Table 4**:** Compression of results obtained from analysis and analytical approaches

Name of parts	Analysis on different component of the parts	Analytical result	Analysis result	Design limits
Top deck frame	Stress on longer side of frame	51.33 N/mm^2	51.32 N/mm^2	63 N/mm^2
	Stress on shorter side of frame	61.46 N/mm^2	61.43 N/mm^2	63 N/mm^2
Base frame	Stress on three rectangular beam	55.13 N/mm^2	55.13 N/mm^2	63 N/mm^2
Support bar	Stress on support bar	47.23 N/mm^2	44.69 N/mm^2	63 N/mm^2
Helical compression spring	Shear stress on helical spring	658 N/mm^2	652.62 N/mm^2	680 N/mm^2
	Total deformation on helical spring	504.3 mm	496.61 mm	500 mm

8. Conclusions of the study

This project work considered the work done in past to understand the need of ergonomic design, to know design criteria and requirements and also learn about computer aided methods and modelling tools. Computer aided design of various components of lifting table is presented and static structural analysis has been carried out.

This research describes the approach to design an optimized component of the lift table with bending stress, strain and deformation. The main objective of this research is modeling and stress analysis of the different components of the lift table. Modeling of various components and their assembly has been done in Creo5.0 software. The solid model is then imported in ANSYS workbench for carrying out the stress analysis. Modeling of lift table can be achieved by using Creo5.0 software. Each component is modelled in part module and assembly has been created in assembly module. FEA analysis has been performed using ANSYS 14.5 Workbench.

Acknowledgments

This paper presents a solution of industrial problem that has been proposed in the form of a lifting table. It is concluded that all the components will withstand the required static load successfully, which ensured numerically.

Assistance given by several individuals from SGSITS Indore, especially Manoj Chouksey and Dinesh Kumar Pasi, is gratefully acknowledged.

References

[1] Bansal, R. K.. "A Textbook of Strength of Material". New Delhi, Laxmi Publications (P) ltd (2005).
[2] Bhandari, V. B.. "Introduction to Machine Design". New Delhi, Tata McGraw-Hill Publishing Company Limited (2006).
[3] Hongyu, T. and Zhang, Z. "Design and Simulation Based on Pro/E for a Hydraulic Lift Platform in Scissors Type." International Workshop on Automobile, Power and Energy Engineering: 772-781 (2011).
[4] Iqbal, M., Rahman, A. N. M., Samsuzzoha, A. H. M. and Iqbal, S. A. "Ergonomics and Design." International Conference on Industrial Engineering and Operations Management: 845-851(2011).
[5] Louhghalam, A., Igusa, T., Park, C., Choi, S. and Kim, K. "Analysis of Stress Concentrations in Plates with Rectangular Openings by a Combined Conformal Mapping – Finite element approach." International Journal of Solids and Structures: 1991–2004 (2011).
[6] Mahadevan, K. and Reddy, K. B. "Design Data Hand Book for mechanical engineers." (2012).
[7] Nisbett, B. "Shigley's Mechanical Engineering Design". United States of America, A Division of The Tata McGraw-Hill Companies (2006).
[8] Purohit, R., Khitoliya, P. and Koli, D. K. "Design and Finite Element Analysis of an Automotive Clutch Assembly." Procedia Materials Science: 490-502(2014).
[9] Rashid, H., Ariffin, M. K. A., Noh, M. H., Hamid, A. H. A. and Jusoh, M. A "Design Review of Scissors Lifts Structure for Commercial Aircraft Ground Support Equipment using Finite Element Analysis." International Symposium on Robotics and Intelligent Sensors 1696-1701 (2012).
[10] Sagot, J. C., Gouin, V. and Gomes, S. "Ergonomics in Product Design: safety factor." Safety Science: 137-154 (2003).