Design & Fabrication of Roller Guide Alternating Mechanism with the Help of Toggle Jack

Prof. A. K. Gaikar[1] Ameya Mulay[2] Shrikant Gangawane[3] Laxman Fadol[4]
[1,2,3,4]Sanghavi College of Engineering Nashik, India

Abstract— Our project Roller Guide Alternating Mechanism is sponsored by "ThyssenKrupp Electric Steel India PVT". The company is known for their processed steel for electrical component. In addition to the steel production, Thyssenkrupp's products range from industrial services and machines, elevators and shipbuilding. A branch of Thyssenkrupp Marine Systems also manufactures frigates, corvettes and submarines for the German and foreign navies. Our project is related to the Tandem Annealing and Decarburizing Line (TADL).In cooling region the very first support roller is near to the heating zone and gets affected by the heating. Because of heat the roller bearings gets jam which causes scratches on the processed sheet. This roller assembly needs to be changed after interval of 1 month regularly. Is take time about 45-60 minutes. Due to this delay the company bears the loss of 1.5 lakhs monthly. For this we design a simple mechanism which will help to change the roller without stoppage of production link. So we decided to design a mechanism similar to the toggle jack which helps to reduce the scrap and the damage over the processed product, which will help to increase the production rate.

Key words: Thyssenkrupp, TADL, Scratches, Simple Mechanism, Toggle Jack

I. INTRODUCTION

Our project "Roller Guide Alternating Mechanism" is sponsored by "ThyssenKrupp Electric Steel India PVT". ThyssenKrupp is a German multinational conglomerate with focus on industrial engineering and steel production. The company is based in Duisburg and Essen and divided into 670 subsidiaries worldwide. It is one of the world's largest steel producers; it was ranked tenth-largest worldwide by revenue in 2015. The company is the result of the 1999 merger of Thyssen and Krupp, and now has its operational headquarters in Essen.

Thyssenkrupp is the result of a merger of two German steel companies, Thyssen founded in 1891 under the name Gewerkschaft Deutscher Kaiser and Krupp founded in 1811. As early as the 1980s, the companies began negotiations on a merger and began closely cooperating in some business areas. In 1997, the companies combined their flat steel activities, with a full merger completed in 1999.

The company is known for their processed steel for electrical component. Our project is related to the Tandem Annealing and Decarburizing Line (TADL). In cooling region the very first support roller is near to the heating zone and gets affected by the heating. Because of heat the roller bearings gets jam which causes scratches on the processed sheet. This roller assembly needs to be changed after interval of 1 month regularly. Which take time about 45-60 minutes. Due to this delay the company bears the loss of 1.5 lakhs monthly. For this we are designing a mechanism which will help to change the roller without stoppage of production line.

A. Problem Definition

At ThyssenKrupp a survey was done at the time when we were doing our Internship there, the problem is defined as, the roller bearings gets jam which causes scratches on the processed sheet, so "Design and Fabrication of Roller Guide Alternating Mechanism" for Tandem Annealing and Decarburizing (TADL) is done to eliminate the problem and also increasing the productivity.

The biggest advantage of using jack is the stability of jack while giving jerks to loosen the wheel nut. Also the common advantage of jack is having small base so as to provide proper support in very complicated space.

Fig. 1:

B. Objectives

The project is related to the design the simple Toggle Jack and its analysis along with structural improvements to make such a modified jack that is very stable and can take enough load.

The project also aims at design and finding stresses, efficiency, expected life of screw. To develop a Simple Toggle Jack such that it is cost effective, having a long life and can be handled roughly.

1) To minimize the time required to replace the roller.
2) To reduce financial losses due to stoppage of production line.
3) To improve production rate and product quality.
4) To increase productivity.

C. Methodology

The term "Toggle Jack" gives a wide variety of mechanism that all follow the same principle to lift loads. They perform this task by acting on the object they are lifting in a diagonal manner; the lift on the right side lifts the object from its left side and vice versa. The major specification of Toggle Jack is that they lift loads all in symmetrical way. In order to work, the distance from the loaded point to the cross point must be the same as the distance from the cross point to the ground. This ensures that weight is distributed equally throughout the toggle jack.

Since Jack lifts have such a wide variety of use, they also have a wide variety of power sources. Jack lifts for

supporting can be powered electrically, hydraulically and of course mechanically. On the other end the, industrial jack lifts is powered by mechanically. As due to the temperature restrictions we cannot use hydraulically operated system.

In ThyssenKrupp we are working in the Tandem Annealing and Decarburizing Line (TADL) section, in which there is a production of "Electric Steel" for their there is a furnace through which the process in the steel is done. As the temperature of the furnace is very high, ranges between 8000c to 12000c due to these high operating temperature condition's we cannot use the hydraulically operated system in the work section.

A Toggle Jack uses a simple theory of gears to get its power. As the screw section is turned, two ends of the jack move closer together at each other. Because the gears of the screw are pushing up the arms, the amount of force being applied is multiplied. It takes a very small amount of force to turn the handle, yet that action causes the arms to slide across and together. As this happens the arms extend upward. The roller's gravitational weight is not enough to prevent the jack from opening or to stop the screw from turning since it is not applying force directly to it.

II. METHODOLOGY

A. Past Work Done

1) Earliest Jack Development

The use of screws is done from the late 1400s, Leonardo-da-Vinci was it who first demonstrated the use of a screw jack for lifting loads. Leonardo design used a threaded worm gear, supported on bearings, that is rotated by the turning of a worm shaft to drive a lifting screw to move the load.

B. Further Development

Screw type mechanical jacks were very common for jeeps and trucks of World War II Vintage. For example, the World War II jeeps (Willys MB and Ford GPW) issued the "Jack, Automobile, Screw type, Capacity 1 1/2 ton". These jacks, and similar jacks for trucks, were activated by using the lug wrench as a handle for the ratchet action to the jack.

The jack was carried in the jeep's tool compartment. Screw type jacks continued in use for small capacity requirements due to low cost of production to raise or lower the load. A control tab is marked up/down and its position determines the direction of movement and with no maintenance. The virtues of using a screw as a machine element, which is essentially an inclined plane wound round a cylinder, was first demonstrated by Archimedes in 200 BC with his device used for pumping water.

Nowadays in this country, most of the cars were equipped with the Toggle Jack. We found that the Toggle Jack are very easy to be used because this types of jack needed less strength and energy to operate this jack by turning the lead screw. Thus, we want to develop a mechanism from the problem faced by the industry who are facing the issue regarding to this. To overcome the problem faced by industry, we has been conducted to find the solution on how to design a jack for the operation using the simplest and cheapest way while it is energy saving.

III. DESIGN OF MECHANISM

A. Proposed Methodology

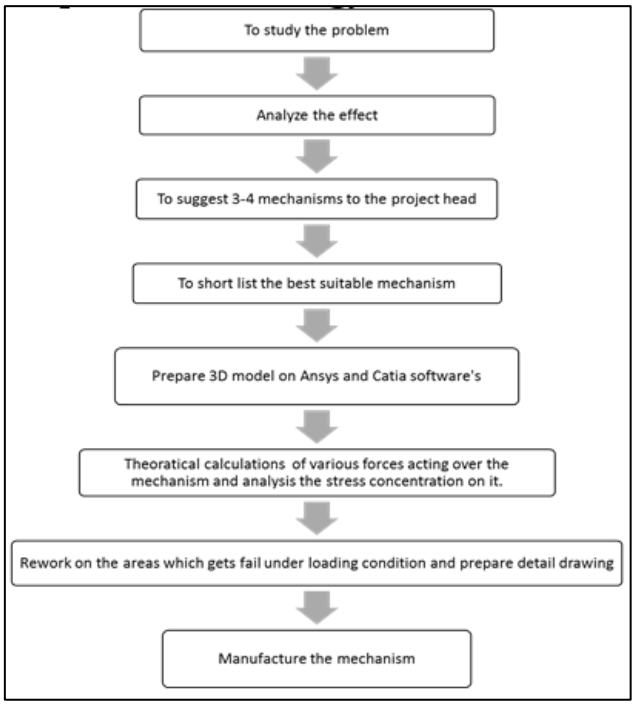


Fig. 2: Proposed Methodology

B. Design of Mechanism

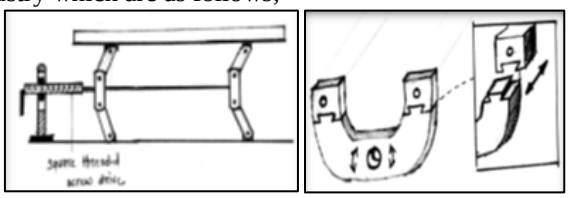
It include about the design concept and selection design of the Toggle Jack. There are four major stages in applying design process of Jack.

1) Step 1: First step to apply the process design is identified the Mechanism Design. Design requirement and design criteria will identify to solve the problem. Some of the criteria that were considered for the mechanism design are performance, material selection, size and maintenance.
2) Step 2: The second stage is the conceptual design. Conceptual design is the important step in design process. This process indicates a sketch of design idea that is suitable with the mechanism. Two processes in this step are concept generation and concept evaluation. There are number of sketching of mechanism from the pre-design and after completed the concept evaluation, one concept has been choose. All of these processes were done to get more ideas and to choose the best ideas to proceed for the next step.
3) Step 3: The third stage is preliminary design. Preliminary design is propose to detail the chosen design from the evaluation that was done in conceptual design. At this level, the dimension has been made to get a dimensional modelling. There are two processes in this steps that is material selection and design analysis.
4) Step 4: The final stage is final design. In the final design process, all the detail drawings and final specifications including the type of material for the components have been finished. Besides that, fabricating processes to build the prototype has also been determined.

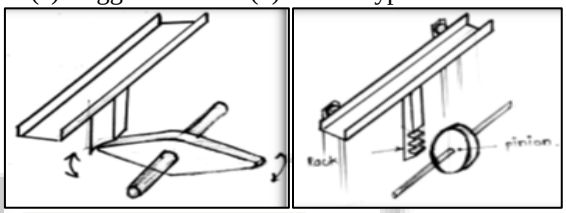
C. Considered Mechanisms

This conceptual sketch is done after have good ideal to identify and analyses all the pros and cons that think logical. The best design is chosen. All the design process is begins from ideal which best ideal was chosen to select the best design. First sketch are important thing of sketch because it is represent a suitable procedure and can settle all the problem that come when design the mechanism.

From the problem definition, the design of jack should be simple and easy mechanism for the easy use, cost effective, having a long life and can be handled roughly. There are various mechanism which can be used in the industry which are as follows;



(a) Toggle Jack (b) Slider Type Mechanism



(c) See-saw Type Mechanism (d) Rack and Pinion Mechanism

Fig. 3:

The above mechanisms and many more can be used. As we need a simple and easy mechanism with having a long life and can be handled roughly. The Toggle Jack mechanism is simple in construction, and rough and tough in use.

Secondly the Rack and Pinion mechanism is also a simple one but due to the slots in the Rack there is possibility that there will be accommodation of the slurry, bur particles which will jam the mechanism after a certain period of time.

The Slider type mechanism and the See-saw type mechanism will be effective but will be too excess cost than the Toggle jack mechanism.

D. Design Specifications

1) Material Selection

The material selection of the mechanism plays a crucial role in the design process. The material selection is done as per the application requirements, possible materials, and physical principles.

Types of material used in the Toggle Jack Design,

- Structural steel
- Mild Steel

2) Number of Links

The number of links used in the Toggle Jack are 4, which operate simultaneously.

3) Number of Pines

The pins are made of structural steel which are used to allow the rotating motion between the pivot point and the link.

E. Design & Analysis

1) Screw

The screw has a thread designed to withstand amount of load. This is due to the fact that it is generally holding up heavy objects for an extended amount of time. Once up, they normally self-lock so that they won't fall if the operator lets go, and they hold up well to the wear of repeated use.

2) Thread Profile

The screw or power screw thread is always a square type because it has more efficiency than trapezoidal threads and there is no radial thrust on screw. Square threads usually turned on lathes using single point cutting tool. It leads us to use free cutting steel. Square threads have maximum efficiency. It has tensile strength of 250 N/mm^2 with 10% elongation.

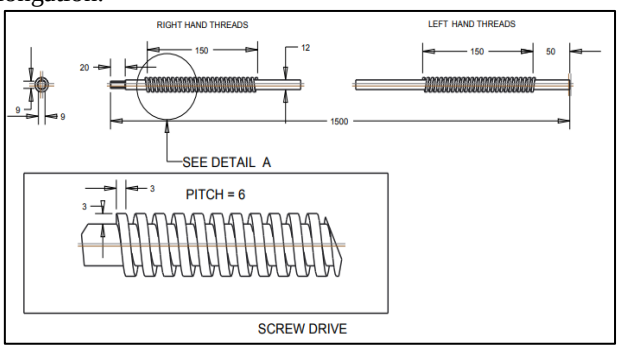


Fig. 4:

3) Nut

As we know there always a relative motion between screw and nut, which cause a friction. The friction causes wear if some material is used for screw & nut it will wears both components. So one out of two has to be softer than other so as to ease of replacement.

Phosphor bronze is ideal material for nut which is a copper alloy having 0.12% phosphor which increases tensile strength. Ultimate tensile strength for this is 460 and coefficient of friction is 0.1.

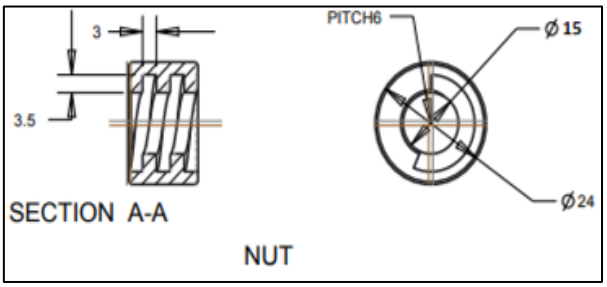


Fig. 5:

4) Pivot Point

The point at which the pin and the link intersects is the pivot point. The pivot allows the link to rotate through it.

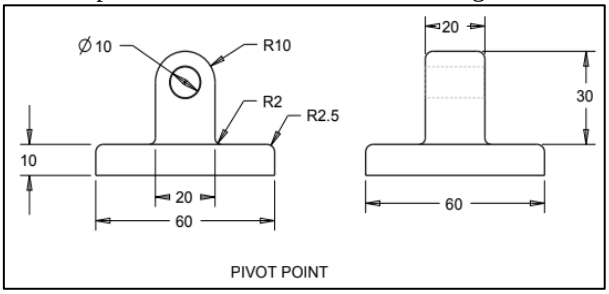


Fig. 6:

F. Assembly of the Mechanism

The following is the assembly of the screw jack consisting of only five parts. The 3D Solid model of the same product is designed in Creo with the same Dimensions

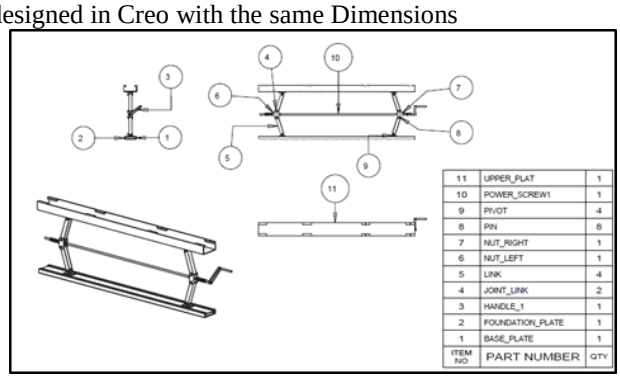


Fig. 7: Assembly Detail Drawing

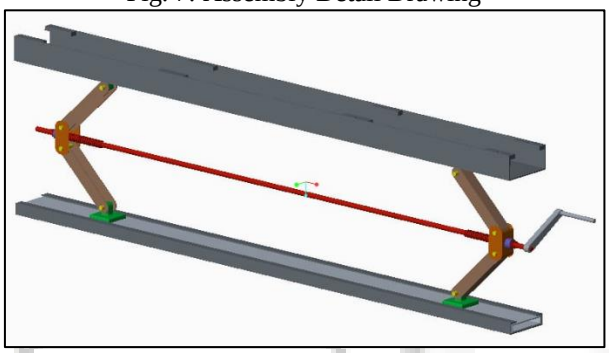


Fig. 8: 3D View

IV. ANASYS OVERVIEW

ANASYS is a general purpose finite element modeling package for numerically solving a wide variety of mechanical problems. These problems include: Static and Dynamic, Structural Analysis (both linear and non-linear) problems. To produce this drawing of this project, we use Catia/Creo software. Under this software, we were able to use many types of function/features such as line, circle, trim, extrude, edit, polyline, arc, fillet, pad and others.

A. ANASYS

Finite element analysis software enables engineers to perform the following tasks:

1) Build computer models of the mechanism.
2) Apply operating loads conditions.
3) Study the physical responses, such as stress levels.
4) Optimize a design early in the development process to reduce production costs.

B. Stress Analysis

There are a number of methods that are used for finding the value of Stress in a part. Finite element method is a powerful tool for the numerical solution of a wide range of engineering problems. Applications range from deformation and stress analysis to field and other problem.

In this method of analysis, a complex region defining a continuum is discredited into simple geometric shapes called Finite Elements. Finite element method solves for forces and Displacement over the entire object. Finite element method is used for solving many industrial problems like Automobile frames, optimization of mechanical parts, artificial limbs etc. Rolling mill housing is one of them.

The analysis on the final assembly is done by the ANASYS software. This gives us a clear ideas of deformation and stress analysis.

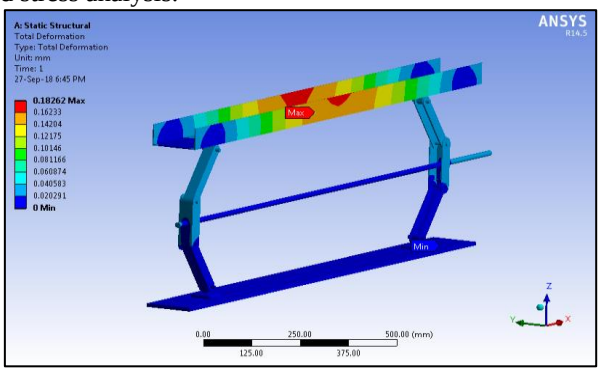


Fig. 9: Deformation Lower Position

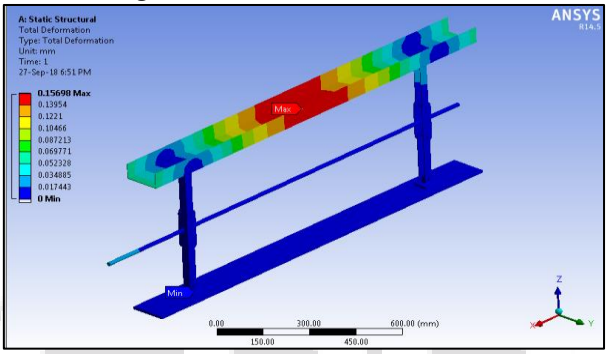


Fig. 10: Deformation Upper Position

The analysis of the Toggle Jack is done on the ANASYS V14. Version available. The Deformation analysis shows the exact failure at the point where the mechanism will fail. Both the Lower and Upper positions deformation analysis is done, in the lower position we can see that the deformation takes place at 0.182mm which is very minimum and the assembly can withstand with it. At the upper position the deformation takes at 0.156mm which is comparatively less than the lower position of the Togge Jack.

The Stress analysis gives the exact failure at the point where themaximum stress acts on the mechanism. Both the Lower and Upper positions sress analysis is done, in the lower position we can see tha the maximum stress takes place at 29.5MPA at which the assembly can withstand with it. At the upper position the deformation takes at 37.8MPA which is comparatively more than the lower position of the Togge Jack.

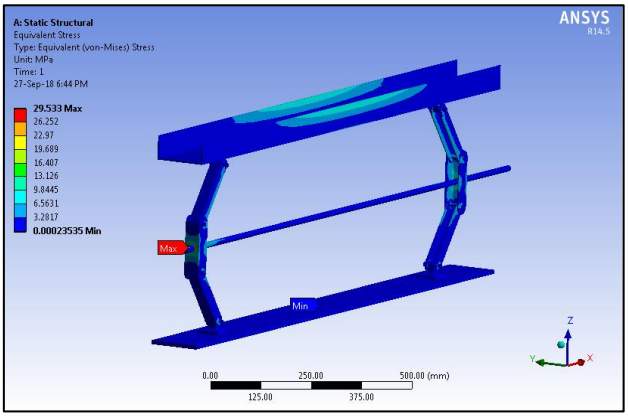


Fig. 11: Stress Lower Position

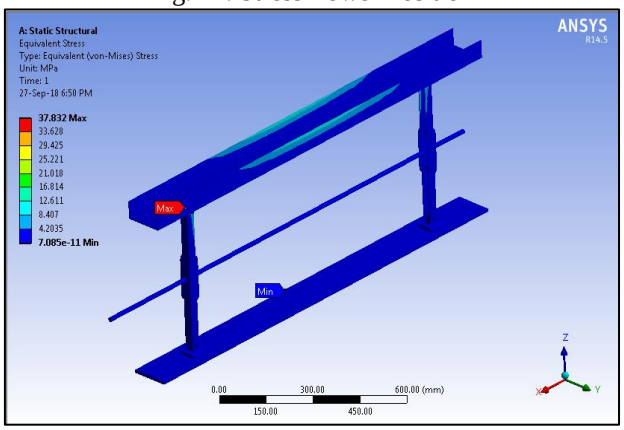


Fig. 12: Stress Upper Position

V. ADVANTAGES OF TOGGLE JACK

1) Can be used to lift a heavy load against gravity.
2) Load can be kept in lifted position.
3) Due to leverage obtained by handle force required to rise load is very less & can be applied manually.

VI. DISADVANTAGES OF TOGGLE JACK

1) Chances of dropping of load.
2) Proper size, strength and stability are the essential requirements for the design of the screw jack from safety considerations.

VII. CONCLUSION

The new proposed design of roller guide mechanism will be effective and will reduced time and complication occurring during maintenance, this design can be preferable for mass production because of reduced lead time and increase production rate.

REFERENCES

[1] RS Khurmi, A text book of Machine Design, Eurasia publishing (chapter no.1, page no.625 to 635).
[2] V. B. Bhandari design of machine elements (Tata McGraw-Hill Education), Third edition (page no. 363 to 416).
[3] Paolo Gallina, "Vibration in screw jack mechanisms" of Energetics, University of Trieste, Via A. Valerio 10, 34127 Trieste, Italy 2004 (page no.282).
[4] Vijay Thakor, Manish Bamaniya, "Design of Toggle Jack Considering Material Selection of Screw – Nut Combination" at International Journal of Innovative Research in Science, Engineering and Technology, Vol. 2, May 2013 (page no. 1748).
[5] S. U. Gunjal, Pravin Adke, "Design of Toggle Jack" at Journal of Innovative Research in Science, Engineering and Technology, Vol. 2, May 2014 (page no.113).
[6] Musa Nicholas* Abodunrin Tosin, "Development of an Integrated Toggle Jack" at Federal University of Technology, Minna, Niger State, Nigeria, 2014 (page no. 13)
[7] Divay Chadha, Sachin Kumar "Designing and Analysis of a Car Jack using Catia and Ansys", technical report on engineering, HMR Institute of Technology & Management, Hamidpur (nov 2014).
[8] P. Gallina, M. Giovagnoni, Design of a screw jack mechanism to avoid self-excited vibrations, Journal of Dynamic Systems, Measurement, and Control 124 (2002) 477–480.
[9] P. Gallina, About the stability of non-conservative undamped systems, Journal of Sound and Vibration 262 (2003) 977–988.

