

INVESTIGATION ON DESIGN, ANALYSIS AND TOPOLOGICAL OPTIMISATION OF HYDRAULIC SCISSOR LIFT

Submitted in partial fulfilment of the requirements for the award of
Bachelor of Engineering degree in Mechanical Engineering

By

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SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with Grade "A" by NAAC 12B Status by UGC | Approved by AICTE

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of KARTHEESHWARAN R (37150090) and SIVA J (37150709) who carried out the project entitled “**INVESTIGATION ON DESIGN, ANALYSIS AND TOPOLOGICAL OPTIMISATION OF HYDRAULIC SCISSOR LIFT**” under my supervision from November 2020 to April 2021

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DECLARATION

We **KARTHEESHWARAN R, SIVA J** Hereby declare that the Project Report entitled **INVESTIGATION ON DESIGN, ANALYSIS AND TOPOLOGICAL OPTIMISATION OF HYDRAULIC SCISSOR LIFT** done by me under the guidance of **Dr.G. Arunkumar, M.E.,Ph.D.**, at **SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY** is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in **MECHANICAL ENGINEERING**.

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ABSTRACT

A water-powered scissor lift is a mechanical gadget utilized for different applications for the lifting of the heaps to stature or level. A lift table is characterized as a scissor lift used to stack, raise or lower, pass on and additionally move material between at least two heights. The principal objective of the gadgets utilized for lifting designs is to make the table customizable to ideal tallness.

A scissor lift gives the most monetary reliable and adaptable strategies for lifting loads; it has not many moving parts which may just require grease. In this venture, we upgraded the heaviness of the base and top of the scissor lift by utilizing the I-outline structure and utilized a regenerative strategy to diminish weight in the pole. Scissor lift gives most financial trustworthy and flexible techniques for lifting loads. The edge is exceptionally solid and sufficient with expansion in underlying respectability. A numerous tallness scissor lift is comprised of at least two leg sets. It is investigated and advanced utilizing Autodesk Fusion 360° software.

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CHAPTER 1

INTRODUCTION

A hydraulic pallet lift is a mechanical device used for different presentations for lifting of the loads to an elevation or level. A lift table is well-defined as a scissor lift used to stack, raise or lesser, carry and/or move one place to other material among two or more rises. The important objective of the devices used for lifting intentions is to make the table flexible to a preferred height. A scissor lift conveys maximum economic reliable & resourceful procedures of lifting loads; it has few moving parts which may only require lubrication. This lift table raises load efficiently to any preferred height. The scissor lift can be used in grouping with any of presentations such as pneumatic, hydraulic, mechanical, etc. Lift tables might include rotating platforms; tilt platforms, etc., as a part of the design.

Scissor lift design is used for the reason that of its ergonomics as related to other heavy lifting devices existing in the market. The frame is very durable & strong sufficient with rise in structural integrity. A various height scissor lift is made up of two or more leg sets. These types of lifts are used to attain high travel with comparatively short platform.

1.1 APPLICATIONS OF SCISSORS LIFT

Industrial scissor lifts & filters are used for a varied variety of applications in various industries which contain manufacturing, warehousing, schools, grocery distribution, military, hospitals and printing.

The scissor lift covers multiple platforms of cross bars which can change a linear displacement among any two points on the series of cross bars into a vertical displacement multiplied by a mechanical gain factor. This factor depends on the position of the points chosen to attach an actuator and the number of cross bar stages.

The amount of force essential from the actuator is also amplified, and can result in very huge forces required to begin lifting even an enough amount of

weight if the actuator is not in a finest position. Actuator force is not constant, then the load factor reduces as a function of lift height.

The assembly of this thesis is scheduled as follows: in the leading part, the theory is presented. It contains of various topics regarding overall of lifting tables of scissors type, things that are required for the design, principles of working, technical characterization and others.

The leading part is required to give an overall concept of the subject and after that comes the practical part which presents and describes how to perform the knowledge. It comprises the 3D model of the lift, calculations of the load, several diagrams, charts, and stress calculations, which confirm the capability and validity of the theory part.

Such a thesis assembly was chosen as the maximum suitable and appropriate for the chosen topic. It permits increasing knowledge by appealing to the literature and adding a uniqueness of the author by making him solve an actual practical problem using own method.



Fig 1.1: CAD Model of Hydraulic Scissor Lift

1.2 CONSTRUCTION AND WORKING PRINCIPLES OF SCISSOR LIFT

The scissors elevator is an elevator with a construction of devices and hydraulic cylinders on which the metal platform is capable of moving in the vertical plane. This is completed by using of connected, folding supports in a crisscross pattern, called scissor mechanism.

The hydraulic lift was preferred as a substance of the thesis since it is a perfect example of mechanical engineering field. This mechanism combines an outcome of various main fields of engineering and at the similar time, it is simple and manageable for understanding. The construction and load scattering represent statics and strength of material subjects, the hydraulic cylinder and the control unit contain knowledge of hydraulic systems and automation. Material science is significant for variety of a suitable material as well as understanding of 3D modelling.

Similarly, scissors lift is an essential part of most of the workshops and building objects. The key benefit of lifts is that they even offer the best way to classify a technological and industrial process. In addition, nearly all lifts give the possibility to change the place of their installation without much effort, which is important in the frequently varying conditions in the production method these days.

The requirement for the utilization of elevators is extremely wide and it runs across workshops, factories, labs, fixing of billboards, residential/commercial buildings to repair street lights, etc.

1.3 MECHANISM OF SCISSOR LIFT

A scissor lift is a vertical lifting device that involves of a platform. The mechanism combined to achieve this function is the use of linked, portable supports in a criss-cross pattern, known as a pantograph. A scissor lift convey the extreme economic, dependable and versatile methods of lifting loads, it has a little moving parts, which may only need lubricated. This lift table increases the load smoothly to any preferred height. This mechanism is combined with a hydraulic cylinder and the top of the scissors is attached a table platform. This device will make use of the power produced from a hydraulic cylinder to raise or lower a platform. The scissor lifts can be classified as Hydraulic lifts, pneumatic lifts and mechanical lifts.

Hydraulic scissor lifts are very powerful tool for relating a ton of force on the platform plate of module which is similarly distributed on scissor arms. A suitably designed and prepared scissor lift increases the logistic infrastructure, improving ability's competitiveness.

They are deliver optimal solution for lifting awkward moulded objects to easy working heights with least worker fatigue and physical strain. It likewise decreases back and muscle injuries by avoiding unsuitable manual lifting methods. In addition these it helps to save time. The beneficiaries are those who are occupied directly on lifting parts in automotive assembly and repair sector.

This paper presents the design and manufacturing of a scissors lift raised by one hydraulic cylinder for the automotive industry. Any machine part in demand to transfer to desired location needs a module which should transfer in horizontal or vertical direction to place it at desired position at required height. Therefore for loading and unloading purpose scissor lift is used which is portable machine that can be simply extended or compressed for transference of the component to its expected position. Scissor lift is a device that has vertical with criss-cross 'X' design scissor arms.

1.4 TYPES OF SCISSOR LIFT

Scissor lifts are classified into hydraulic, pneumatic and mechanical scissor lift. Hydraulic scissor lifts are used very commonly due to their capability to bear heavy load operations. The main components of scissor lift are lowest and highest frame, scissor arm, link connector and cylinder. Hydraulic scissor lift is a vertical transportation cab which can be raised or lowered by using hydraulic actuator. The model of hydraulic scissor lift originates from Pascal's Law applied to the hydraulic ram which states that "The pressure exerted by incompressible fluid wherever is transmitted similarly in all directions during the course of the fluid such that its pressure ratio remains the similar".

The scissor lift contain of a different lifting platform is determined by the simple metallic structure having links which expression similar number of scissors linked with each other to form a extended chain. This scissor like structure moulded by the links is contains of two well-known mechanisms which is four bar mechanism and slider crank mechanism.

The lift component is a type of development utilized in the industry. In fact, they are stage systems that are utilized in high places that are in available on the grounds that it is a lifting sending machine. Scissor-type frameworks are regularly utilized as lifting frameworks in the business.

The frameworks are for the most part liked to do upkeep, fix, and clean. Lifting frameworks are for the most part utilized for motivations behind lifting a heap or giving at inaccessible statures.

These days, many lifting frameworks are intended to be utilized for different purposes in industry. These frameworks can be utilized in multi-reason applications and a scope of administrations like cleaning administrations, upkeep fix exercises, load lifting and bringing down exercises. Air terminals and indoor arena are instances of these. Lifting frameworks can be delegated adaptive lifts, enunciated lifts, and scissor lifts.

Scissor lifting instrument is the best option for autos and enterprises for rise work. There are a few methodology for determining dynamic conditions of unbending bodies in traditional mechanics. Yet, these are work serious for huge and confounded frameworks there by mistake inclined. This depicts the execution of general multi body framework elements on Scissor lift Mechanism (for example four bar parallel system).

1.5 METHODOLOGY

Any machine part can't be moved to an ideal situation with use of less measure of outside power. For setting a segment in required area, the movement of segment follows ordinarily even or vertical course. Numerous machines like flying lift, blast lifts, scissor lift, man lift, tele overseer, towable lift are utilized to move apparatus and labour in various ways dependent on the necessity. A scissor lift is a versatile, handily broadened and compacted, safe working machine utilized for transportation of medium estimated segments to its normal position. A scissor lift is machine which moves vertical way utilizing crosswise 'X' design scissor arms. The necessary height of the lift is accomplished dependent on the quantity of confuse 'X' design scissor arms appended. The scissor lift component depends on connected arms in a mismatch 'X' design which can be collapsed and stretched out accurate way like a pantograph. The upward movement is accomplished by the use of strain to the outside of the least arrangement of supports, extending the intersection design, and moving the work stage vertically upwards. The stage may likewise have an expanding 'connect' to permit nearer admittance to the work zone.

A scissor lift is such a stage which will move just vertically. With Today's advancement of science and innovation, an ever increasing number of new advances were applied to material taking care of. The primary point of the scissor lift was material dealing with and giving solace to the administrator while playing out the activity. The scissor lift was helpful to work or utilize and it will be utilized oftentimes in enterprises and other normal spots. A scissor lift table is utilized to hold, stack, raise or lower, pass on or move materials or burdens between at least two tallness. The component utilized in a scissor lift to accomplish this capacity was only the use of connected, collapsing arms during a mismatch 'X' design, alluded to as a pantograph. A scissor lift gives the most financially trustworthy and flexible techniques for lifting substantial burdens in the business; it had not many moving parts which can just require grease. A scissor lift used to broaden or withdraw a stage by pneumatic, pressure driven, or precisely. There are a few uses of pressure driven jack are bed dealing with, vehicle stacking, and work situating, programmed creation lines, circulation lines, etc. Scissor lifts (Aerial work stages when all is said in done) are for the most part utilized for transitory access purposes like upkeep and for development work for crisis access, which recognizes them from lasting access hardware like lifts. They're intended to lift restricted loads. The expansion and withdrawal activity of the scissor arms are for the most part done by water powered, pneumatic, or precisely. A Scissors lifts are the most conservative gadget to raise the heap. It is additionally a trustworthy and adaptable technique for lifting weighty burdens. Scissors lifts have less moving parts; they are all around greased up and give numerous years without giving difficulty. These lift tables raise the heaps easily to any necessary tallness and might be handily arranged to fulfil the necessary speed, limit, and impression prerequisite of any water driven lifting application. Also, it is so mainstream and productive of all styles of scissors lift utilized in material dealing with applications.

CHAPTER 2

LITERATURE SURVEY

2.1 Gaffar G Momin et al, Design, Manufacturing and Analysis of Hydraulic Scissor Lift.

The project described in the paper is developed observance in mind that the lift can be functioned by mechanical means by using pantograph so that the complete cost of the scissor lift is reduced.

2.2 WubshetYimer et al, Design, Analysis and Manufacturing of Double Scissors Lift Elevated by One Hydraulic Cylinder.

The resulting paper explains the design, analysis and manufacturing of a hydraulic scissor lift having two levels raised by one hydraulic cylinder.

2.3 Suraj B. Dhanawade et al, Design, Analysis and Development of Hydraulic Scissor Lift.

This paper determinations problem of material handling for cold storage industry. Goods were in cartoons which are probable to be perished if not loaded to cold room in required time. The resulting paper explains the design, analysis and to fabricate a hydraulic scissor lift which lifts maximum 2000kg load with least time.

2.4 BekirCirak et al, Dynamic Analysis of the Hydraulic Scissors Lift Mechanism.

In this study, model of lifting platform comprising of scissors and hydraulic cylinder is designed. Static state equivalences have been used for the mathematical model of the mechanism. The weights and mass inertia moments of the platform followers and the higher table have been ignored.

2.5 S. D. Wankhede et al, Analysis and Optimization of Hydraulic Scissor Lift.

This paper deals with analysis and optimization of hydraulic scissor lift. Catia is used for exhibiting purpose, MSC Apex for engaging and Sim Xpert for

analysis work i.e. to check stress, strain, displacement and deformation brought in the system.

2.6 Sabde Abhijit Manoharrao et al, Design and Analysis of Hydraulic Scissor Lift by FEA.

In this report a hydraulic pallet lift is a mechanical method used for different presentations for lifting of the loads to a height or equal. A lift table is distinct as a scissor lift used to stack, raise or lower, convey and/or transfer material between two or more raises.

2.7 M. Kiran Kumar et al, Design & Analysis of Hydraulic Scissor Lift.

In this paper is mostly concentrated on force acting on the hydraulic scissor lift when it is stretched and contracted. Commonly, a hydraulic scissor lift is used for lifting and holding heavy weight machineries.

2.8 Varun Jaiswal et al, Final modeling and prototype & analysis of hydraulic scissor lift.

In this paper it studies about the project of “Spurce up Industries pvt. Ltd.” In this work procedure they design and analysis of hydraulic scissor lift which is used as an elective or alternative of regular car jack just because of this jack is only used for change the tires.

2.9 U Uttam Panwar et al, Operating Mechanism and Design of Hydraulic Scissor Lift.

In this research paper explains material handling and provide relief to the operator. This paper shows the study in addition to design of hydraulic scissor lift components.

2.10 Sandeep G. Thorat et al, Design and Construction of Hydraulic Scissor Lift.

In this report a hydraulic scissor lift is a mechanical method used for lifting of the loads to a height or level. In this paper the design presented in the similar is targeted to explain the problem faced by the industry.

CHAPTER 3

AIM AND SCOPE

3.1 AIM

This paper intends to give the answer for the issue found in stacking the crude materials(rectangular steel bars) according to the determination, that is 0.5 to 1.5 ton/bar, the distance across going from 55 mm to 75 mm, and length shifting from 1.5 m to 2 m. We chose to plan a Hydraulic Scissor lift utilized as the blend for tackling the material taking care of issues looked at by the business. The objective of the examination is to plan the pressure-driven scissors lift to lift up to a stature of 1. meters and with the conveying limit of 200 kilograms. The driving system of the lift should be a water-powered chamber. Counts of the inward burdens should be done and a 3D model should be made. It is likewise important to pick the material. The current lift has a mass of 2829 kg and conveys weight up-to tallness of 1.5 m. Since the heaviness of lift is high so weight advancement is the goal. Likewise stacking and dumping may not be consistently conveyed so lift is to be broken down for Moment Loading. Connection connector, one of the segments of scissor lift comprises a huge load of complete lift weight. They effectively support chambers. Along these lines, we need to track down an option for interface connector which has less weight or change chamber position with the end goal that the connection connectors are supplanted.The weight optimization will be achieved by two techniques one is topology optimization and another is generative design.

3.2 SCOPE OF THE PROJECT

- To rises (or) lower platforms for lifting the devices
- To control the lift easily
- To reduce material weight
- To make scissor lift as a portable product
- To Provide Safe Working Conditions

CHAPTER 4

MATERIAL SELECTION

4.1 MILD STEEL

Table 4.1 Values of Mechanical Properties

Mechanical Properties	Values
Tensile Strength, Yield	370 MPa
Elongation at Break (In 50 mm)	15.0 %
Reduction of Area	40.0 %
Modulus of Elasticity (Typical for steel)	205 GPa

Mild steel has lower carbon content than medium and high carbon steel. The carbon content is up to 0.25% in gentle steel however a few ways of thinking consider carbon steel as mild steel up to a carbon substance of 0.45%.

The low carbon content makes this steel a profoundly machine able metal. It very well may be cut, machined, framed into many-sided shapes without adding relative anxieties to the workpiece. It additionally encourages better weldability. A large group of alloying components improves the compound properties. These components will influence the physical/synthetic properties well and make the eventual outcome reasonable for the application. The components that might be added incorporate chromium (Cr), cobalt (Co), phosphorus (P), sulphur (S), manganese (Mn), among others.

For example, chromium confers the property of erosion opposition and increments gentle steel's hardness. In its unadulterated structure, gentle steel will rust effectively because of oxidation. In contrast to press oxide, chromium metal on openness to the climate shapes a thick layer of chromium oxide that doesn't tumble off, and eventually shields the metal under from additional erosion assaults. Copper in restricted amounts likewise works like chromium oxide. Gentle steel lines might be excited for better assurance from the environment. Different components might be added to improve wear obstruction, extreme rigidity, and warmth opposition.

It is important to assess the specific kind of powers forced on parts with the end goal of deciding the specific mechanical properties and essential material for every hardware. An exceptionally concise investigation of every segment follows in this manner:

- Scissors arms
- Hydraulic cylinder
- Top plat form
- Base plat form
- Wheels

4.1.1 Scissors Arms: This segment is exposed to clasping burden and twisting burden having a tendency to break or cause bowing of the segments. Thus dependent on strength, solidness, versatility, and hardness. A suggested material is tempered steel.

4.1.2 Hydraulic Cylinder: This part is considered as a swagger with the two closures stuck. It is exposed to coordinate compressive power which forces twisting pressure which may cause clasping of the segment. It is additionally exposed to an inner compressive pressing factor which produces circumferential and longitudinal burdens all around the divider thickness. Consequently, the vital material property should incorporate strength, pliability, sturdiness, and hardness. The suggested material is mild steel.

4.1.3 Top Platform: This part is exposed to the heaviness of the worker and his gear, consequently strength is required, the edge of the stage is gentle steel and the base is wood.

4.1.4 Base Platform: This segment is exposed to the heaviness of the top stage and the scissors arms. It is likewise answerable for the dependability of the entire get-together, accordingly strength. Hardness and solidness are required mechanical properties. Gentle steel is utilized.

4.2 METHODOLOGY

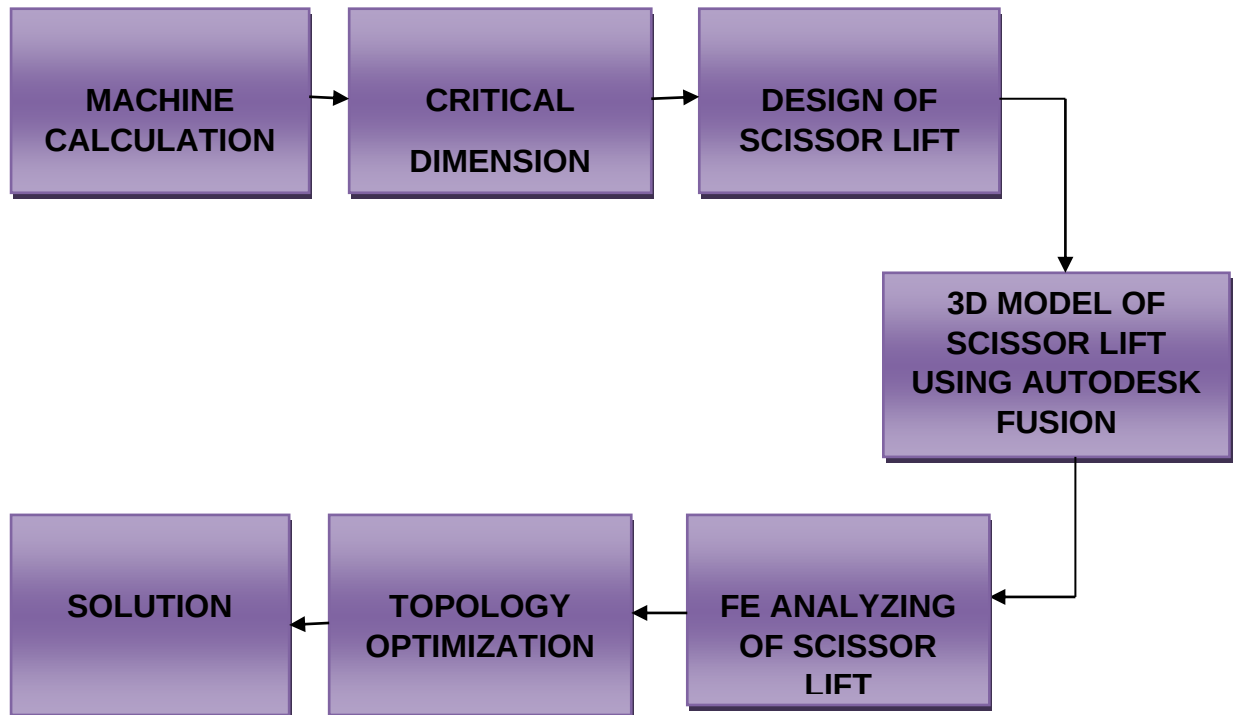


Fig 4.1: Flow diagram

Deflection in scissors lifts can be characterized as the adjustment in height, everything being equal, to the first size of the whole get together for example from the floor to the highest point of the stage deck, at whatever point loads are applied to or taken out from the lift. Every part inside the scissors lift can possibly store or deliver energy when stacked and dumped.

Diversion happens to take all things together pieces of the scissor lift i.e. Scissors Legs, Platform Structure, Base Frame, Pinned Joints. To lessen stresses and redirection in scissor lift the heap should move similarly between the two scissors arm pair. Base edges ought to be joined to the surface on which they are mounted.



Fig 4.2: Fully Assembled View of Hydraulic Scissor Lift

In this segment, all plan ideas created are examined and dependent on assessment models and interaction created, and a last here changed to additional upgrade the usefulness of the plan.

Contemplations made during the plan and manufacture of a solitary acting chamber is as per the following:

- Functionality of the design
- Manufacturability
- Economic availability

The general expense of material and creation procedures utilized Hydraulic chamber: The water-driven chamber is mounted in a slanted position. The all-out load following up on the chamber comprises of:

$$\text{LOAD} = W = 200\text{kg}$$

$$d = 789\text{mm}$$

$$L2 = 1543\text{mm}$$

$$a = 140\text{mm}$$

$$L = 1684\text{mm}$$

$$\alpha = 33^\circ$$

$$\beta = 28.5^\circ$$

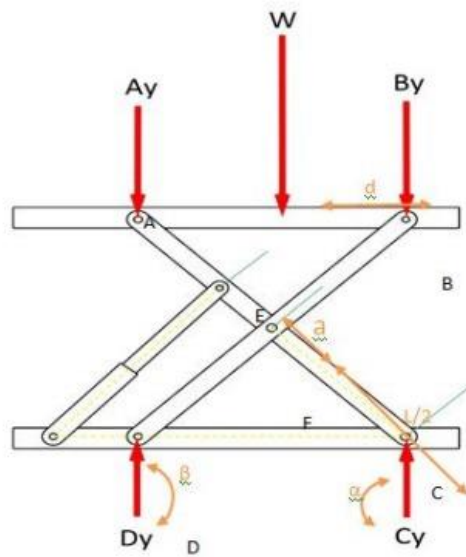


Fig 4.3: Explanation diagram

TO FIND REACTION FORCE

Taking moment at point C

$$\Sigma M_c = 0$$

$$W.d - Dy.AB = 0$$

$$Dy = W.d/AB$$

$$= W. 789/1543 = 0.511W = Dy$$

$$\Sigma F_{OY} = 0$$

$$Dy + Cy - w = 0$$

$$Cy = W - Dy$$

$$Cy = W - 0.511W$$

$$Cy = 0.489W$$

$$\Sigma F_{OX} = 0$$

$$Px - Fx = 0$$

$$Px = Fx$$

$$F_x = P \cdot \cos \beta$$

$$\Sigma F_{OY} = 0$$

$$-D_y + P_y - F_y + C_y = 0$$

$$F_y = P_y + C_y - D_y$$

$$F_y = P_y + 0.489W - 0.511W$$

$$F_y = P \cdot \sin \beta - 0.022W$$

Taking moment about C

$$\Sigma M_c = 0$$

$$D_y \cdot L \cdot \cos \alpha - P_y(L/2 + a) \cos \alpha + F_y \cdot L/2 \cos \alpha - P_x \cdot (L/2 + a) \cdot \sin \alpha + F \cdot L/2 \sin \alpha = 0$$

$$0.511W \cdot L \cdot \cos \alpha - P \sin \beta (L/2 + a) \cos \alpha + P \sin \beta \cdot L/2 \cdot \cos \alpha - 0.022W \cdot L/2 \cdot \cos \alpha - P \cos \beta (L/2 + a) \cdot \sin \alpha + P \cos \beta \cdot L/2 \cdot \sin \alpha = 0$$

$$0.489W \cdot L \cdot \cos \alpha - P \cdot a (\sin \beta \cdot \cos \alpha + \cos \beta \cdot \sin \alpha) = 0$$

4.2.1 Rule of geometry

$$(\sin \beta \cdot \cos \alpha + \cos \beta \cdot \sin \alpha) = \sin(\alpha + \beta)$$

$$P = 0.489W \cdot L \cdot \cos \alpha / a \cdot \sin(\alpha + \beta)$$

At height position of Lift

The angle,

$$\alpha = 33^\circ$$

$$\beta = 28.5^\circ$$

$$P = 0.489 \times 2000 \times 1684 \times \cos 33 / 140 \times \sin(33 + 28.5)$$

$$P = 11226.54 \text{ N}$$

This force is by piston cylinder.

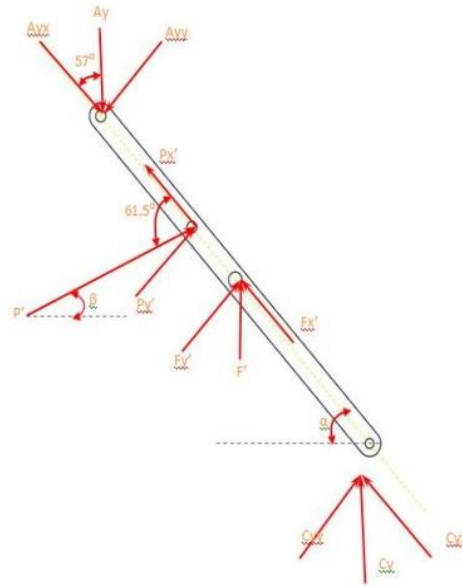


Fig 4.4: Free Body Diagram

As we can see in free body diagram

$$A_y = D_y \text{ \& } C_y = B_y$$

but opposite in direction

$$C_{yx} = C_y \cdot \cos 57$$

$$= 0.489 \cdot W \cdot \cos 57 \quad (w=200 \text{ kg} = 2000\text{N})$$

$$= 532.67 \text{ N}$$

$$A_{yx} = A_y \cdot \cos 57$$

$$= D_y \cdot \cos 57$$

$$= 0.511 \cdot W \cdot \cos 57$$

$$= 556.62 \text{ N}$$

$$C_{yy} = C_y \sin 57$$

$$= 0.489 \cdot W \cdot \sin 57$$

$$= 820.22 \text{ N}$$

$$A_{yy} = D_y \cdot \sin 57$$

$$= 0.511 \cdot W \cdot \sin 57$$

$$= 857.12 \text{ N}$$

$$P_x' = P \cdot \cos 61.5^\circ$$

$$= 11226.54 \cdot \cos 61.5^\circ$$

$$= 5356.84 \text{ N}$$

$$P_y' = P \cdot \sin 61.5^\circ$$

$$= 11226.54 \cdot \sin 61.5^\circ$$

$$= 9866.10 \text{ N}$$

$$F_x' = -A_{yx} + P_x' + C_{yn}$$

$$= -556.62 + 5356.84 + 532.67 \text{ N}$$

$$F_x' = 5332.89 \text{ N}$$

$$F_y' = -A_{yy} + P_y' + C_{yy}$$

$$= -857.12 + 9866.10 + 532.67$$

$$= 9541.65 \text{ N}$$

$$F' = \sqrt{(F_x')^2 + (F_y')^2}$$

$$F' = \sqrt{(5332.89)^2 + (9541.65)^2}$$

$$F' = 10930.82 \text{ N}$$

4.3 DESIGN CALCULATION

Shape= Hollow square section

Material = Mild steel

Outside = 76mm

Inside = 56mm

Thickness = 10mm

4.3.1 Cross-Section area

$$A = \text{Outside}^2 - \text{Inside}^2$$

$$A = 76^2 - 56^2$$

$$A = 2640 \text{ mm}^2$$

4.3.2 Compressive Stress

$$\begin{aligned}\sigma &= F/A = A_{yx} - P_{x'}/A \\ &= 556.62 - 5356.84/2640 \\ &= -1.82 \text{ MPa}\end{aligned}$$

4.3.3 Tensile Stress

$$\begin{aligned}\Sigma n &= F/A = A_{yy} - P_{y'}/A \\ &= 857.12 - 9866.10/2640 \\ &= -3.41 \text{ MPa}\end{aligned}$$

4.3.4 Equivalent Stress

$$\begin{aligned}&= \sqrt{((\Sigma n)^2 + \tau^2)} \\ &= \sqrt{((1.82)^2 + (3.41^2))} \\ &= 3.865 \text{ MPa}\end{aligned}$$

ACCORDING TO HOOKE'S LAW

$$E = \sigma/\rho$$

$$E = \sigma/(dL/L)$$

For Base/Top

$$dl = \sigma \times L/E$$

$$dl = 3.865 \times 2200/(2 \times 10^5)$$

$$dl = 0.043 \text{ mm}$$

For Rod

$$dl = \sigma \times l/E$$

$$dl = 3.865 \times 1684/(2 \times 10^5)$$

$$dl = 0.0325 \text{ mm}$$

4.4 PROCEDURE FOR DESIGNING HYDRAULIC LIFT

4.4.1 Platform

This is the top of the lift table where they lifted hefty workpieces. It very well may be accessible in an assortment of sizes. This part is exposed to the heaviness of the workpiece and its hardware, consequently, strength is required.

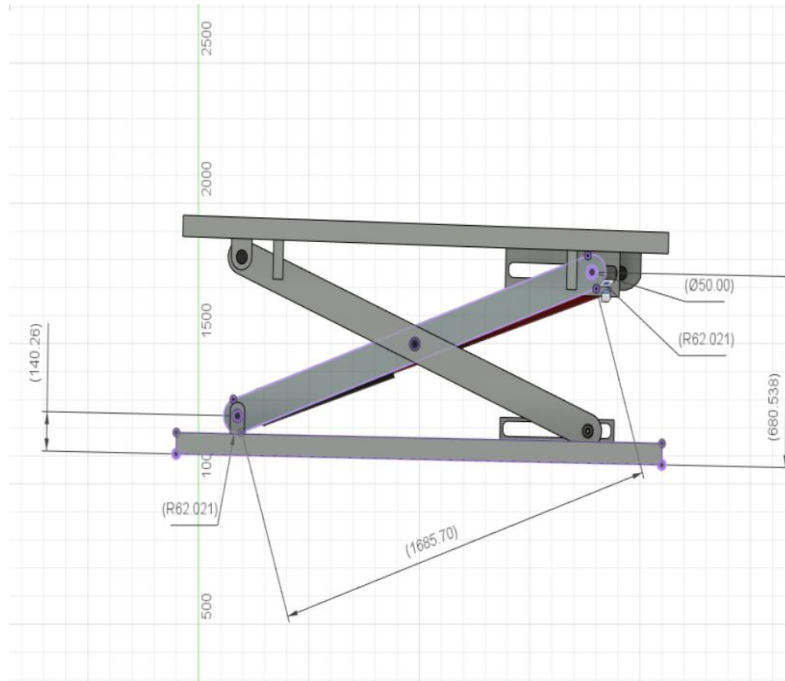


Fig 4.5: Representation for Hydraulic Scissor Lift

4.4.2 Base Platform

This is the lower part of the design that lays on the ground. It contains the track the scissor legs travel in his segment is exposed to the heap of the top stage and the scissors arms.

It is likewise at risk for the solidness of the entire get-together, accordingly strength. Hardness and solidness are required mechanical properties for the scissor lift.

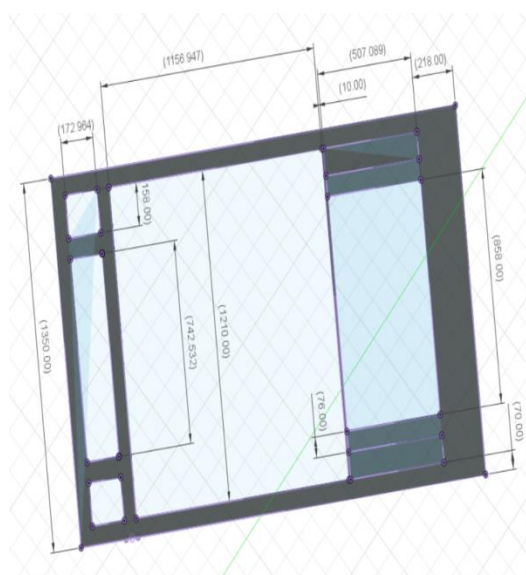


Fig 4.6: Top view for base platform

4.4.3 Scissor legs

These are the parallel members that allow the platform to vary elevation. This component is subjected to buckling load and also bending load causes breaking or cause bending of the components. Hence based on strength, stiffness, plasticity, and hardness requirement the suggest material is stainless steel or mild steel. The longer the scissors legs are, the harder it is to control bending under heavy load. Increased leg strength via increased leg material height also better resistance to deflection.

Hydraulic cylinder: Modern scissors lifts are for the most part worked by one, two, or three single-acting water-driven chambers. These permit the scissor lift table to lift and lower the heap to the necessary stature. This segment is known as a swagger with the two closures stuck. So they are exposed to coordinate compressive power which would cause bowing pressure which can cause clasping of the segment. It is exposed to an inside compressive pressing factor which produces circumferential burdens and longitudinal anxieties all around the divider thickness.

Subsequently, the essential material property should incorporate strength, pliability, durability, and hardness.

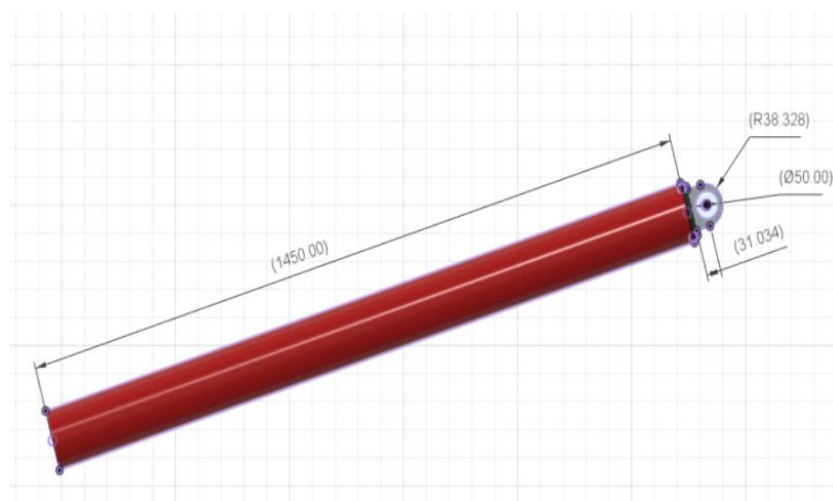


Fig 4.7: Hydraulic Cylinder Rod Dimensions

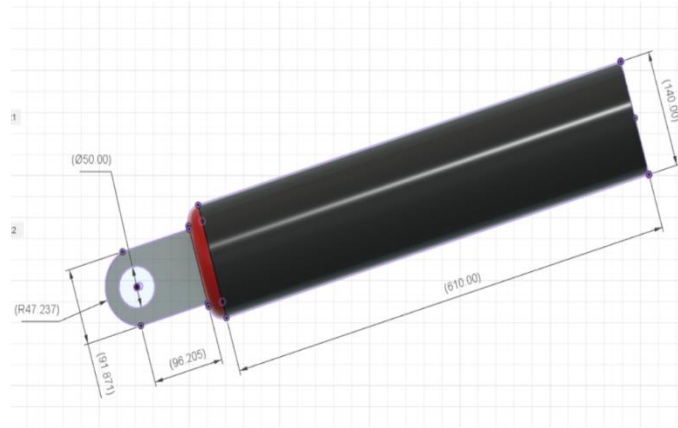


Fig 4.8: Hydraulic Cylinder Suspension Assembly Dimensions

4.4.4 Motor or Power Source

For the most part, hydraulic scissor lifts are fueled by an electric engine or air engine. These give the capacity to the water-powered siphon which impels the lift table to move upward or descending.

Hydraulic scissor lift chips away at the guideline of Pascal Law. The guideline of transmission of liquid pressing factor or Pascal Law is the standard in liquid mechanics that clarify that the pressing factor applied anyplace in a limited incompressible liquid is sent similarly every which way all through the liquid to such an extent that the pressing factor varieties stay consistent.

The basic rationale behind each pressure-driven system is straightforward is Force that is applied at one point is communicated to another point utilizing an incompressible liquid. The power is quite often duplicated in a cycle. A typical pressure-driven system comprises two cylinders and an oil-filled line interfacing with them. Because of the state of the first gadget, a pantograph is additionally alluded to as such a design that will withdraw or broaden like an agreeing, shaping a trademark rhomboidal example. The rhomboidal example will be found in the expansion of arms for divider mounted mirrors, transitory wall, scissor lifts, and other scissor components like the pantograph is used in electric trains and prepares.

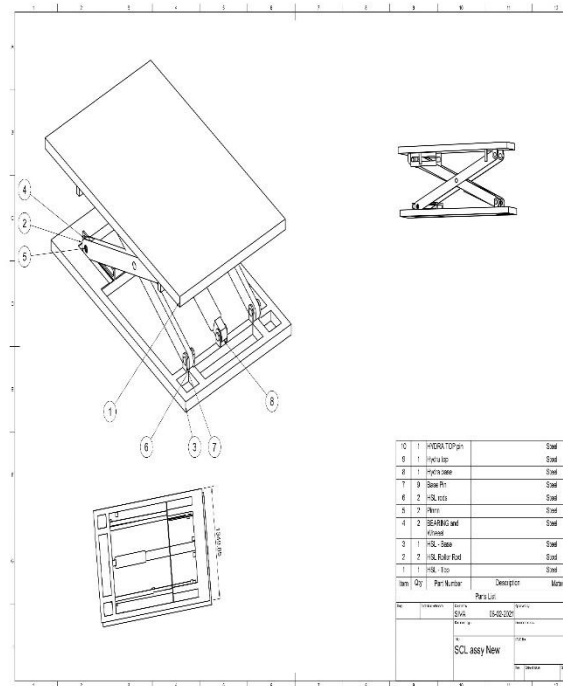


Fig 4.9: Detail Design for Hydraulic Scissor Lift

The pressure-driven sort scissor lift supplanted the lead screw by a water-powered slam or water-driven chamber fuelled by a siphon or an electric engine and generator. One remarkable component of this plan anyway is that its free activity and expanded productivity. Liquid Force is one of the more noteworthy types of force where little info causes bring about an exceptionally enormous measure of yield. This scissors lift frequently dealt with by one individual to a region of utilization, and force the generator.

The hydraulic lift doesn't lift the heap quickly; right off the bat the administrator ascensions on the stage and opens the hydraulic circuit by changes in this way prompting an upward expansion of the lift. At the point when the predetermined tallness arrives at the circuit is shut, and lifting stops the control board or station is situated on the top edge of the lift. At the point when work gets finished, at that point, the scissors lift is collapsed by utilizing a pressure-driven circuit and took care of back to the place of assortment.

4.5 TOPOLOGY OPTIMIZATION

During the 20th century, planners and designers have utilized inventive and novel techniques to create ideal types of constructions and figures. While the methods utilized by these trendsetters created proficient and stylish

structures, they shared a typical limit: arriving at the ideal design. Albeit the reason for applying geography streamlining has never been a standard methodology, advancements in discovering ideal construction structures let the scientists and originators be free to develop better plans.

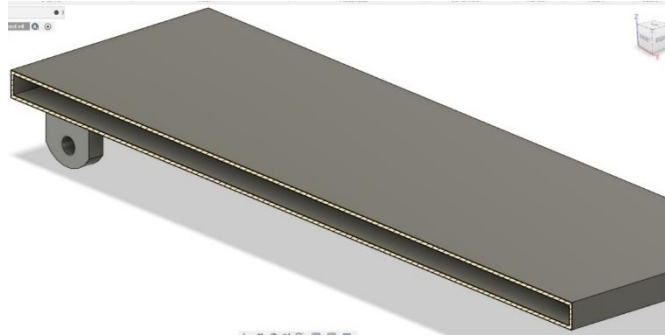


Fig 4.10: Optimization in Top design based on design calculations

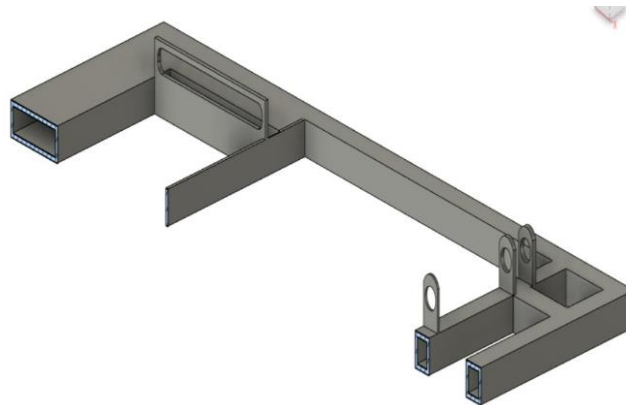


Fig 4.11: Optimization in Base platform design based on design calculations

Geography streamlining offers a calculated plan for lighter and stiffer constructions. It assists with arriving at productive and stylish plans inside a modest span. The advantages are:

- Building weight-saving and complete designs.
- Decrease needed time to present and test product.
- By the help of FEM software, you are able to check your design.

When to has shown its force and effectiveness in the plan of designs by the expansion in progress on computational speed and force. Changes in PC equipment and programming innovation have likewise changed the way to deal with geography development of designs. These days, you could utilize attractive programming framing various geographies as though it is a standard errand, thus, you can modify old plans and produce new elective plans in a virtual climate. Originators and architects are satisfied to have an amazing asset in their work.

4.6 GENERATIVE DESIGN

Generation design is a repetitive design process which is a program generates a selective number of outcomes according to the constrains given.

Where designs can be selected according to the material, factor of safety, stress and strain, weight, volume, deformation and manufacturing method etc. In this project the mass optimization are performed for parts of Hydraulic scissor lift is Scissor Rod.



Fig 4.12: Generative design for Scissor Rod

4.7 SETTING UP THE PART

In generative design process numerous components are dependent on agreeing to plan part to run this cycle. First, the part setting should be with a predefined model. At that point place the mountings in the model so the heaps are been set. The current math highlights assists with characterizing the load point.

The generative design process consists of 3 steps :

- Part modeling
- To create obstacle and preserve geometry model
- Model configuration

4.7.1 Part Modelling

The starting step in the generative design process is predefine a model or to make another model with fundamental shapes like openings, load area, mountings and so on. These models should be possible utilizing essential 3D model strategies and keep them as a solitary body and get together model can create numerous complexities to settle the plan and any sort of fringe parts can be taken out.

4.7.2 To create obstacle and preserve geometry model

After completion of modeling, new bodies have to be created for representing of two sets of data called obstacles and preserve regions and these help to define the generative design areas. The areas where generative design must not be allowed to enter is called obstacles. And preserve regions are the regions where the shape and size has to be conserved which is defined from the model.

4.7.3 Configure the Model

Before starting the generative design process two more significant boundaries must be taken to thought. The first is to set the material kind to the body and set the units. The ideal material will be given as contribution before that the ideal weight decrease must be given for the specific weight must be additionally noted. Different bodies are set with colors in the next step. There are three colors used here for different areas in the generative design process, red is set for obstacle geometry, yellow is set for starting shape and green for preserve geometry.

4.8 COMPARE RESULTS WITH INITIAL EXPECTATIONS

Once the results are generated have to be validated according to the desired shape or design. The results are refined in various iterations by the starting shape. The manoeuvre result make an appreciable starting shape for the secondary study. For few results validated by using additional FEA package.

4.8.1 Design modification

Once the satisfied result is generated, the design is exported as a B-rep/T-rep and it is placed back as the base model. Again brainstorm about the steps must take next according to the CAM, CAE simulated validation and additive

manufacturing. Required features must be added like T- spline modifications are considered to get desired design requirements. The final model is taken to CAM, 3D printing software as STL file and CAE then assemble the part in the original design.

This process is iteratively continuous work to refine the designs in further. This generative design process is a complicated set of tools which help to develop the parts to give their performance at its best, it is as good as the more information given to solve the model easily and to get accurate results.

4.8.2 Generative design for scissor rod

These are the parallel members that allow the platform to vary elevation. This component is subjected to buckling load and also bending load causes breaking or cause bending of the components. Hence based on strength, stiffness, plasticity, and hardness requirement the suggest material is stainless steel or mild steel. The longer the scissors legs are, the harder it is to control bending under heavy load. Increased leg strength via increased leg material height also better resistance to deflection.

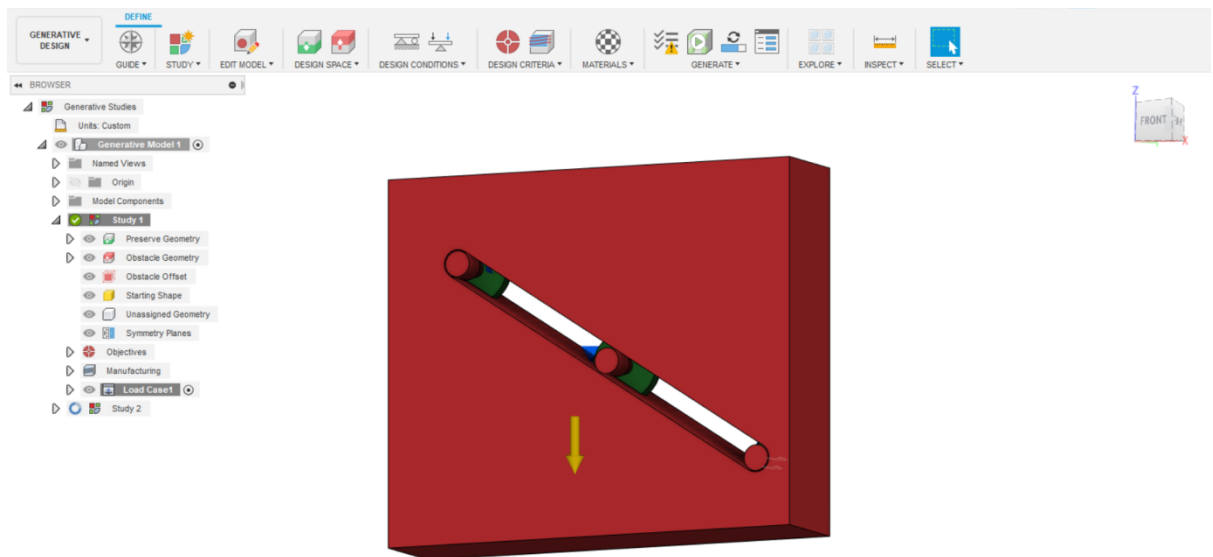


Fig 4.13: Generative design setup for Scissor Rod

4.8.3 To identify the problem and collect data

The initial step expects to conceptualize to tackle the issue as indicated by the gathering leeway and the sort of assembling and other ongoing boundaries

are thought of. The powerful parts like burden variety, moving parts, and so forth are likewise thought of. At long last, mass decrease, execution, feel, and other plan changes additionally to be thought of.

4.8.4 Create Preserve Geometry

Start the process with existing 3D model whether it can be single component or assembly. At that point interface calculation must be made like jolts, ribs and so on for the generative plan measure as new bodies. This area consistently depends as indicated by the utilization of the part or gathering.

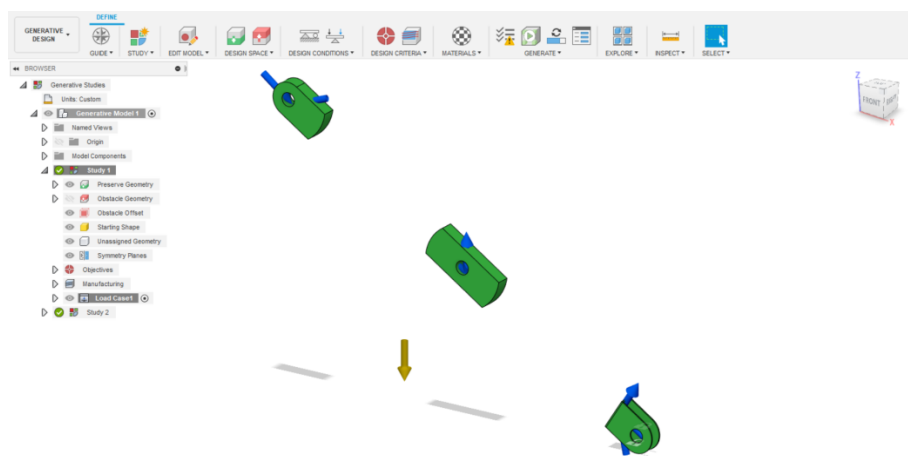


Fig 4.14: Preserves bodies for Scissor Lift

4.8.5 Create Obstacle Geometry

Presently again the base model must be altered again on the grounds that a snag calculation must be made. These calculation incorporates fasteners, screws, nuts, pins and so on and other invulnerable math bodies are considered as a hindrance calculation. In any case, thing is clearances must be noted. And finally the obstacles has to cover the problem statement.

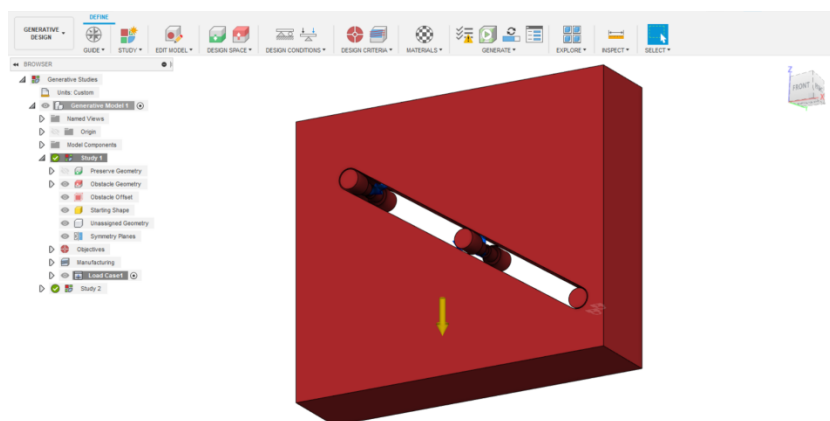


Fig 4.15: Obstacle bodies for Scissor Lift

4.8.6 Setting up Boundary Conditions

The parameter or constraints like loads, manufacturing method, material, factor of safety, stiffness, mass target and buckling frequency are specified. Proper or calculated load cases are set on the preserves according to the motions that are involved. In this case the fork and wishbone are experienced with braking, cornering, horizontal and vertical forces.

Table: 4.2 Boundary Conditions Values

BOUNDARY CONDITIONS	VALUES
MATERIALS	Stainless Steel 304
FACTOR OF SAFETY	3
MANUFACTURING METHOD	ADDITIVE MANUFACTURING
FORCE (N) These forces act at different scenarios and has different load cases on the Scissor Rod or leg	556.62 N 857.12 N 5356.84 N 9866.10 N 5332.89 N $1.093 \times 10^4 \text{N}$ 9541.65 N

4.8.7 Run the Study

Final step for this analysis study is to run the process. The early results has to be ensured, to get the expected result in different iterations. During this process if any parameter input is missed can be identified. The analysis is reviewed to check the data given by the software is accurate and correct which is defined to get the generative design. The results are previewed with various

options according to the number of materials given as input and other parameters given to the system.

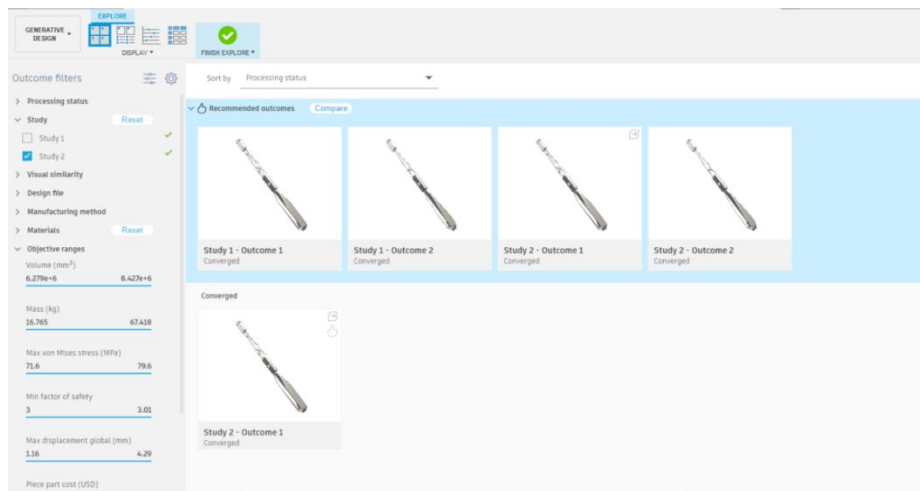


Fig 4.16: Selection of design outcome according to the shape, material, weight, cost of manufacturing, FOS, Stress etc.

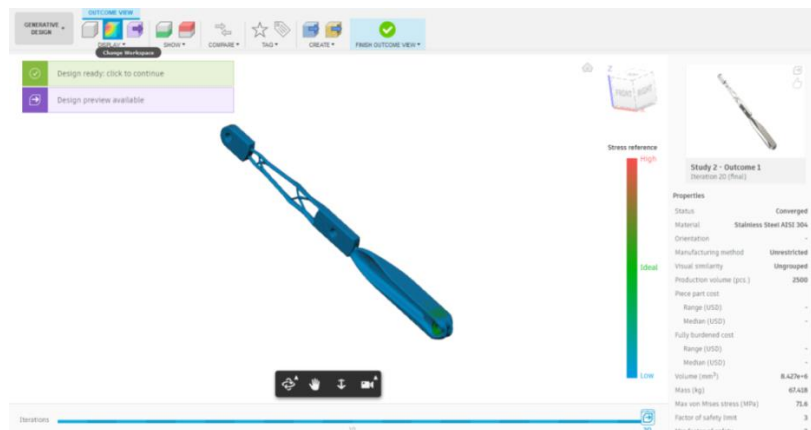


Fig 4.17: Selection of design outcome after solving various iterations and according to the shape and stresses shown in the outcome view

CHAPTER 5

RESULT AND DISCUSSIONS

5.1 FINITE ELEMENT ANALYSIS

FEA or finite element analysis is a commonly used method for physical problems using numerical techniques, since Hydraulic Scissor Lift is a heavy mechanism it is hard to tackle in a hypothetical way. It is utilized to tackle exceptionally troublesome continuous engendering or liquid stream. Any nonstop item in space has different levels of opportunity which makes it hard to tackle ordinarily the result of the arrangement is a long way from the constant examination.

In FEA, the article is should have been addressed can be platted the surface body into a discrete number of components for which the arrangement can be determined and tackled. The component can be spread its limit condition all through the entire domine. FEA increases the value of the item plan process it gives critical understanding and plan that assists with making better items. A portion of the particular advantages and result of utilizing FEA incorporate the accompanying:

- It can predict the performance of the plan to be used
- It can predict the failure accusation for the case study
- It is used to evaluate and correct observed failures
- It is used to evaluate the design and improve the performance and safety
- Improvises the cost for manufacturing
- Improvises the weight of the known design with optimal performance
- To develop new innovative concepts with high savings on development
- Gains insight into the design concepts or directions
- Modeling decisions a be driven through the goals

5.2 MESHING

It is an important process to obtain results accurately in finite element analysis. The smaller the mesh size the more resolution of the design solutions as samples across the physical domains for higher accuracy the mesh size to be very fine result in an increase in time taken for processing.

A finite element mesh includes both nodes and elements

- Nodes are points in 3d space
- Elements are area or volume defined by nodes

The geometry provided by the element poses the template for meshing. Based on the area defined in a domain the element types are wildly classified into four types they are

- Shell elements
- Solid elements
- Line elements

The shell elements are usually used in modal structures in which one dimension, the thickness, is significantly smaller than the other dimensions. Conventional shell elements use the condition to discretize the body of 3d model by defining the geometry at a reference surface of the model. Conventional shell elements have both displacement and rotational degrees of freedom but in the continuum, shell element discretizes an entire three-dimensional body only. The thickness is decided from the element nodal geometry. While the Continuum shell elements have transposition degrees of freedom only in the thickness property of the material. From a modelling point of view, continuum shell elements appear as if 3d continuous solid, but their kinetic and constitutive behaviour is analogous to standard shell elements. In Solid elements, the entire geometry is been described by the cad model geometry. The tetrahedrons are the element type for three-dimensional, solid meshes.

There are two types of tetrahedrons

- Linear tetrahedrons

- Parabolic tetrahedrons

In linear tetrahedral element is defined by four corner nodes connected by straight edges. In parabolic tetrahedral element is described by four corner nodes, six mid-side nodes, four corner nodes, and six edges.

For the same mesh density for a number of elements, parabolic tetrahedral elements possess improved results than linear elements because they denote curved boundaries more accurately and they make better mathematical approximations. The parabolic tetrahedral elements require more computational resources than linear elements.

5.3 FEA ANALYSIS BEFORE OPTIMIZATION FOR TOP

Table 5.1 Stress Values before Optimization for Top

Average Element Size (% of model size)		
Average Element Size (absolute value)		10 mm
Create Curved Mesh Elements		Yes
Max. Turn Angle on Curves (Deg.)		60
Max. Adjacent Mesh Size Ratio		1.5
Max. Aspect Ratio		10
Minimum Element Size (% of average size)		20
TYPE	NODES	ELEMENTS
Solids	2081606	1455903

Table: 5.2 Result Summary

Name	Minimum	Maximum
Safety Factor		
Safety Factor (Per Body)	15	15

Stress		
Von Mises	1.09E-08 MPa	1.279 MPa
Displacement		
Total	0 mm	0.001324 mm
Reaction Force		
Total	0 N	44.73 N
Strain		
Equivalent	9.01E-14	6.914E-06

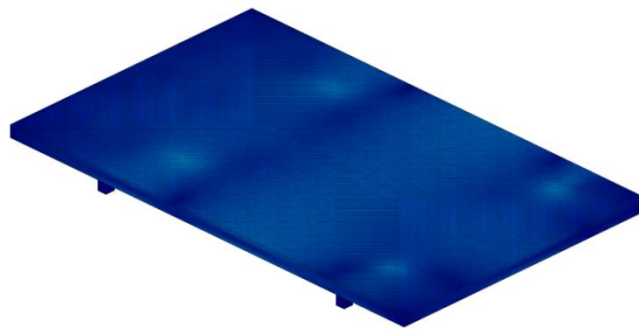


Fig 5.1 : Stress for before optimization for top

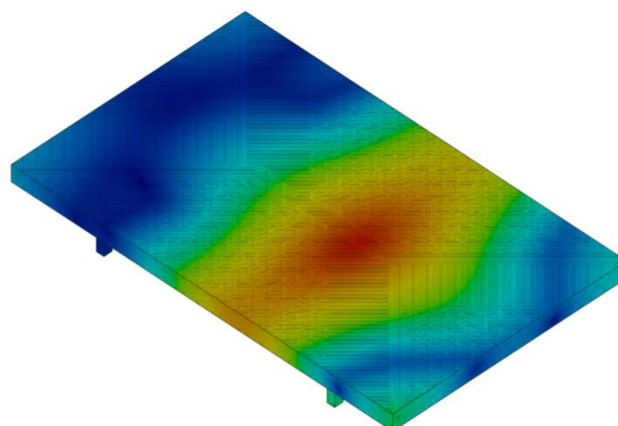


Fig 5.2 Displacement for before optimization for top

5.4 FEA ANALYSIS BEFORE OPTIMIZATION FOR BASE PLATFORM

Table: 5.3 Stress Values before Optimization for base platform

Average Element Size (% of model size)		
Average Element Size (absolute value)		10 mm
Element Order		Parabolic
Create Curved Mesh Elements		Yes
Max. Turn Angle on Curves (Deg.)		60
Max. Adjacent Mesh Size Ratio		1.5
Max. Aspect Ratio		10
Minimum Element Size (% of average size)		20
Type	Nodes	Elements
Solids	713201	477651

Table: 5.4 Result Summary

Name	Minimum	Maximum
Safety Factor		
Safety Factor (Per Body)	3.182	15
Stress		
Von Mises	9.347E-06 MPa	65.06 MPa
Displacement		
Total	0 mm	0.004315 mm
Reaction Force		
Total	0 N	65.01 N
Strain		
Equivalent	6.14E-11	5.326E-04

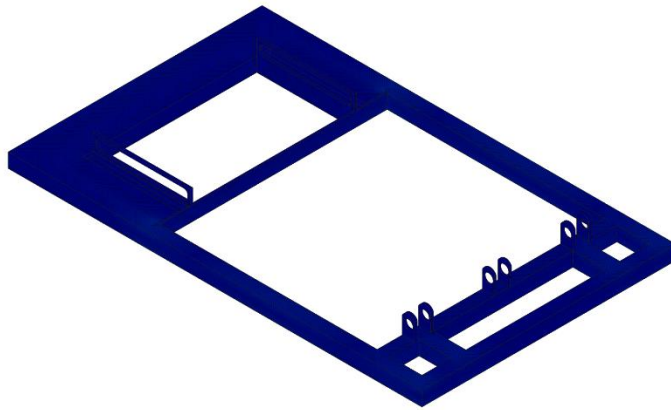


Fig 5.3: Stress for before optimization for base platform

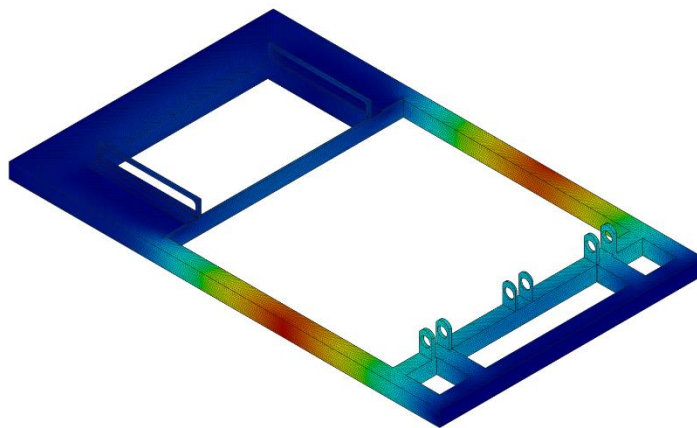


Fig 5.4: Displacement for before optimization for base platform

5.5 FEA ANALYSIS BEFORE OPTIMIZATION FOR SCISSOR ROD

Table: 5.5 Stress Values before Optimization of Scissor Rod

Average Element Size (% of model size)	
Average Element Size (absolute value)	10 mm
Element Order	Parabolic
Create Curved Mesh Elements	Yes

Max. Turn Angle on Curves (Deg.)		60
Max. Adjacent Mesh Size Ratio		1.5
Max. Aspect Ratio		10
Minimum Element Size (% of average size)		20
Type	Nodes	Elements
Solids	102969	67172

Table: 5.6 Result Summary

Name	Minimum	Maximum
Safety Factor		
Safety Factor (Per Body)	0.3792	15
Stress		
Von Mises	0.006455 MPa	545.9 MPa
Displacement		
Total	0 mm	7.258 mm
Reaction Force		
Total	0 N	5582 N
Strain		
Equivalent	4.535E-08	0.003964



Fig 5.5 : Stress for before optimization for scissor rod



Fig 5.6: Displacement for before optimization for scissor rod

5.6 FEA ANALYSIS AFTER OPTIMIZATION FOR TOP

Table: 5.7 Stress Values after Optimization for Top

Average Element Size (% of model size)		
Average Element Size (absolute value)		10 mm
Element Order		Parabolic
Create Curved Mesh Elements		Yes
Max. Turn Angle on Curves (Deg.)		60
Max. Adjacent Mesh Size Ratio		1.5
Max. Aspect Ratio		10
Minimum Element Size (% of average size)		20
Type	Nodes	Elements
Solids	1192914	695548

Table :5.8 Result Summary

Name	Minimum	Maximum
Safety Factor		
Safety Factor (Per Body)	15	15
Stress		
Von Mises	9.91E-07 MPa	10.08 MPa
Displacement		
Total	0 mm	0.3527 mm
Reaction Force		
Total	0 N	189.4 N
Strain		
Equivalent	6.377E-12	6.211E-05

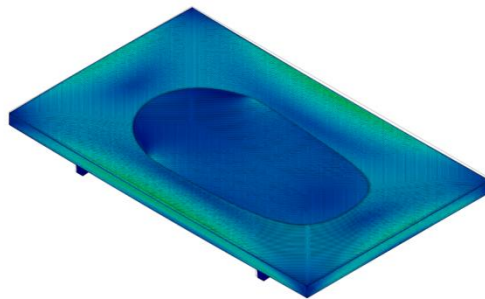


Fig 5.7: Stress for after optimization for top

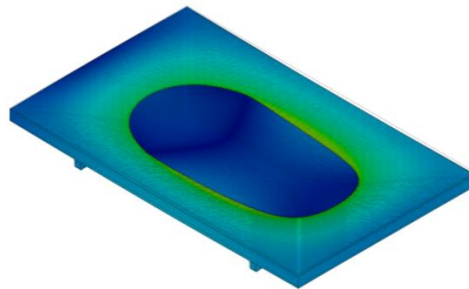


Fig 5.8 Displacement for after optimization for top

5.7 FEA ANALYSIS AFTER OPTIMIZATION FOR BASE PLATFORM

Table: 5.9 Stress Values after Optimization for Base Platform

Average Element Size (% of model size)		
Average Element Size (absolute value)		10 mm
Element Order		Parabolic
Create Curved Mesh Elements		Yes
Max. Turn Angle on Curves (Deg.)		60
Max. Adjacent Mesh Size Ratio		1.5
Max. Aspect Ratio		10
Minimum Element Size (% of average size)		20
Type	Nodes	Elements
Solids	474292	266424

Table: 5.10 Result Summary

Name	Minimum	Maximum
Safety Factor		
Safety Factor (Per Body)	7.028	15
Stress		
Von Mises	1.982E-05 MPa	29.45 MPa
Displacement		
Total	0 mm	0.009001 mm
Reaction Force		
Total	0 N	27.9 N
Strain		
Equivalent	1.332E-10	2.412E-04

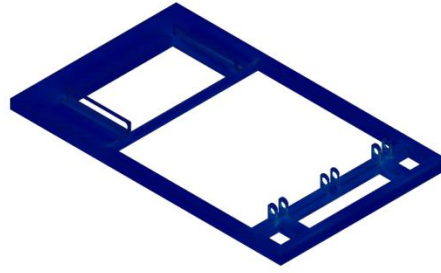


Fig 5.9: Stress for after optimization for base platform

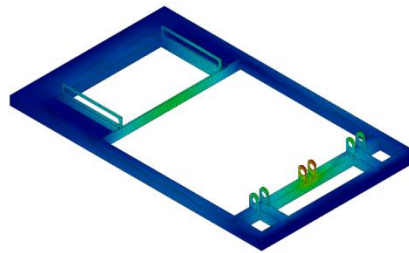


Fig 5.10: Displacement for after optimization for base platform

5.8 FEA ANALYSIS AFTER OPTIMIZATION FOR SCISSOR ROD

Table: 5.11 Stress Values after Optimization of Scissor Rod

Average Element Size (% of model size)		
Average Element Size (absolute value)		10 mm
Element Order		Parabolic
Create Curved Mesh Elements		Yes
Max. Turn Angle on Curves (Deg.)		60
Max. Adjacent Mesh Size Ratio		1.5
Max. Aspect Ratio		10
Minimum Element Size (% of average size)		20
Type	Nodes	Elements
Solids	102969	67172

Table: 5.1 Results Summary

Name	Minimum	Maximum
Safety Factor		
Safety Factor (Per Body)	1.116	15
Stress		
Von Mises	7.283E-04 MPa	185.4 MPa
Displacement		
Total	0 mm	0.9036 mm
Reaction Force		
Total	0 N	3404 N
Strain		
Equivalent	3.788E-09	0.001461

Table 5.13 FOS, Stress and Displacement optimized values

CATEGORY	TOP	BASE PLATFORM	SCISSOR ROD	TOP OPTIMIZED	BASE PLATFORM OPTIMIZED	SCISSOR ROD OPTIMIZED
FOS	15	3.182	0.3792	15	7.028	1.116
STRESS (MPa)	1.279	65.05	545.91	10.08	29.4	185.4
DISPLACEMENT (mm)	0.001324	0.004315	7.256	0.3527	0.009001	0.9036
REACTION FORCE (N)	44.73	0	5582	189.4	27.9	3404
STRAIN	6.91*10 ⁻⁶	5.32*10 ⁻⁴	0.003964	6211*10 ⁻⁴	2.412*10 ⁻⁴	0.001461
MASS (GRAMS)	1812.157	519.291	79.046	537.156	255.476	66.254



Fig 5.11: Stress for after optimization for scissor rod



Fig 5.12: Displacement for after optimization for scissor rod

5.9 COMPARISON STUDY ON ALL 3 PARTS OPTIMIZATION

Thereafter, we have compared the parts before and after optimization of scissor lift, after the comparison, the top, base platform and scissor rod show better results but the rod has a complicated design. The design of the optimized scissor lift shows excellent results, and the material Stainless Steel 304 is used to make the hydraulic scissor lift more strong.

From this, we can conclude that the optimized parts (top, base platform and scissor rod) have got improved than the existing design because the parameters show improved results.

CHAPTER 6

CONCLUSION

The hydraulic scissor lift was basic being used. It can likewise lift heavier burdens. Material dealing with and giving solace to the administrator was our primary inspiration driving the improvement of this lift. With such a plan of scissor lift, the intricacies in a plan and manufacture time were decreased. Yet, the restriction of this lift is the high introductory expense. The analysis and simulation on AUTODESK FUSION 360° programming has additionally shown that the plan was protected under certain acknowledged boundaries. In this paper, we did a definite analysis of scissor component joins against bowing and clasping disappointment and furthermore centered around different plan viewpoints. In this, the lift was just fit for lifting the load up to 200kg with the least exertion.

In this paper, we have discussed the important points for optimizing the design and analyzing the Hydraulic Scissor Lift performance in various scenario. From the simulation results, it is clear that using generative design and topology optimization technique has been reduced according to the kerb weight of the the scissor lift. Since, mass is one of the important criterion in the racing and cruiser bikes, as mass gets reduced the vehicles gets to travel faster, hence generative design and topology optimization are helpful to reduce mass up to 38% of the Hydraulic Scissor Lift.

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INVESTIGATION ON DESIGN, ANALYSIS AND TOPOLOGICAL OPTIMISATION OF HYDRAULIC SCISSOR LIFT Submitted in partial fulfilment of the requirements for the award of

Bachelor of Engineering degree in Mechanical Engineering By KARTHEESHWARAN R (37150090) SIVA J (37150709) DEPARTMENT OF MECHANICAL ENGINEERING SCHOOL OF MECHANICAL ENGINEERING SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY (DEEMED TO BE UNIVERSITY)

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Submitted for Viva
Voce Examination held on _____ Internal Examiner External
Examiner DECLARATION I KARTHEESHWARAN R, Hereby declare that the Pro
Report entitled INVESTIGATION ON DESIGN, ANALYSIS AND TOPOLOGICAL

OPTIMISATION OF HYDRAULIC SCISSOR LIFT done by me under the guidance of Dr.G. Arunkumar, M.E.,Ph.D., at SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in MECHANICAL ENGINEERING.

DATE: _ _ _PLACE: CHENNAI _ SIGNATURE OF THE CANDIDATE _ _

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