Design & Fabrication of Electro Mechanical Ladder

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Abstract

Our project mainly intends to fabricate an electrically operated mechanical ladder actuated by electrical cum mechanical systems. Conventional method of using rope, scaffold lift etc., in getting to a height encounter a lot of limitations like time, energy consumption, portability, storage, cost-effectiveness etc. The electro mechanical scissor lift ladder overcomes these shortcomings. It will be an important tool which can probably be used in different kinds of job such as changing of electrical fittings like fans & lights, painting walls etc. The device is limited to an average load of 120 kg and will have maximum lift of around 6-7 meters and must be operated on a flat surface. But however we are planning to fabricate a scaled version prototype of the proposal. Our project model consists of components such as a rigid base, working platform, scissor lift mechanism, and electro mechanical actuation system. The rigid base forms the base of the system, fixed arm of scissor lift is connected firmly to one end of the base, while the other movable arm of the scissor, slides through the shaft link in base provided on of the nut meshed with lead screw. In order to obtain the desired motion electro mechanical actuation system (i.e. a lead screw passing through the middle of the base has its external threads in communication with the internally threaded nut affixed to the movable arm) is used. Thus by Screw Jack principle, rotary motion of screw is converted to linear motion of movable arm. As the lead screw is rotated in first angular direction scissor lift mechanism vertically extends towards the expanded condition whereas reverse angular direction vertically contracts towards the retracted condition and thereby causes movement of the work platform towards the lowered position. The semi-automation feature enables the person working on the platform to easily move the entire ladder to left or right by operating a gear wheel wiper motor in mesh with the gear mounted on the wheel shaft by appropriate electrical systems which can drag the ladder over a flat surface. Eg:- A painter working on the platform with his paint job can move to the sides to cover up non painted regions. The ultimate aim of our project is to commercialize the product in the market targeting, small scale industries, colleges, schools and other organizations. To get maximum possible acceptance in the market will be our objective.

Keywords: Semi automation, Screw jack, Movable arm, Platform

I. INTRODUCTION

Nowadays, ladder becomes the common facilities for human. Different types of ladders are available in worldwide market such as fixed ladder, extension ladder, step ladder, orchard ladder and others. The main purpose of electro mechanical ladder is to help human to do their work especially at the high place that can't be reached and help them to keep it without using a large space. It can reduce time, increase efficiency and reduce space to store. However the existing ladders are either highly costly or bulky. Each one has its own disadvantages which makes them unsatisfactory. The electromechanical ladder we designed and fabricated can eliminate the dis-advantages of the conventional ladders. Our project aims at the design and fabrication of an Electro Mechanical Ladder for the purpose of using it in small scale industries, domestic areas etc. The principle used here is that of a scissor lift which will raise loads to heights, in our project the scissor lift is being raised with the help of a lead screw which is coupled to an electric motor (low speed high torque motor). Also this device is likely to be used in domestic purposes such as in houses, small paper mills etc.

A problem remains a problem until a solution is proffered. With the limitations encountered in the use of ropes, ladders, scaffold and mechanical scissors lifts in getting to elevated height such as the amount of load to be carried, conformability, time

consumption, much energy expended etc., the idea of Electro Mechanical Ladder which will overcome the above stated limitations. These electro mechanical ladder is foldable, portable and easy to use. It can be fabricated in many sizes and design to make customer to choose which one is more suitable for them. From the advantages and disadvantages of the ladder in the worldwide market, one new product design can be created. For jobs such as changing of tube lights, painting of buildings and walls around the houses, schools etc. This project reviews all the studies up to this date and hope our product will get optimum acceptance in the market.

II. OBJECTIVE

The project is aimed at designing and constructing an electrically powered mechanical scissors lift ladder to raise and lower worker and his working equipment with ease and in the most economical way. The lift is expected to work with minimal technical challenges and greater comfort due to its wide range of application. The device can easily be handled to the site to be used with a tow-van and then powered by a generator. Between the heights of lift (i.e. the maximum height) the device can be used in any height with in this range and can be descend immediately in case of emergency, and can be operated independent of a second party.

The aim of this study is to design a scissors lifting device that can be used in the Domestic and Industrial sector. The design conditions are to meet the following specifications;

- The device is limited to an average load of 120 Kg .
- The device will have a maximum lift of 5-6 m.
- This objective is desirable to be achieved through the rotation of the lead-screw to raise or lower the scissor platform.
- The system must be operated on a flat surface.

III. EXPERIMENTAL / ANALYTICAL PROCEDURES

A. Components Selected:

The major components that are effectively involved in the Fabrication of the Electro mechanical ladder are as follows.

- Motor
- scissors
- Battery
- Bearing with bearing cap
- Platform
- Lead screw
- Spur gears

IV. DESIGN CONCEPT

A. CAD/CAE:

Computer aided design or CAD has very broad meaning and can be defined as the use of computers in creation, modification, analysis and optimization of a design. CAE (Computer Aided Engineering) is referred to computers in engineering analysis like stress/strain, heat transfer, and flow analysis. CAD/CAE is said to have more potential to radically increase productivity than any development since electricity. CAD/CAE builds quality form concept to final product. Instead of bringing in quality control during the final inspection it helps to develop a process in which quality is there through the life cycle of the product. CAD/CAE can eliminate the need for prototypes. But it required prototypes can be used to confirm rather predict performance and other characteristics. CAD/CAE is employed in numerous industries like manufacturing, automotive, aerospace, casting, molding making, plastic, electronics and other general-purpose industries. CAD/CAE systems can be broadly divided into low end, mid end and high-end systems. Low-end systems are those systems which do only 2D modeling and with only little 3D modeling capabilities. According to industry static's 70-80% of all mechanical designers still uses 2D CAD applications. This may be mainly due to the high cost of high-end systems and a lack of expertise. Mid-end systems are actually similar high-end systems with all their design capabilities with the difference that they are offered at much lower prices. 3D sold modeling on the PC is burgeoning because of many reasons like affordable and powerful hardware, strong sound software that offers windows case of use shortened design and production cycles and smooth integration with downstream application. More and more designers and engineers are shifting to mid end system. High-end CAD/CAE software's are for the complete modeling, analysis and manufacturing of products. High-end systems can be visualized as the brain of concurrent engineering. The design and development of products, which took years in the past to complete, is now made in days with the help of high-end CAD/CAE systems and concurrent engineering

B. Modelling:

Model is a Representation of an object, a system, or an idea in some form other than that of the entity itself. Modeling is the process of producing a model; a model is a representation of the construction and working of some system of interest. A model is similar to but simpler than the system it represents. One purpose of a model is to enable the analyst to predict the effect of changes to the system. On the one hand, a model should be a close approximation to the real system and incorporate most of its salient features. On the other hand, it should not be so complex that it is impossible to understand and experiment with it. A good model is a judicious tradeoff between realism and simplicity. Simulation practitioners recommend increasing the complexity of a model iteratively. An important issue in modeling is model validity. Model validation techniques include simulating the model under known input conditions and comparing model output with system output. Generally, a model intended for a simulation study is a mathematical model developed with the help of simulation software.

Software for modeling:

- Solid works,
- Creo,
- CATIA,
- Unigraphics, etc.

V. ENGINEERING DESIGN (SOLID WORKS)

Solid works offers a range of tools to enable the generation of a complete digital representation of the product being designed. In addition to the general geometry tools there is also the ability to generate geometry of other integrated design disciplines such as industrial and standard pipe work and complete wiring definitions. Tools are also available to support collaborative development.

A number of concept design tools that provide up-front Industrial Design concepts can then be used in the downstream process of engineering the product. These range from conceptual Industrial design sketches, reverse engineering with point cloud data and comprehensive free-form surface tools.

The figures represents CAD model in SolidWorks.

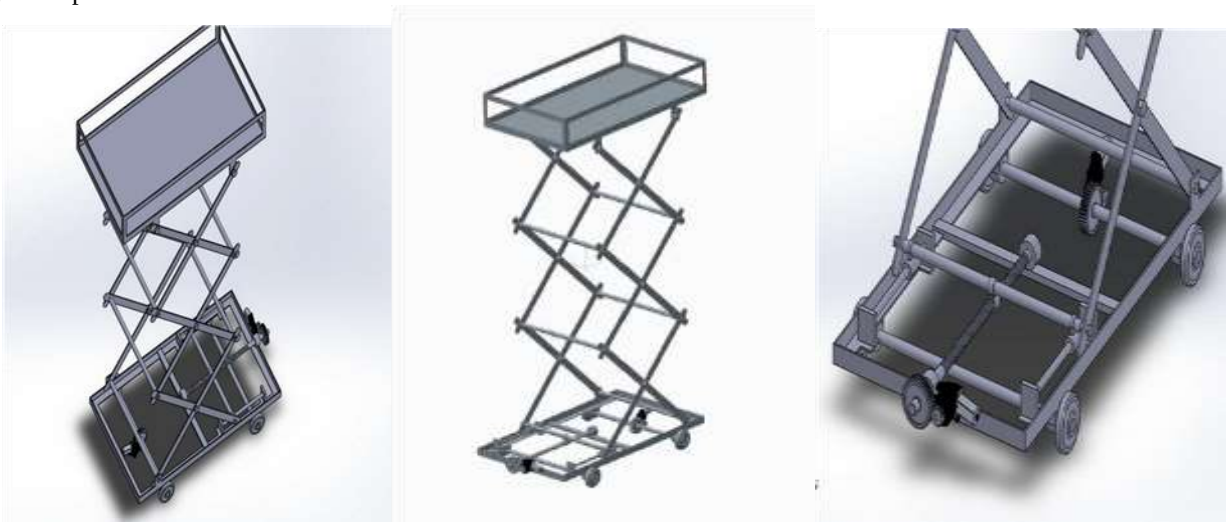

Fig. 1: Cad design

VI. DESIGN CALCULATIONS

Torque in the Motor = $\frac{\varphi Z P I_a}{2\pi A}$ Nm

$= 0.159 \times \varphi \times Z \times I_a \times \frac{P}{A}$ Nm

$= 0.162 \times \varphi \times Z \times I_a \times \frac{P}{A}$ Kgm

Torque Given By Motor = $\frac{60P}{2\pi N}$

Gear

Gear Ratio = $\frac{\text{number of teeth on driven gear}}{\text{number of teeth on driver gear}}$

Output Rpm = input rpm$\times \frac{1}{\text{gear ratio}}$

Output Torque = input torque$\times$gear ratio

Lead Screw

Torque required to raise the load = $w \times \tan(\lambda+\Phi)\frac{dm}{2}$

Torque required to lower the load = $w \times \tan(\Phi-\lambda)\frac{dm}{2}$

W is the load and d_m is the mean diameter

Efficiency of lead screw = $\frac{\tan(\lambda)}{\tan(\Phi+\lambda)}$

Φ is the friction angle and λ is the lead angle of power screw

VII. RESULTS AND DISCUSSION

A. Analysis and Results:

ANSYS is the usually preferred analysis software package because of its functionality. In this interface, you can apply forces, pressures, torques, etc on models and see how the stresses develop. The ANSYS Workbench platform is the framework upon which the industry's broadest and deepest suite of advanced engineering simulation technology is built. An innovative project schematic view ties together the entire simulation process, guiding the user through even complex multi physics analyses with drag-and-drop simplicity. With bi-directional CAD connectivity, an automated project level update mechanism, pervasive parameter management and integrated optimization tools, the ANSYS Workbench Platform delivers unprecedented productivity, enabling simulation driven product development.

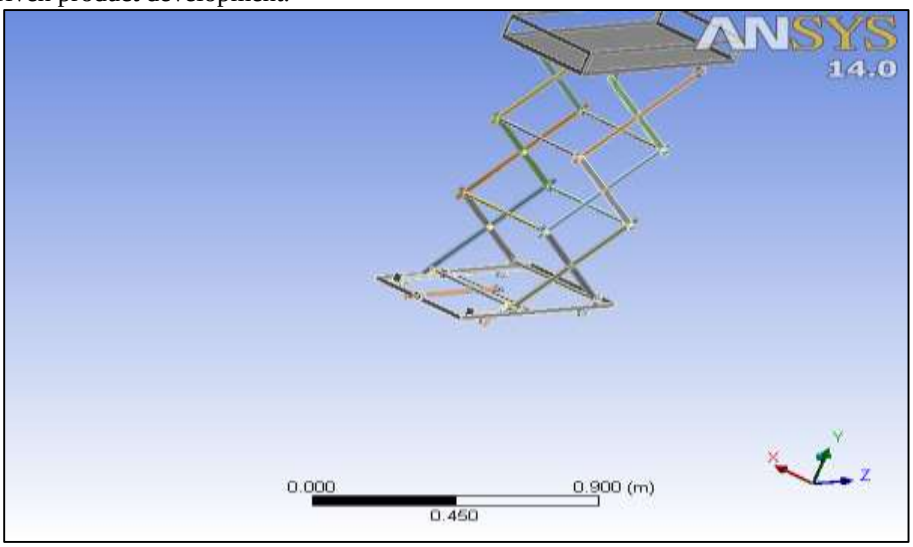

Fig. 2: Model

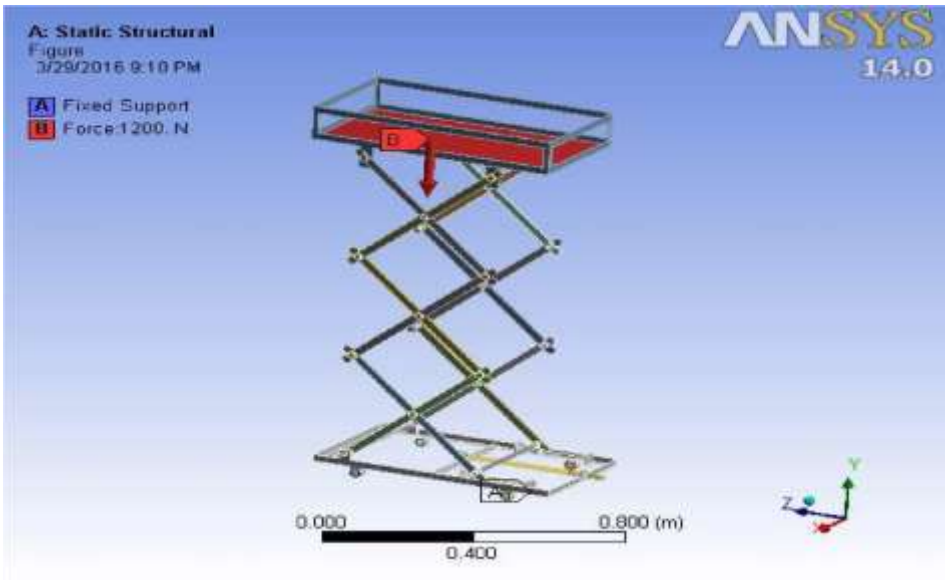

Fig. 3. Boudary Conditions

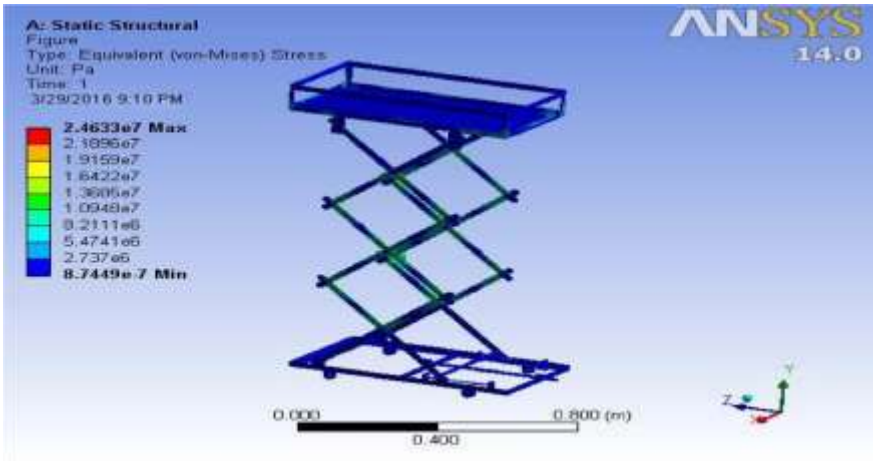

Fig. 4: Von Mises Stress

VIII. FABRICATION DETAILS

Fig. 5: Figures of Fabrication

IX. DETAILS OF FABRICATION

After a long procedure of Design and Analysis the scaled version of Electro Mechanical ladder is allowed to enter into its fabrication stages.

- Its base consist of a rigid support rectangular structure formed by cutting and finally welding at its corners (1 Inch X 1 Inch X 3mm). It is successfully mounted over four wheels having 4inch diameter made of fiber. s
- Over the base has a pair of sliding rods which enables smooth sliding motion of sliders attached to the movable arm of the scissor lift. It is helpful in reducing the frictional effects.
- Thus an idea of moving a sliding rod attached to movable arm through slotted base was dropped due to high friction factors. Another main structure is the scissor lift formed by 6 pairs of scissor plates made of mild steel.
- Scissor have a dimension of breadth 1inch and thickness 4mm. Scissors are assembled and blotted accordingly to optimize the lift action and also by considering in reducing the rubbing and contact friction between each pair of members.
- Over the scissor lift a platform is mounted made of 18 gauge M.S. sheet metal surrounded by a strong mild steel fencing. This entire structure was analyzed in Ansys v14.5 and successful results were interpreted.
- To actuate the sliding mechanism of cylindrical slider over the sliding rod a lead screw (Diameter -16mm,Pitch- 3mm and length – 16inch) powered by a PMDC motor (12v ,90w,60rpm) was used.
- For torque multiplication a spur reduction gear (2.65:1) was also employed. For the semi automation feature backside wheels are driven by another set of spur geared motor of gear ration 1:1.5.
- It enables sidewise movement. ISI -6202 ball bearing are used to reduce friction effects between two rotating parts. All electrical components are powered by a 12V DC battery capable of delivering 7.5 Ah.
- Set of control switches are provided to actuate the lift and semi automation feature. Control panel toggles switches enable easy control of ladder without any third party assistance.

X. CONCLUSION

This project work has provided us an excellent opportunity and experience, to use our limited knowledge. We gained a lot of practical knowledge regarding, planning, purchasing, assembling and machining while doing this project work. We feel that the project work is a good solution to bridge the gates between the institution and the industries.

We are proud that we have completed the work with the limited time successfully. The "DESIGN, FABRICATION AND ANALYSIS OF ELECTRO MECHANICAL LADDER" system is working with satisfactory conditions. We were able to understand the difficulties in maintaining the tolerances and also the quality. We have done to our ability and skill making maximum use of available facilities. In conclusion of remarks of our project work, let us add a few more lines about our project work.

Thus we have developed an "ELECTRO MECHANICAL LADDER" which helps to fabricate a less weight and more compactable ladder that is actuated using simple mechanisms. This project reviews all the studies up to this date and hope our product will get optimum acceptance in the market. By using more techniques, they can be modified and developed according to the applications.

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