CALCULATIONS FOR STRUCTURAL DESIGN OF HYDRAULIC SCISSOR LIFT WITH LOAD CAPACITY 3.5 TONS AT TMC INDUSTRIAL PUBLIC CO., LTD. THAILAND

FINAL PROJECT REPORT

Submitted to Department of Mechanical Engineering
Faculty of Industrial Technology in Partial Fulfillment of the Requirement for Bachelor Degree of Mechanical Engineering at Universitas Islam Indonesia

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YOGYAKARTA
2017

DECLARATION LETTER

I hereby declare that the project work entitled "CALCULATIONS FOR STRUCTURAL DESIGN OF HYDRAULIC SCISSOR LIFT WITH LOAD CAPACITY 3.5 TONS AT TMC INDUSTRIAL PUBLIC CO., LTD. THAILAND "submitted to Department of Mechanical Engineering, Faculty of Industrial Technology in Partial Fulfillment of the requirement for the Bachelor Degree of Mechanical Engineering at Islamic University of Indonesia, is a final project done by me under the guidance of my advisor, Dr. Eng. Risdiyono, S.T., M.Eng. after the completion of three months' work at T.M.C. Industrial Public Co., Ltd. and Rajamangala University of Technology Tawan-ok (RMUTTO), Thailand.

If someday this project has proven as a plagiarism, Universitas Islam Indonesia has right to revoke its confession.

Yogyakarta, June 1st 2017

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ADVISOR VALIDATION PAGE

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Chonburi, May 2017

Advisor,

Dr. Eng. Risdiyono, S.T, M.Eng.

THESIS APPROVAL OF EXAMINATION COMMITTEE

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DEDICATION PAGE

This final project report I dedicate to my family who always provide moral and material support and prayers for the success of my life.

MOTTO

"Verily, with every difficulty, there is a relief" (QS. Al-Insyiroh: 6).

"If you wait me to give up, so you will be waiting forever"(Naruto Shippuden, Uzumaki Naruto)

"Stop thinking. Just do it" (anonymous)

"The best revenge is massive success"(Frank Sinatra)

ACKNOWLEDGMENT

بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ

Assalamu'alaikum wa rahmatullahi wa barakatuhu.

Alhamdulilahirobbil 'alamin, praise for Allah SWT for all the blessing and grace to enable me to complete this bachelor thesis entitled: Calculations For Structural Design Of Hydraulic Scissor Lift With Load Capacity 3.5 Tons In Tmc Industrial Co., Ltd. Thailand. This bachelor thesis is a requirement for accomplishing S-1 degree in Department of Mechanical Engineering, Faculty of Industrial Technology, Islamic University of Indonesia.

The writer also want to express his sincere thank to all of individual who has given the contribution for the writer. The writer want to extend his thanks to:

1. Allah SWT., who always bestows health and mercy for writer carry out the final project.
2. Prophet Muhammad SAW., who always motivate through a legacy in the form of Al-Hadith who always read by author.
3. My beloved parents and families.,who always support and pray for everything to go well.
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The final word the author realized that in the writing of this thesis is still far from perfection. Therefore, the authors invoke suggestions and criticisms which built for the sake of perfection and may be useful for all of us.

Wassalamu'alaikum wa rahmatullahi wa barakatuhu.

Chonburi, 20th May 2017

Author

ABSTRACT

Scissor lift is device that is used to lift something to a higher place. In the design of frame structure, good accuracy is required in order to avoid the constraints that occur from the safety factor and strength. However, in determining the structure, it takes a layout that conforms to a predetermined specification. In addition, a hydraulic cylinder of 2 is used to balance the lift load. After the structure of the frame can be known value and strength, it needs to check by using the comparison of safety factor. If the comparison results do not match, then the design process must be repeated from the beginning. Therefore, assumptions on layout and structural assumptions are very influential on good results. Motor power, pump and oil tank volume need to be calculated to support force on cylinder in order to lift load.

The results of the calculation and selection of hydraulic cylinders obtained are outside diameter 95 mm, Inside diameter 80 mm, Rod 60 mm. Meanwhile, for motor power used is 3HP, flow rate pump is 6.4 cc / rev, oil tank volume is 18.6 liters. Therefore, the calculation results for the design of this scissor lift is very suitable to lift the load 3.5 tons.

Keywords : scissor lift, cylinder hydraulic, safety factor.

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CHAPTER I

INTRODUCTION

1.1 Background

TMC Industrial Public Co., Ltd. is a manufacturing company of hydraulic and system mechanical press. The company was founded on January 13, 1972 by Mr.Tweemate Kwonmongkonsouk with vision*" it's possible for Thai people to invent and manufacture of hydraulic and mechanical* presses ".With this commitment, TMC awarded *"The Most Noble Order of the Crown of Thailand*" as a developer and a system press of hydraulic and mechanical (www.tmc.co.th, 2011). In addition, one of products of this company is a scissor lift.

Scissor lift is mechanical device which used for various applications removal of the load to a height or a certain level. Scissor lift can work with several combinations of application, such as pneumatic, hydraulic, mechanical, and others. (Sabde Abhijit Manoharrao, 2016)

In this final project design is used scissor lift using hydraulic cylinders as an application appointment. It should be considered in this design is to determine the specifications of scissor lift such as the platform size, load capacity, maximum height, minimum height, travel height, arm lifts, hydraulic cylinder, up-speed. After knowing the value of the desired specification, it is necessary to calculate the strength of frame structure, motor specification, pump specification and hydraulic cylinder size. Calculations of the structure are important before making with software design in order to know size and material strength in accordance with the specifications.

The result of this design is to produce structural calculations scissor lift with reference to the specification and to determine the specifications of the motor, pump, oil tank and hydraulic cylinder.

1.2 Problems Formulation

Based on the background that has been submitted, it is necessary to formulate the problems as follows:

1. How to make layout for assumption calculations?
2. How to calculate the structure and strength of scissor lift ?
3. How to calculate and determine the hydraulic cylinder size and strength which support to the structure of scissor lift?
4. How to calculate and determine the specifications of motor, pump and oil tank volume which support with scissor lift?

1.3 Scope of the Project

The scope of the projects "Calculations for Structural Design of Hydraulic Scissor Lift with Load Capacity 3.5 Tons at T.M.C Industrial Co.,Ltd Thailand "as follows:

1. The calculations performed are frame structure, hydraulic cylinder size, motor specifications, pump specifications and oil tank volume.
2. Hydraulic cylinders which used are type a single speed.
3. Design specifications are determined by TMC Industrial Co., Ltd.

1.4 Objective

Based on the background outlined, we can conclude the issues to be studied are:

1. To design and calculate the structures of scissor lift which safety in accordance with the desired.
2. To determine the size of hydraulic cylinder which supporting for structure of scissor lift.
3. To determine the specifications of motor, pump and oil tank volume in accordance with the structure of the scissor lift after doing the calculations.

1.5 Benefits Design

The benefit of this design is to determine all the size and strength of the scissor lift structure which safe before making a design with drawing software.

1.6 Outline of the Reports

To understand regarding this final project, the writing is done by grouping into chapters with systematic writing as follows:

CHAPTER I : INTRODUCTION

This chapter explains the general information such as background, problems formulation, scope of the project, design objectives, benefits design and systematics writing.

CHAPTER II : LITERATURE REVIEW

This chapter explains the design of the study or previous or recent developments on the topic of research, comparison-comparison which includes a review of the literature. As well as in it there are the basic theory to identification, explanation and discussion of research issues.

CHAPTER III: RESEARCH METHODOLOGY

This chapter explains the flow of research, or methods used to calculate the design of the product.

CHAPTER IV : RESULTS AND DISCUSSION

This chapter contains the results obtained from studies such as product design and research data are supported or supplemented by tables, figures, charts and diagrams. The results section only displays data or the product design and discussions carried out by comparing the specifications requested by the results that have been obtained.

CHAPTER V : CONCLUSION

This chapter contains about the conclusions and suggestions regarding the summary of the results of the design.

CHAPTER II

LITERATURE REVIEW

2.1 Literature Review

Scissor lift is a device to raise something, such as worker, materials or objects to a certain height as desired. However, if the scissor lift is designed, manufactured and maintained in accordance properly, it will improve job performance, productivity and safety factor. Unfortunately, there are still many accidents that occur due to the lack of safety factors in the design. Some of these factors are scissor-speed, heavy load which not appropriate and the material strength. It is necessary to design highly appropriate to determine the sizes and strength on this device. (Ren G.Dong, 2012)

Every part of the machine cannot move to a position corresponding to the desired to move a component. Some of them are aerial lifts, boom lifts, scissor lift, towable elevator used to move a material or device to different directions as desired. A scissor lift is a portable, easily extended and compressed, used for safe operating machine. (M.Kiran Kumar, 2016)

2.2 Scissor Lift

2.2.1 Scissor Lift Components

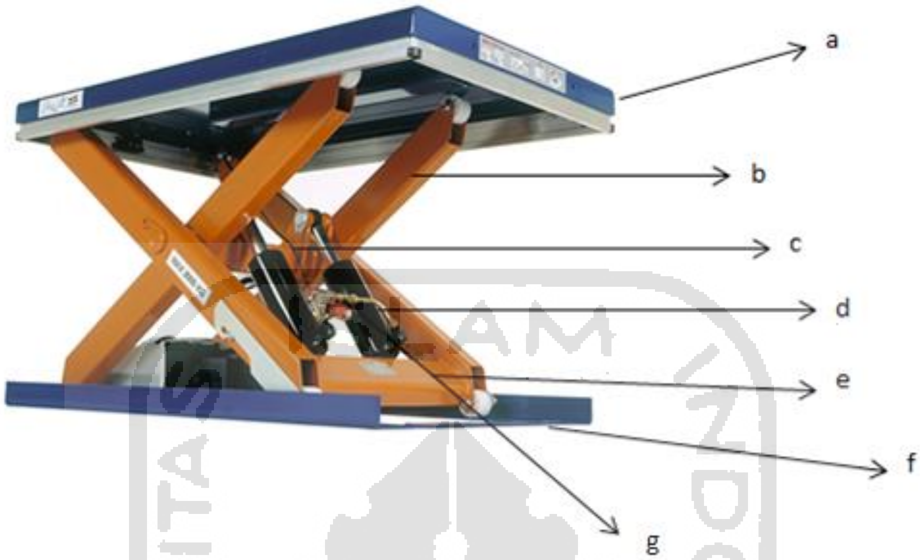

Figure 2. 1 Structure Components

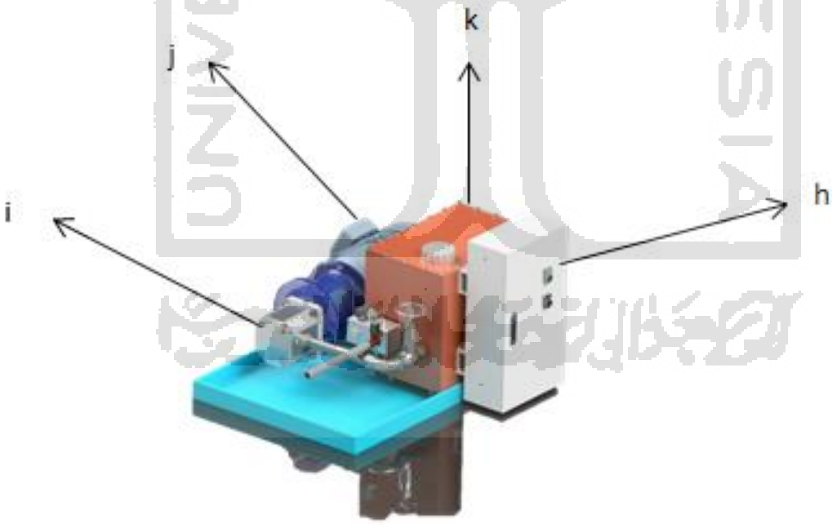

Figure 2. 2 Motor components

Where:

a) Platform
b) Scissor package

c) Top beam
d) Lift cylinder
e) Bottom beam
f) Base frame
g) Safety valve
h) Control unit
i) Pump
j) Motor
k) Oil tank

2.3 Material Used

2.3.1 SS400

SS400 material is mild steel in which the chemical composition of only carbon (C), Manganese (Mn), silicon (Si), sulfur (S) and phosphorus (P) used for the application of structure / general construction, for example for bridge, plate ships, oil tank and structure of lift. (steelindopersada.com, 2015)

Table 2.1 material properties ss400

Base Metal Price	2.9 % rel
Density	7.9 g/cm^3 (490 lb/ft^3)
Elastic (Young's, Tensile) Modulus	210 GPa (30 x 10^6 psi)
Electrical Conductivity	12 % IACS
Electrical Resistivity Order of Magnitude	-7 10^x Ω-m
Elongation at Break	23 %
Modulus of Resilience (Unit Resilience)	200 kJ/m^3
Poisson's Ratio	0.29
Specific Heat Capacity	480 J/kg-K
Strength to Weight Ratio	61 kN-m/kg
Tensile Strength: Ultimate (UTS)	480 MPa (70 x 10^3 psi)

Tensile Strength: Yield (Proof)	290 MPa (42 x 10^3 psi)
Thermal Conductivity	50 W/m-K
Thermal Diffusivity	13 m^2/s
Thermal Expansion	11 µm/m-K
Unit Rupture Work (Ultimate Resilience)	96 MJ/m^3

2.4 Hydraulic cylinder

Hydraulic cylinders are used single-acting type. This cylinder has only one movement, usually just to lift or push.

Figure 2. 3 Hydraulic cylinder single acting

Figure 2.3 It shows the hydraulic cylinder which has a single-acting, i.e. one direction only. And also characterized by having one port hose burst.

2.5 Beam

A beam is a structural member which subjected primarily to transverse loads and negligible axial loads. Transverse loads that occur causing the bending moment on the beam. (Prof.Dr.A.Varma, 2012)

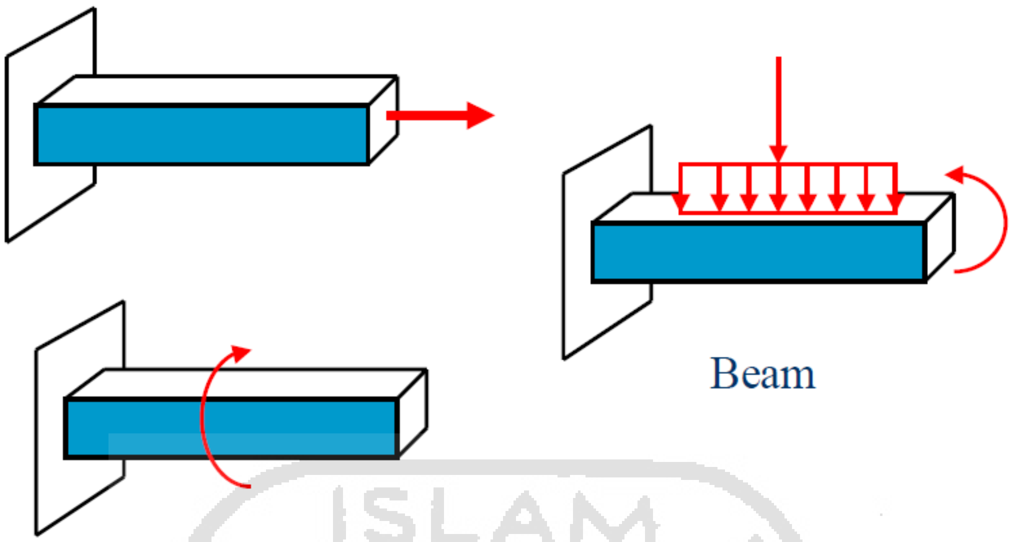

Figure 2. 4 Load on beams

Figure 2.4 It shows some of the force which occur on beam, such as tensile force, torsional force and compressive force.

2.5.1 Top Beam

Top beam is used square beam as anchoring scissor package and hydraulic cylinder.

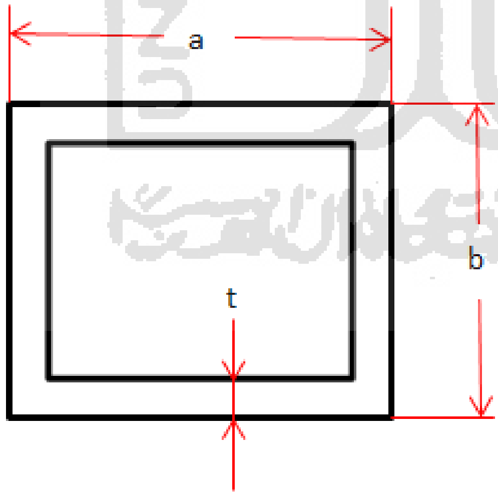

Figure 2. 5 Top beam shape

Figure 2.5 It shows the shape of the top beam which has the same size on both sides. Catalog beam is used to select the appropriate specifications.

2.5.2 Bottom Beam

The bottom beam is used as an equal angle beam shape retaining scissor package and hydraulic cylinders.

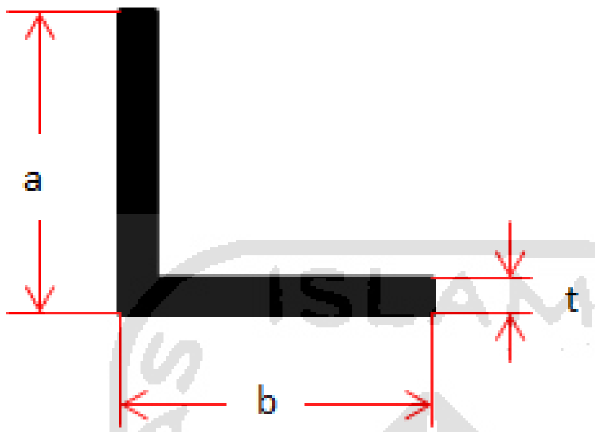

Figure 2. 6 Equal angle beam

Figure 2.6 It shows the shape of the bottom beam that have the same size on the side of a and b. Catalog beam is used to select the appropriate specifications.

2.6 Safety Factor

In book 'Machine Design', D.G Ullman said " *The factor of safety is a factor of ignorance. If the stress on a part at a critical location (the applied stress) is known precisely, if the material's strength (the allowable strength) is also known with precision, and the allowable strength is greater than the applied stress, then the part will not fail. However, in the real world, all of the aspects of the design have some degree of uncertainty, and therefore a fudge factor, a factor of safety, is needed. Afactor of safety is one way to account for the uncontrollable noises. In practice the factor of safety is used in one of three ways: (1) It can be used to reduce the allowable strength, such as the yield or ultimate strength of the material, to a lower level for comparison with the applied stress; (2) it can be used to increase the applied stress for comparison with the allowable strength; or (3) it can be used as a comparison for the ratio of the allowable strength to the applied stress*". (Ullman, 1986)

Safety factor can be determined by the following formula :

$$FS = \frac{\sigma}{\sigma ap}$$

(2.1)

Where FS is safety factor, σ is allowable strength of material used in Kg/cm², σ_{ap} is applied stress in Kg/cm².

CHAPTER III

RESEARCH SCHEMATIC

3.1 Research schematics

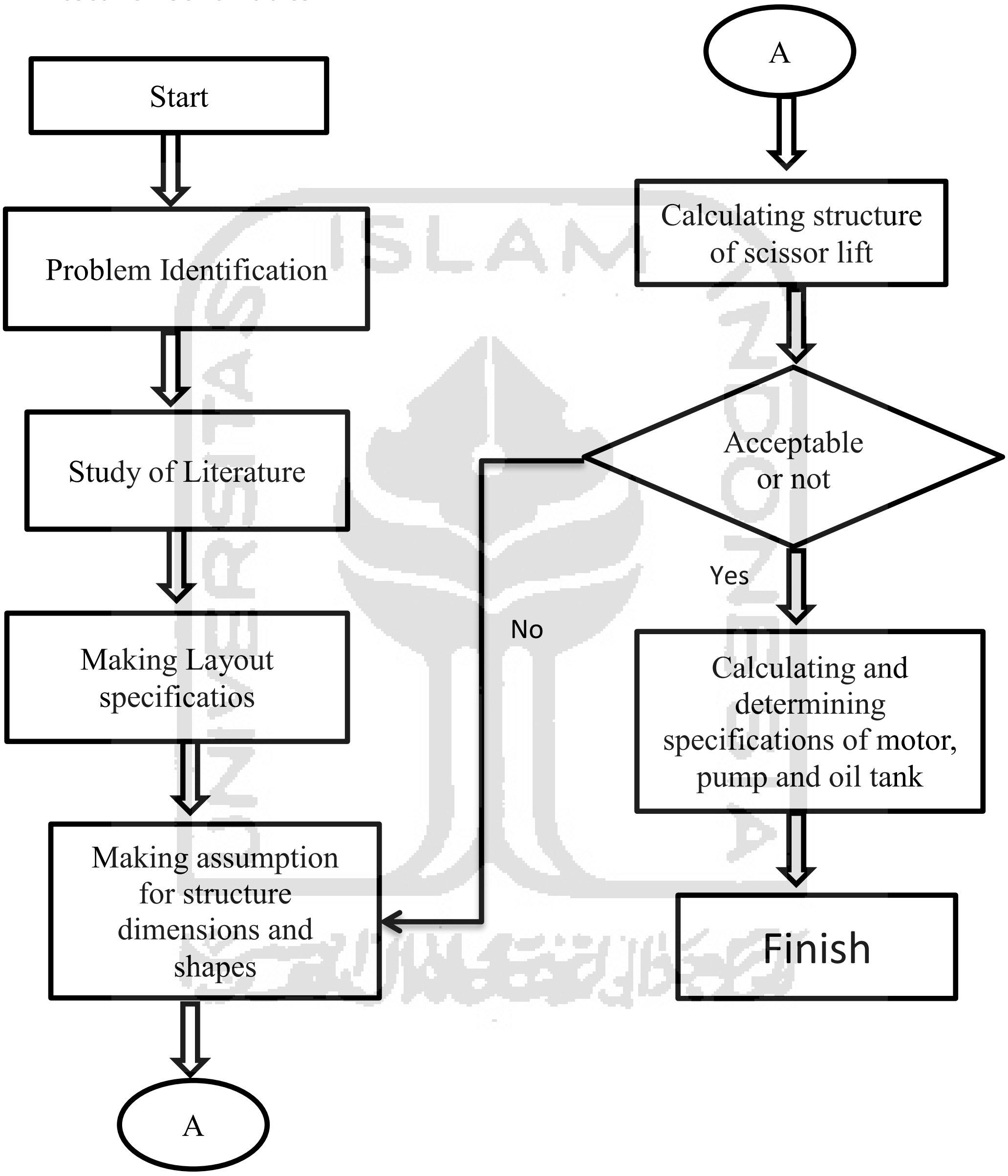

Figure 3.1 Research schematics

3.2 Design Steps

3.2.1 Determining the specification will be designed

The first thing to do before designing is to determine the specification of the lift scissor to designed.

Table 3.1 Specifications design

Specifications	
Platform size	1500x1300 mm
Load Capacity	3500 Kg
Maximum Height	1100 mm
Minimum Height	350 mm
Travel Height	750 mm
Lift arm	1 set
Hyd. Main cylinder	2 set
Up-speed	≥ 50 mm/sec

3.2.2 Make assumption for load total

Addition to lifting the load, there is some amount of load to lift by hydraulic cylinders, such as platforms, scissor package, beams and other supporting parts. However, to make initial assumptions, the beam cannot be assumed to be due to calculate the strength of the beam, must be determine the size and strength first of the scissor package. Therefore to make assumptions load on the beam and the other parts supported, in making assumptions on the scissor package and the platform must be greater than the original load. It is intended that the hydraulic cylinder can lifting the load safely.

a) Lifting load

Lifting load amount has been determined on the specifications requested which is 3500 Kg.

b) Platform table load

To calculate the number of platforms loaded, first determine the assumptions for the size and thickness.

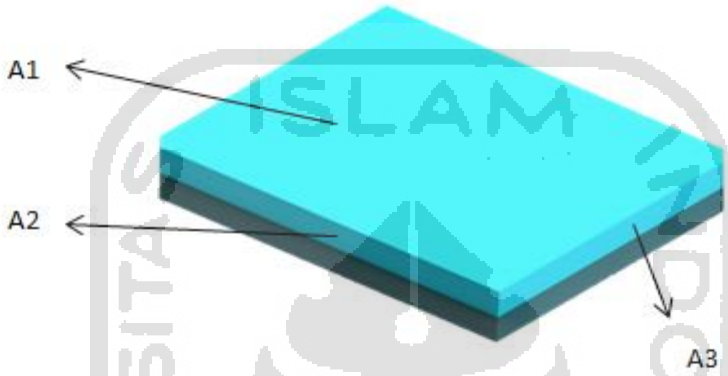

Figure 3.2 Platform table load

figure 3.2 It shows the load at points A1, A2 and A3 which in points A2 and A3 has two sides.

To calculate the load platform can be determined by the following formula:

$$Load\ platform = \frac{A \times h \times T \times \rho}{1000000} \tag{3.1}$$

Where the value of A is the amount of load of A1, A2, A3 and h is the thickness of the material used, ρ is density of mild steel which has 7.85 g / cm^3.

c) Scissor Load

Scissor load is calculated after making various assumptions for size and can be seen after designing with software design.

d) Total Load

To calculate the total amount of load can be determined using the following formula:

$$Load\ Total\ = (Lifting\ load\ + Platform\ load + scissor\ load) \times 1.5$$

(3.2)

The safety factor value of 1.5 is used.

3.2.3 Make Layout for Scissor Lift

After all specifications have been obtained, the next step is to make assumptions layout for the scissor lift. It is intended that the specifications requested in accordance with the designed.

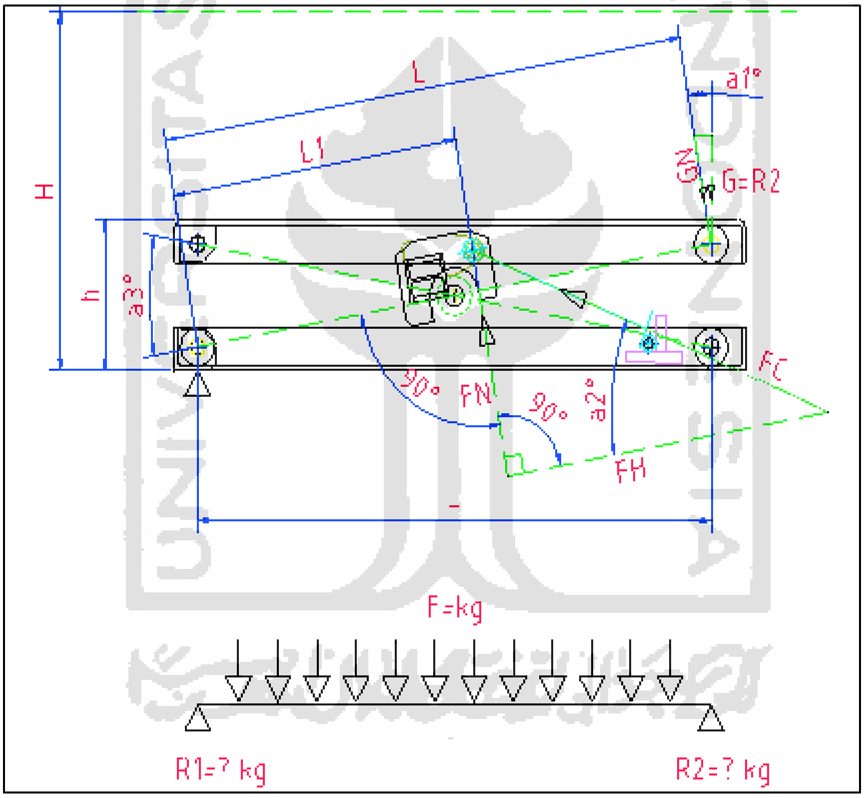

Figure 3.3 Scissor Lift Layout

Figure 3.3 showing the scissor lift layout. Calculating the angles and values on each symbol before doing the design.

3.2.4 Calculate the Value of G

G is a force perpendicular to the ground. To calculate the value of G can be determined by the following formula:

$$G = \frac{Load}{2}$$

(3.3)

3.2.5 Calculate the Value of GN

GN is a force perpendicular to the scissor bar. To be able to calculate the value of GN can be determined by the following formula:

$$GN = G \; x \cos\gamma$$

(3.4)

The value of $\cos_{\gamma}$ is 10˚.

3.2.6 Calculate Force for Hydraulic Cylinder

F (force) for the cylinder is used to lift the load, and therefore the assumption that the total load used greatly affect the strength of the cylinder. To be able to calculate F can be determined by the following formula:

$$F = G \times \frac{L}{L1} \times \frac{\cos\gamma}{\sin\beta}$$

(3.5)

Where the value of F indicates force in Kgf, L is the length of the scissor in cm, L1 is the length of the scissor tip to hydraulic cylinders in cm, sinβ indicates the angle a2 ˚.

3.2.7 Calculate the Value of FC'

'FC' is the actual force value the cylinder after distributed of the number of cylinders used. To determine the value FC 'can be determined by the following formula:

$$FC' = \frac{F}{NO}$$

(3.6)

Where No is the number of cylinders used.

3.2.8 Determine the size of the cylinder are used

To determine the size of the cylinders used previously should know the standard pressure of the cylinder. Can be determined by the following formula:

$$P = \frac{FC'}{A}$$

$$A = \frac{FC'}{P}$$

(3.7)

P indicates the pressure in Kg / cm². A is area in cm².

After knowing the value of A, we can determine the value of the diameter of the cylinders by using the following formula:

$$\emptyset = A = \frac{\pi d^2}{4}$$

$$d = \sqrt{\frac{A \times 4}{\pi}}$$

(3.8)

d indicates the diameter of the cylinder in cm and π in 3.14.

3.2.9 Calculate the value of FN

FN value is perpendicular force that occurs at the point of the hydraulic cylinder. Can be calculated with the following formula:

$$FN = FC' \times \sin \beta$$

(3.9)

3.2.10 Calculate the Value of Bending Moment

Bending moment value may occur due to the pressing of load. Can be calculated with the following formula:

$$Mb = FN \times L1$$

(3.10)

Value of bending moment Mb shown in Kg.cm.

3.2.11 Calculate the value of bending stress in the cross section area.

$$\sigma b = \frac{Mb \times E}{I}$$

(3.11)

Where the σb bending stress shown in Kg / cm², I is the moment of inertia in cm⁴, E is the vertical distance away from the neutral axis in cm.

3.2.12 Calculate the value of compressive stress

Compressive stress is force occurs in scissor package. Can be calculated with the following formula:

$$\sigma = \frac{FN}{Atop}$$

(3.12)

Value A_{top} can be calculated using the formula:

$$A\ top = b \times d$$

(3.13)

Where b is the thickness of scissor in cm and d is the diameter of the hole of Scissor.

3.2.13 Calculate the value of shear stress

Shear stress is force that occurs in scissor package. Can be calculated with the following formula:

$$\tau = \frac{FN}{A}$$

(3.14)

A is the area of the cross section and can be calculated using the following formula:

$$A = \frac{\pi d^2}{4}$$

(3.15)

3.2.14 Calculate deflection of scissor

The deflection is calculated to determine the curvature that occurs on the scissor after getting the load. The smaller the deflection value, the better the assumptions are used. Can be calculated using the following formula:

$$f = \frac{FN \times L1^3}{3 \times E \times I}$$

(3.16)

3.2.15 Calculate the Strength of top beam

To know whether the beam is safe or not to be used, it is necessary to determine the shape assumption and thickness of the beam using the catalog and also to calculate several things, one of which is the bending stress that occurs. Can be calculated using the following formula:

$$\sigma b = \frac{Mb \times E}{I}$$

(3.17)

After the bending stress can be determined, it is necessary to calculate the deflection due to the force of the hydraulic cylinder. Can be calculated by the formula:

$$f = \frac{FC' \times a}{24 \times E \times I}(3 \times l^2 - 4 \times a^2)$$

(3.18)

Where a (cm) shows the distance between the forces that occur on the beam with the scissor package and l is the beam length in cm.

3.2.16 Calculate the strenght of bottom beam

The strength of the bottom beam needs to be calculated to know the assumptions used are safe or not to be used. To calculate the value of bending stress can be calculated by:

$$\sigma b = \frac{Mb \times E}{I} \tag{3.19}$$

Determine the deflection value of the bottom beam by using the following formula:

$$f = \frac{F \times a}{24 \times E \times I}(3 \times l^2 - 4 \times a^2) \tag{3.20}$$

3.2.17 Calculate the strength of platform

To find out whether the assumption is safe or not, there is calculation needed on the platform. To calculate the deflection value on the platform can be determined by the following formula:

$$f = \frac{c3 \times P \times b^4}{E \times h^3} \tag{3.21}$$

For the value of c3 can be determined by the ratio a / b where is the length of plate and b is the width of the plate and it is determined from the following table :

Table 3.2 platform table

Gelenkid gelagerte platte				
a/b	C1	C2	C3	C4
1	1.15	1.15	0.71	0.26

1.5	1.2	1.95	1.35	0.34
2	1.11	2.44	1.77	0.37
3	0.97	2.85	2.14	0.37
4	0.92	2.96	2.24	0.38
∞	0.9	3	2.28	0.38

3.2.18 Determine compressive stress on y axis and x on platform.

Can be calculated using the following formula:

$$\sigma y = c5 \times P \times \frac{b^2}{h^2}$$

(3.22)

Where the value of c5 = a / b and h is the thick assumption of plates in cm.

$$\sigma x = 0.3 \times \sigma y$$

(3.23)

3.2.19 Speed of cylinder

To determine the speed of the cylinder when moving is determined by the following formula:

$$v' = \frac{v \times ST}{h'}$$

(3.24)

Where v' is the speed in cm / sec, v is the required speed in cm / sec, ST is the length of the stroke in cm and h' is the travel height in cm.

3.2.20 Calculate flow rate pump

Can be calculated using the following formula:

$$Q = \frac{v' \times A' \times NO \times 60}{Mo}$$

(3.25)

Where Q is the flow rate in cc / rev, NO is the number of cylinders, Mo is the motor capacity in RPM and 60 is the time in sec.

3.2.21 Selecting the flow rate pump capacity from the catalog (Q ')

To select the flow rate capacity can be selected with the catalog, if no value matches with the calculated, then the value of the greater flow rate pump is chosen.

Table 3.3 flow rate pump catalog

TYPE	Flow rate cc/rev.
ALP2-D-6	4.5
ALP2-D-9	6.4
ALP2-D-10	7.0
ALP2-D-12	8.3
ALP2-D-13	9.6
ALP2-D-16	11.5
ALP2-D-20	14.1
ALP2-D-22	16.0
ALP2-D-25	17.9
ALP2-D-30	21.1
ALP2-D-34	23.7
ALP2-D-37	25.5
ALP2-D-40	28.2
ALP2-D-50	35.2

3.2.22 Determine the actual moving speed of hydraulic cylinder

To calculate actual moving speed of cylinder can be calculated with the following formula:

$$Vc = \frac{Q' \times Mo}{A' \times NO \times 60} \tag{3.26}$$

3.2.23 Determine actual speed of scissor

To determine the actual speed of a scissor can be determined by the following formula:

$$Vx = \frac{Vc \times h'}{ST}$$

(3.27)

3.2.24 Calculate the size of motor

Can be calculated by the following formula:

$$M = \frac{Q' \times \left(\frac{1450}{1000}\right) \times P}{600 \times 0.85 \times 0.746}$$

(3.28)

3.2.25 Calculate the maximum pressure a hydraulic cylinder

Can be calculated by the following formula:

$$P\ max = \frac{M \times 600 \times 0.85 \times 0.746}{Q' \times (\frac{Mo}{1000})}$$

(3.29)

3.2.26 Determine capacity of oil tank

Can be calculated by the following formula:

$$V = Q' \times 1.45 \times 2$$

(3.30)

CHAPTER IV

DESIGN RESULT

4.1 Design Results

4.1.1 Assumption for load total

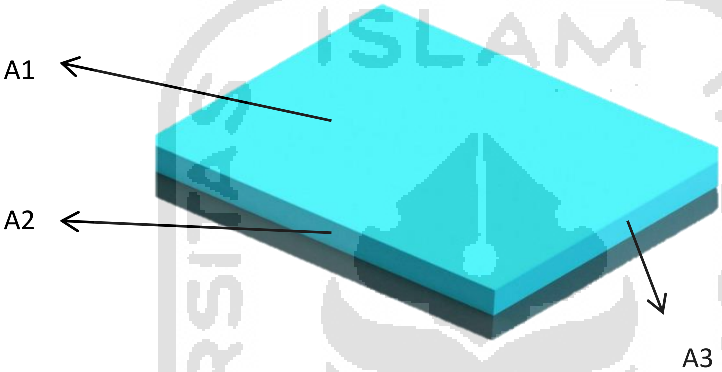

Figure 3.1 Assumption platform load

1) Platform table load

$$A1 = \frac{B \times H \times T \times \rho}{1000000}$$

$$A1 = \frac{1500 \times 1300 \times 12 \times 7.85}{1000000}$$

$$A1 = 183.69\ Kg$$

$$A2 = \frac{B \times H \times T \times \rho}{1000000} \times 2$$

$$A2 = \frac{1500 \times 100 \times 12 \times 7.85}{1000000} \times 2$$

$$A2 = 14.13\ \times 2$$

$A2 = 28.26\ Kg$

$$A3 = \frac{B \times H \times T \times \rho}{1000000} \times 2$$

$$A3 = \frac{1300 \times 100 \times 12 \times 7.85}{1000000} \times 2$$

$$A3 = 12.246\ \times 2$$

$$A3 = 24.492\ Kg$$

$$\therefore Platform\ load\ total = 183.69 + 28.26 + 24.492$$

$$Platform\ load\ total = 236.442\ Kg$$

*The asummption must be higher,

Platform load = 260 Kg

2) Scissors Load

Scissors load are calculated after designing with autodesk inventor.

1 scissor = 114.16 Kg

2 scissors = 228.32 Kg

*The asummption must be higher,

2 scissors = 250 Kg

3) Load Total

- Load for lift up = 3500 Kg
- Platform table load = 260 Kg
- Scissor load =250 Kg

- Safety factor = 1.5

$$\therefore Load\ Total = (3500 + 260 + 250) \times 1.5$$

$$= 6015\ Kg$$

4.1.2 Make layout for scissor lift

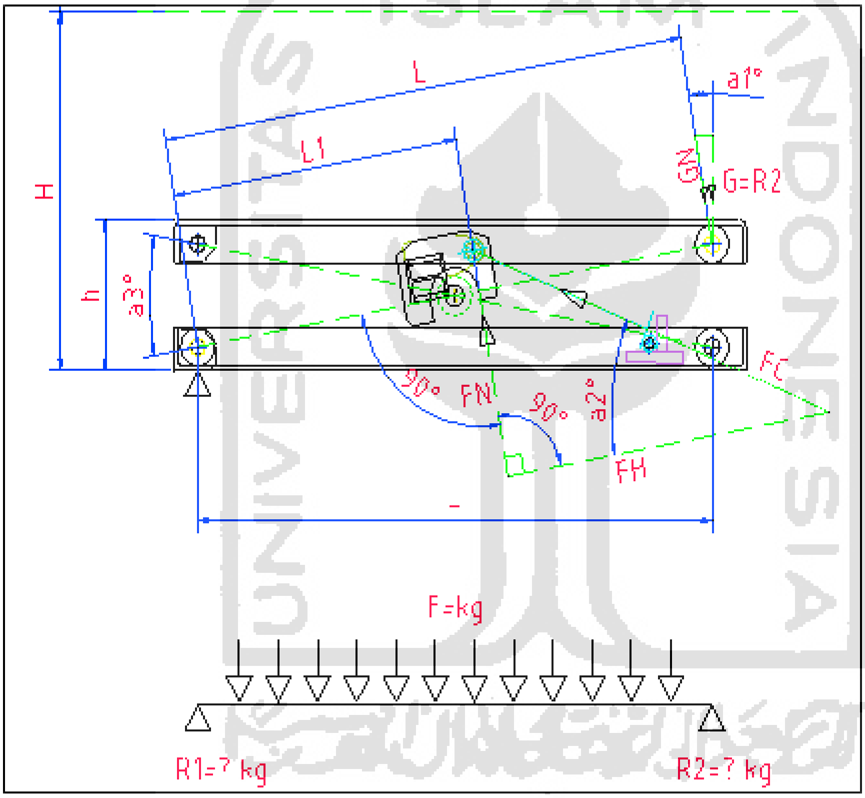

Figure 4.2 layout scissor lift

4.1.3 Find G

G = R2

$$G = \frac{6015}{2}$$

$$G = 3007.5\ Kg$$

1. Find GN

$GN = G\ x \cos\gamma$

$\gamma = 10°$

$GN = 3007.5\ Kg\ x \cos 10°$

$GN = 3007.5\ x\ 0.984$

$GN = 2959.38\ Kg$

4.1.4 Calculate F for Cylinder

Equation 1,

$$F = \frac{FN}{\sin\beta}$$

Equation 2,

$$FN = GN \times \frac{L}{L1}$$

Equation 3,

$$GN = G \times Cos\ \gamma$$

$$\therefore F = GN \times \frac{L}{L1 \times \sin\beta}$$

$$F = G \times \frac{L}{L1} \times \frac{\cos\gamma}{\sin\beta}$$

$$F = 3007.5 \times \frac{1370}{789} \times \frac{\cos 10°}{\sin 32°}$$

$$F = 3007.5 \times 1.736 \times \frac{0.984}{0.5299}$$

$$F = 3007.5 \times 1.736 \times 1.856$$

$F = 9695.194\ Kgf$

1 Cylinder force is 9695.194 Kgf

4.1.5 Find FC’

$$FC' = \frac{F}{NO}$$

Where:

FC’ = force for find area of cylinder

NO = Number of Cylinder (choose 2 cylinder)

$$FC' = \frac{F}{NO}$$

$$FC' = \frac{9695.194\ Kgf}{2}$$

$$FC' = \frac{9695.194\ Kgf}{2}$$

$$FC' = 4847.59\ Kgf$$

4.1.6 Find Cylinder Dimension

$$P = \frac{FC'}{A}$$

Where:

P = Pressure (Kg/cm^2)

P = 120 – 150 Kg/cm^2 (TMC’s standard)

P = 120 Kg/cm^2 (Chosen)

FC’= cylinder force (Kgf)

A= Area (cm^2)

$$P = \frac{FC'}{A}$$

$$A = \frac{FC'}{P}$$

$$A = \frac{4847.59\ Kgf}{120\ Kg/cm^2}$$

$$A = 40.39\ cm^2$$

$$\emptyset = A = \frac{\pi d^2}{4}$$

$$d^2 = \frac{40.39\ cm^2 \times 4}{\pi}$$

$$d = \sqrt{\frac{40.39\ cm \times 4}{3.14}}$$

$$d = \sqrt{52.124\ cm}$$

$$d = 7.21\ cm$$

d = ID = 7.21 cm

Find the spec diameter from cylinder catalog

Choose ID = 80 mm

OD = ID = Rod

95 mm = 80 mm = 60 mm

Table 4.1 Cylinder standard for scissor lift

Cylinder Standard of Scissor Lift		
OD (mm)	ID (mm)	Rod (mm)

76	63	45
95	80	60
110	90	80
125	110	80
140	125	90
160	140	90

4.1.7 Cross section Area

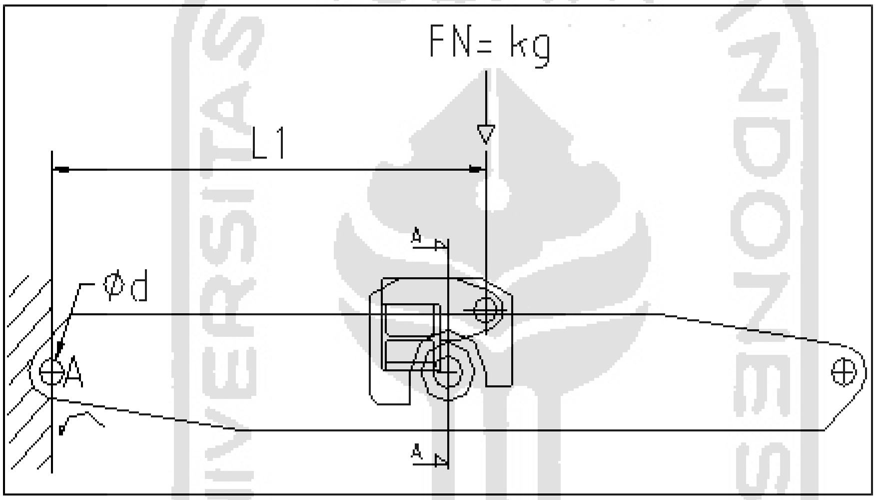

Figure 4.3 bending moment

$FN = FC' \times \sin\beta$

$FN = 4847.59\ Kg \times \sin\beta$

$FN = 4847.59\ Kg \times \sin 32°$

$FN = 4847.59\ Kg \times 0.5299$

$FN = 2568.7\ Kg$

4.1.8 Bending Moment in scissor

$Mb = FN \times L1$

$Mb = 2568.74\ Kg \times 78.9\ cm$

$Mb = 202673.716\ Kg.cm$

4.1.9 Bending stress in cross section area

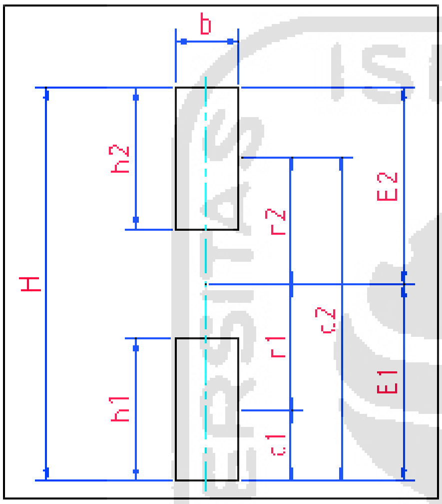

Figure 4.4 cross section scissor package

$$\sigma b = \frac{Mb \times E}{I}$$

Where:

σb = Bending stress (Kg/cm^2)

Mb = Bending moment (Kg/cm^2)

E = vertical distance away from neutral axis (cm)

I = Moment of Inertia around of neutral axis (cm^4)

Make assumption for dimension of scissor package

b1 = b2 = 32 mm

h1=h2 = 62.5 mm

H = 180 mm

c1 = 31.25 mm

c2 = 148.75 mm

Find E

$$E1 = \frac{(b1 \times h1 \times c1) + (b2 \times h2 \times c2)}{(b1 \times h1) + (b2 \times h2)}$$

$$E1 = \frac{(3.2\ cm \times 6.25\ cm \times 3.125\ cm) + (3.2\ cm \times 6.25\ cm \times 14.875\ cm)}{(3.2 \times 6.25) + (3.2 \times 6.25)}$$

$$E1 = \frac{360\ cm^3}{40\ cm^2}$$

$$E1 = 9\ cm$$

$$E2 = H - E1$$

$$E2 = 18\ cm - 9\ cm$$

$$E2 = 9\ cm$$

E1 = E2 = 9 cm

r1 = r2 = distance from center of h to neutral axis

r1 = r2 = 58.75 mm

Find moment of Inertia

$$I = I1 + I2$$

$$I1 = I2$$

$$I1 = \frac{b \times h^3}{12} + b \times h \times r^2$$

$$I1 = \frac{3.2 \times 6.25^3}{12} + 3.2 \times 6.25 \times 5.875^2$$

$$I1 = 65.1\ cm^4 + 690.31\ cm^4$$

$$I1 = I2 = 755.41\ cm^4$$

$$I = 755.41\ cm^4 \times 2$$

$$I = 1510.82\ cm^4$$

$$\sigma b = \frac{Mb \times E}{I}$$

$$\sigma b = \frac{202673.716\ Kg.cm \times 9\ cm}{1510.82\ cm^4}$$

$$\sigma b = 1207.32\ Kg/cm^2$$

Safety factor = 1.5 – 2

σ ss400 = 2350 Kg/cm²

$$\sigma b = 1207.32\ Kg/cm^2$$

$$\frac{\sigma\ ss400}{\sigma b} = \frac{2350\ Kg/cm^2}{1207.32\ Kg/cm^2}$$

$$\frac{\sigma\ ss400}{\sigma b} = 1.94$$

4.1.10 Compressive Stress "P" in scissor

$$\sigma = \frac{FN}{Atop}$$

Where:

P = compressive Stress (Kg/cm^2)

A top= Projection Area

$$A\ top = b \times d$$

Where:

b = thickness of scissor (cm)

d = diameter of hole scissor (cm)

$$A\ top = 3.2\ cm \times 5.5\ cm$$

$$A\ top = 17.7\ cm^2$$

$$P = \frac{FN}{Atop}$$

$$P = \frac{2568.74\ Kg}{17.7\ cm^2}$$

$$P = 145.12\ Kg/cm^2$$

4.1.11 Shear Stress in scissor

$$\tau = \frac{FN}{A}$$

Where:

$$\tau = shear\ stress\ (\frac{Kg}{cm^2})$$

$$A = Area\ of\ cross\ section\ (\frac{Kg}{cm^2})$$

$$A = \frac{\pi d^2}{4}$$

$$A = \frac{3.14 \times 5.5^2}{4}$$

$$A = \frac{30.25\ cm^2}{4}$$

$$A = 7.56\ cm^2$$

$$\tau = \frac{FN}{A}$$

$$\tau = \frac{2568.74\ Kg}{7.56\ cm^2}$$

$$\tau = 339.78\ Kg/cm^2$$

4.1.12 Scissors Deflection

$$f = \frac{FN \times L1^3}{3 \times E \times I}$$

Where:

$f = deflection\ (cm)$

$E = modulus\ elasticity\ \left(\frac{Kg}{cm^2}\right)$

$$f = \frac{2568.74\ Kg \times 78.9^3\ cm}{3 \times 2100000 \frac{Kg}{cm^2} \times 1510.83\ cm^4}$$

$$f = 0.13\ cm$$

4.1.13 Calculate top beam

Make an assumption distance of cylinder hydraulic force

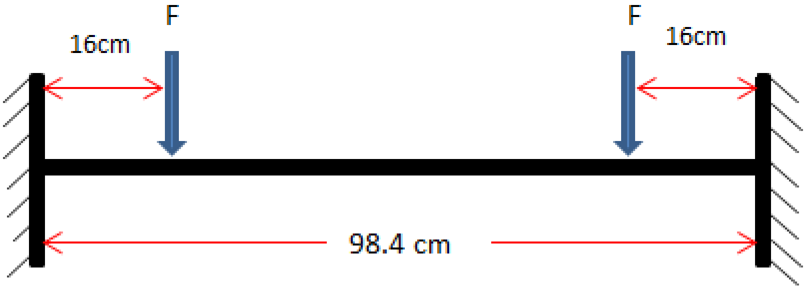

Figure 4.5 assumption distance of cylinder hydraulic force

$$\sigma b = \frac{Mb \times E}{I}$$

Where:

$Mb = F \times a$

$Mb = 4847.59\ Kg \times 16\ cm$

$Mb = 77561.44\ Kg.cm$

E = vertical distance away from neutral axis (cm)

I = Moment of Inertia around of neutral axis (cm4)

Assumption shape and dimension of top beam

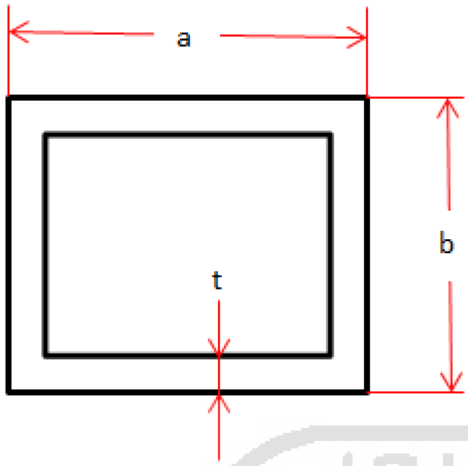

Figure 4.6 assumption shape and size of beam

a = b = 125 mm

t= 3.2 mm

I = 374.91 cm^4

5 x 5	125 x 125	2.80	10.59	13.48	332.52	53.20	4.97
		3.00	11.31	14.41	353.87	56.62	4.96
		3.20	12.03	15.33	374.91	59.99	4.95
		4.50	16.62	21.17	504.42	80.71	4.88
		6.00	21.69	27.63	639.27	102.28	4.81

Figure 4.7 size of beam from catalog

$$\sigma b = \frac{Mb \times E}{I}$$

$$\sigma b = \frac{77561.44\ Kg.cm \times 6.25\ cm}{374.91\ cm^4}$$

$$\sigma b = 1293\ Kg/cm^2$$

SF = 1.5 – 2

Beam material = ss400

σ ss400 = 2350 Kg/cm^2

$$\frac{\sigma ss400}{\sigma b} = \frac{2350\ Kg/cm^2}{1293\ Kg/cm^2}$$

$$\frac{\sigma ss400}{\sigma b} = 1.81$$

1.81 is acceptable

4.1.14 Calculate deflection of top beam

$$f = \frac{FC' \times a}{24 \times E \times I}(3 \times l^2 - 4 \times a^2)$$

$$f = \frac{4847.59\ Kg \times 16\ cm}{24 \times 2100000\ Kg/cm^2 \times 374.91\ cm^4}(3 \times 78.9^2 cm - 4 \times 16^2 cm)$$

$$f = \frac{77561.44\ Kg.cm}{24 \times 2100000\ Kg/cm^2 \times 374.91\ cm}(17651.63\ cm^4)$$

$$f = 0.072\ cm$$

4.1.15 Bottom beam calculation

Make an assumption distance of cylinder hydraulic force

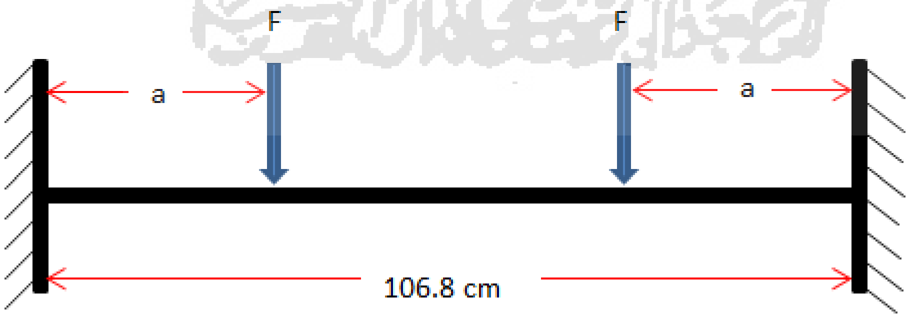

Figure 4.8 assumption distance of cylinder hydraulic

a = 20.2 cm

$$\sigma b = \frac{Mb \times E}{I}$$

Where:

$$Mb = F \times a$$

$$Mb = 4847.59\ Kg \times 20.2\ cm$$

$$Mb = 97921.318\ Kg.cm$$

E = vertical distance away from neutral axis (cm)

I = Moment of Inertia around of neutral axis (cm4)

Assumption shape and dimension of bottom beam

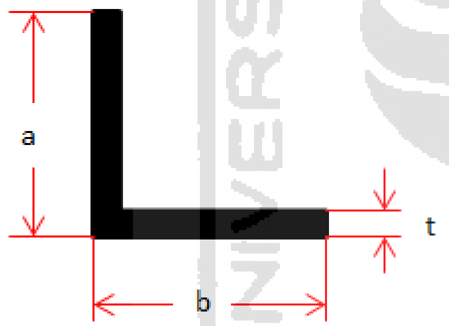

Figure 4.9 assumption shape and size bottom beam

a = b = 120 mm

t= 8 mm

I = 258 cm^4

100x100	7	10	5.0	13.62	10.7	2.71	2.71	129	129	205	53.2	3.08	3.08	3.88	1.98	17.7	17.7
	10	10	7.0	19.0	14.9	2.82	2.82	175	175	278	72.0	3.04	3.04	3.83	1.95	24.4	24.4
	12	12	4.8	22.7	17.8	2.90	2.90	207	207	328	85.7	3.02	3.02	3.80	1.94	29.1	29.1
120x120	8	12	5.0	18.76	14.7	3.24	3.24	258	258	410	106	3.71	3.71	4.67	2.38	29.5	29.5
130x130	9	12	6.0	22.74	17.9	3.53	3.53	366	366	583	150	4.01	4.01	5.06	2.57	38.7	38.7

Figure 4.10 equal angle beam from catalog

$$\sigma b = \frac{Mb \times E}{I}$$

$$\sigma b = \frac{97921.318\ Kg.cm \times 3.24\ cm}{258\ cm^4}$$

$$\sigma b = 1229.7\ Kg/cm^2$$

SF = 1.5 – 2

Beam material = ss400

σ ss400 = 2350 Kg/cm²

$$\frac{\sigma ss400}{\sigma b} = \frac{2350\ Kg/cm^2}{1229.7\ Kg/cm^2}$$

$$\frac{\sigma ss400}{\sigma b} = 1.91$$

1.91 is acceptable.

4.1.16 Calculate deflection of bottom beam

$$f = \frac{F \times a}{24 \times E \times I}(3 \times l^2 - 4 \times a^2)$$

$$f = \frac{4847.59\ Kg \times 20.2\ cm}{24 \times 2100000\ Kg/cm^2 \times 258\ cm^4}(3 \times 106.8^2 cm - 4 \times 20.2^2 cm)$$

$$f = 0.245\ cm$$

4.1.17 Calculate the strength platform Size

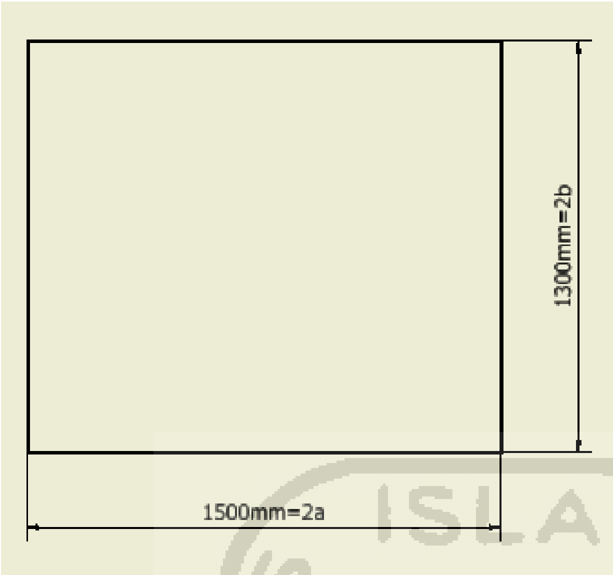

Figure 4.11 size of platform

$$\frac{a}{b} = \frac{750}{650} = 1.15 = c5$$

Find 1.15 from table

X = 1.15 , Y= a/b = ...?

X1= 1 , Y1=0.71

X2= 1.5 , Y2= 1.35

Interpolation step

$$Y = X + [(\frac{X - X1}{X2 - X1})(Y2 - Y1)]$$

$$Y = 0.71 + [(\frac{1.15 - 1}{1.5 - 1})(1.351 - 0.71)]$$

$$Y = 0.71 + [(\frac{0.15}{0.5})(0.64)]$$

$$Y = 0.71 + [(0.3)(0.64)]$$

$Y = 0.71 + 0.192$

$Y = C3 = 0.902$

1) Find pressure of platform size

$$P = \frac{load}{area}$$

$$P = \frac{3500\ Kg}{150\ cm \times 130\ cm}$$

$$P = 0.17\ Kg/cm^2$$

2) Platform deflection

$$f = \frac{c3 \times P \times b^4}{E \times h^3}$$

Where :

h = thickness assumption = 1.2 cm

E = Modulus elasticity (2100000 Kg/cm^2)

$$f = \frac{0.902 \times 120\ Kg/cm^2 \times 65^4 cm}{2100000\ Kg/cm^2 \times 1.2^3\ cm}$$

$$f = 0.75\ cm$$

3) σy

$$\sigma y = c5 \times P \times \frac{b^2}{h^2}$$

$$\sigma y = 1.15 \times 0.17 \times \frac{65^2}{1.2^2}$$

$\sigma y = 573\ Kg/cm^2$

4) σx

$\sigma x = 0.3 \times \sigma y$

$\sigma x = 171.9\ Kg/cm^2$

4.1.18 Cylinder Speed "moving speed of cylinder"

$$v' = \frac{v \times ST}{h'}$$

Where:

$v' = cylinder\ speed\ (\frac{cm}{sec})$

$v = scissor\ speed\ requirement\ (\frac{cm}{sec})$

$ST = length\ of\ stroke\ (cm)$

$h' = travel\ height\ (cm)$

$$v' = \frac{v \times ST}{h'}$$

$$v' = \frac{5\frac{cm}{sec} \times 20.04\ cm}{75\ cm}$$

$v' = 1.33\ cm/sec$

4.1.19 Flow rate pump

$$Q = \frac{v' \times A' \times NO \times 60}{Mo}$$

Where:

$Q = flow\ rate\ pump\ \left(\frac{cc}{rev}\right)$

$A' = area\ of\ cylinder\ from\ selected\ (cm^2)$

$$A' = \frac{3.14 \times d^2}{4}$$

$$A' = \frac{3.14 \times 8^2}{4}$$

$$A' = 50.24\ cm^2$$

$NO = number\ of\ cylinder$

$NO = 2$

$60 = times\ (seconds)$

$Mo = Motor\ (RPM)$

The selected motor is 4 pole motor (1450 RPM)

$$Q = \frac{1.3\frac{cm}{sec} \times 50.24\ cm^2 \times 2 \times 60\ sec}{1450\ RPM}$$

$Q = 5.4\ cm^3/rev$

$Q = 5.4\ cc/rev$

4.1.20 Choose actual pump from catalog (Q')

Table 4.2 pump catalog

TYPE	Flow rate cc/rev.
ALP2-D-6	4.5
ALP2-D-9	6.4

ALP2-D-10	7.0
ALP2-D-12	8.3
ALP2-D-13	9.6
ALP2-D-16	11.5
ALP2-D-20	14.1
ALP2-D-22	16.0
ALP2-D-25	17.9
ALP2-D-30	21.1
ALP2-D-34	23.7
ALP2-D-37	25.5
ALP2-D-40	28.2
ALP2-D-50	35.2

Choose ALP2-D-9 = 6.4 cc/rev

Q' = 6.4 cc/rev

4.1.21 Actual moving speed of cylinder (Vc)

$$Vc = \frac{Q' \times Mo}{A' \times NO \times 60}$$

$$Vc = \frac{6.4\frac{cm^3}{rev} \times 1450\ RPM}{50.24\ cm^2 \times 2 \times 60\ sec}$$

$$Vc = \frac{9280\ cm^3}{6028.8\ sec}$$

$$Vc = 1.539\ cm/sec$$

4.1.22 Actual scissors speed / X speed

$$Vx = \frac{Vc \times h'}{ST}$$

$$Vx = \frac{1.539 \frac{cm}{sec} \times 75\ cm}{20.04\ \ cm}$$

$$Vx = 5.759\ cm/sec$$

4.1.23 Calculating size of motor

$$M = \frac{Q' \times \left(\frac{1450}{1000}\right) \times P}{600 \times 0.85 \times 0.746}$$

$$M = \frac{6.4 \times 1.45 \times 120}{600 \times 0.85 \times 0.746}$$

$$M = 2.92\ HP$$

4.1.24 Choose size of motor from catalog

OUTPUT		FULL LOAD rpm	FRAME NO.	EFFICIENCY				POWER FACTOR				CURRENT		TORQUE				ROTOR GD2 kg-m2	APPROX. WEIGHT kg
HP	kW			FULL LOAD (%)	3/4 LOAD (%)	2/4 LOAD (%)	1/4 LOAD (%)	FULL LOAD (%)	3/4 LOAD (%)	2/4 LOAD (%)	1/4 LOAD (%)	FULL LOAD (A)	LOCKED ROTOR (A)	FULL LOAD N•m	LOCKED ROTOR %FLT	PULL UP %FLT	BREAK DOWN %FLT		
0.5	0.37	915	80M	65.5	63.8	57.9	40.5	65.0	55.5	44.0	31.0	1.25	5	3.856	230	215	260	0.009	17.5
0.75	0.55	1425	80M	78.1	78.0	75.1	64.1	72.5	62.0	47.5	30.0	1.40	8	3.680	290	260	305	0.010	17.5
		900	80M	68.5	68.8	64.9	50.2	67.0	57.0	44.0	29.0	1.73	7	5.827	225	220	250	0.012	19.5
1	0.75	2850	80M	77.4	78.0	76.3	64.3	85.5	78.5	66.0	44.5	1.64	9	2.509	215	180	280	0.005	17.0
		1415	80M	79.6	79.5	76.9	66.3	73.5	63.5	49.5	31.0	1.85	11	5.054	300	330	325	0.013	20.5
		935	90S	75.9	76.4	73.9	63.8	69.5	60.0	46.5	29.5	2.05	10	7.649	210	185	260	0.019	25.5
		695	100L	71.8	71.0	68.0	54.0	65.0	56.0	43.5	28.0	2.32	10	10.29	210	175	235	0.046	37.5
1.5	1.1	2875	80M	79.6	80.0	78.3	68.5	85.5	79.0	67.0	45.0	2.33	17	3.648	255	200	305	0.007	19.5
		1445	90S	81.4	81.4	78.9	69.8	76.0	67.0	53.0	33.5	2.57	19	7.259	270	205	325	0.017	25.0
		930	90L	78.1	78.8	76.9	68.2	71.5	62.0	48.5	30.5	2.84	14	11.28	215	190	260	0.026	30.0
		690	100L	74.7	75.0	73.0	61.5	67.5	58.5	45.5	28.0	3.15	14	15.20	210	175	230	0.059	44.5
2	1.5	2880	90S	81.3	81.8	80.3	73.5	86.5	80.5	69.0	48.0	3.08	24	4.966	260	245	325	0.011	24.5
		1435	90L	82.8	83.7	82.6	75.7	81.0	73.0	59.5	38.0	3.23	23	9.967	250	180	300	0.022	28.0
		950	100L	79.8	80.5	78.8	68.5	70.5	61.5	48.5	30.0	3.85	19	15.06	170	140	240	0.048	39.0
		700	112M	76.8	77.0	75.5	63.0	66.0	57.0	45.0	28.0	4.27	18	20.43	200	150	225	0.071	49.5
3	2.2	2875	90L	83.2	84.3	83.4	77.9	87.5	82.0	70.5	48.5	4.36	35	7.297	285	240	335	0.014	28.0
		1450	100L	84.3	85.0	84.1	76.1	81.5	74.0	61.0	39.0	4.62	33	14.47	210	170	300	0.041	37.0
		950	112M	81.8	82.4	81.1	72.6	75.0	66.5	53.0	33.5	5.18	34	22.08	280	255	300	0.071	49.0
		710	132S	79.4	82.0	79.5	69.0	64.5	55.0	42.0	25.0	6.20	31	29.55	240	235	300	0.138	65.5
4	3	2895	100L	84.6	85.9	85.7	80.4	88.0	83.0	73.0	50.0	5.82	49	9.88	245	225	310	0.022	37.6
		1445	100L	85.5	85.9	84.8	77.3	82.0	75.0	62.5	40.0	6.18	44	19.80	210	170	300	0.050	40.0
		960	132S	83.3	84.1	83.2	76.8	78.0	71.0	58.0	37.0	6.66	37	29.80	190	165	300	0.103	61.0
		700	132M	81.3	83.0	81.5	72.0	69.0	59.5	46.0	28.0	7.72	37	40.87	215	210	270	0.162	71.0

Figure 4.12 motor catalog

The selected of motor is 3 HP

M = 3HP

4.1.25 Maximum pressure of cylinder

$$P\ max = \frac{M \times 600 \times 0.85 \times 0.746}{Q' \times (\frac{Mo}{1000})}$$

$$P\ max = \frac{3 \times 600 \times 0.85 \times 0.746}{6.4 \times (\frac{1450}{1000})}$$

$$P\ max = \frac{1141.38}{9.28}$$

$P\ max = 122.99\ Kg/cm^2$

4.1.26 Oil tank volume

$V = Q' \times 1.45 \times 2$

Where 2 is safety factor

$V = 6.4 \times 1.45 \times 2$

$V = 18.56\ liters$

CHAPTER V

CONCLUSIONS

5.1 Conclusion

a) Scissor lift has been designed with safe because all of safety factor is between 1.5 through 2.
b) Scissor lift has been designed according to the requested specifications.

5.2 Recommendation

In this study there are still many shortcomings and possible to do further research, among others:

a) Double acting hydraulic cylinders would be better used to smooth the scissor lift when it goes down, because there is a retaining force.

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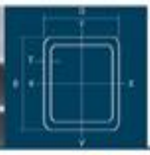
APPENDICES

Square beam



HOLLOW STEEL SECTIONS
For General Structural Purposes
Square Tubes

TMT

Side Length D x D		Thickness (mm.)	Calculate Weight (kg./m.)	Cross Sectional Area (cm^2)	Geometrical Moment of Inertia (cm^4)	Modulus of Section (cm^3)	Radius of Gyration (cm.)
in.	mm.	T	W	A	I_x, I_y	Z_x, Z_y	i_x, i_y
4 x 4	100 x 100	1.70	5.19	6.61	105.74	21.15	4.00
		2.00	6.07	7.74	122.84	24.57	3.98
		2.30	6.95	8.85	139.49	27.90	3.97
		2.50	7.53	9.59	150.35	30.07	3.96
		2.80	8.39	10.68	166.26	33.25	3.94
		3.00	8.96	11.41	176.63	35.33	3.93
		3.20	9.52	12.13	186.61	37.36	3.92
		4.00	11.73	14.95	225.70	45.14	3.89
		4.50	13.08	16.67	248.59	49.72	3.86
		6.00	16.98	21.63	311.55	62.31	3.79
5 x 5	125 x 125	2.80	10.58	13.48	332.52	53.20	4.97
		3.00	11.31	14.41	353.87	56.62	4.96
		3.20	12.03	15.33	374.91	59.98	4.95
		4.50	16.62	21.17	504.42	80.71	4.88
		6.00	21.69	27.63	639.27	102.28	4.81
6 x 6	150 x 150	2.80	12.78	16.28	583.68	77.82	5.99
		3.00	13.67	17.41	621.89	82.92	5.98
		3.20	14.54	18.53	659.63	87.95	5.97
		4.50	20.15	25.67	894.18	119.22	5.90
		5.00	22.26	28.36	979.54	130.60	5.88
		6.00	26.40	33.63	1142.59	152.35	5.83
8 x 8	200 x 200	4.50	27.21	34.67	2187.99	218.80	7.94
		6.00	35.82	45.63	2826.04	282.60	7.87
		8.00	46.94	59.79	3611.14	361.11	7.77
		9.00	52.34	66.67	3977.50	397.75	7.72

Equal angle beam

EQUAL ANGLE
Sizes and Properties
TIS/JIS Standards

TMT

(TIS/JIS)
Grade : SM400, SM490, SM520, SS400, SS490 or SS540

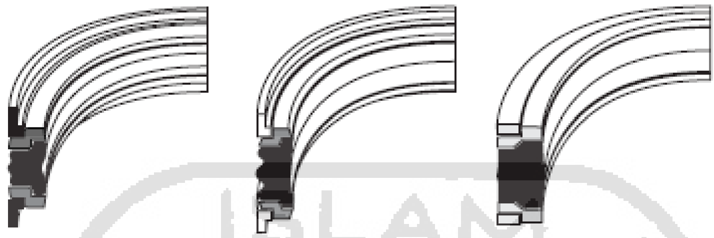
Standard Sectional Dimensions (mm.)				Sectional Area (cm²)	Weight (kg./m.)	Position of Center of Gravity (cm.)		Moment of Inertia (cm⁴)				Radius of Gyration (cm.)				Modulus of Section (cm³)	
AxB	t	r_1	r_2			C_x	C_y	I_x	I_y	Max I_u	Min I_v	i_x	i_y	Max i_u	Min i_v	Z_x	Z_y
	6	6.5	4.5	5.644	4.43	1.44	1.44	12.6	12.6	20.0	5.23	1.50	1.50	1.88	0.963	3.55	3.55
60x60	4	6.5	3.0	4.692	3.68	1.61	1.61	16.0	16.0	25.4	6.62	1.85	1.85	2.33	1.19	3.66	3.66
	5	6.5	3.0	5.802	4.55	1.66	1.66	19.6	19.6	31.2	8.09	1.84	1.84	2.32	1.18	4.52	4.52
65x65	5	8.5	3.0	6.367	5.00	1.77	1.77	25.3	25.3	40.1	10.5	1.99	1.99	2.51	1.28	5.35	5.35
	6	8.5	4.0	7.527	5.91	1.81	1.81	29.4	29.4	46.6	12.2	1.98	1.98	2.49	1.27	6.26	6.26
	8	8.5	6.0	9.761	7.66	1.88	1.88	36.8	36.8	58.3	15.3	1.94	1.94	2.44	1.25	7.96	7.96
70x70	6	8.5	4.0	8.127	6.38	1.93	1.93	37.1	37.1	58.9	15.3	2.14	2.14	2.69	1.37	7.33	7.33
75x75	6	8.5	4.0	8.727	6.85	2.06	2.06	46.1	46.1	73.2	19.0	2.30	2.30	2.90	1.48	8.47	8.47
	9	8.5	6.0	12.69	9.96	2.17	2.17	64.4	64.4	102	26.7	2.25	2.26	2.84	1.45	12.1	12.1
	12	8.5	6.0	16.56	13.00	2.29	2.29	81.9	81.9	129	34.5	2.22	2.22	2.79	1.44	15.7	15.7
80x80	6	8.5	4.0	9.327	7.32	2.18	2.18	56.4	56.4	89.6	23.2	2.46	2.46	3.10	1.58	9.70	9.70
90x90	6	10	5.0	10.55	8.28	2.42	2.42	80.7	80.7	128	33.4	2.77	2.77	3.48	1.78	12.3	12.3
	7	10	5.0	12.22	9.59	2.46	2.46	93.0	93.0	148	38.3	2.76	2.76	3.48	1.77	14.2	14.2
	10	10	7.0	17.00	13.3	2.57	2.57	125	125	199	51.7	2.71	2.71	3.42	1.74	19.5	19.5
	12	11	4.0	20.30	15.9	2.66	2.66	140	140	234	61.7	2.70	2.70	3.40	1.75	23.3	23.3
	13	10	7.0	21.71	17.0	2.69	2.69	156	156	248	65.3	2.68	2.68	3.38	1.73	24.8	24.8
100x100	7	10	5.0	13.62	10.7	2.71	2.71	129	129	205	53.2	3.08	3.08	3.88	1.96	17.7	17.7
	10	10	7.0	19.0	14.9	2.82	2.82	175	175	278	72.0	3.04	3.04	3.83	1.95	24.4	24.4
	12	12	4.8	22.7	17.8	2.90	2.90	207	207	328	85.7	3.02	3.02	3.80	1.94	29.1	29.1
120x120	8	12	5.0	18.76	14.7	3.24	3.24	258	258	410	106	3.71	3.71	4.67	2.38	29.5	29.5
130x130	9	12	6.0	22.74	17.9	3.53	3.53	366	366	583	150	4.01	4.01	5.06	2.57	38.7	38.7

SPEC SEAL
Seals & O-rings Specialist

Compact Seal

Piston Seals (Double Acting)

KGD, DAS, TPM, SPS, TPL, TPS/G, MHM (Metric Size)

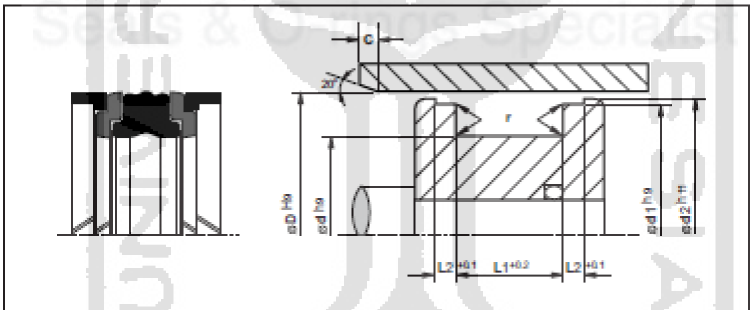


KGD, DAS TPM, SPS, TPL, TPS/G MHM

Material	Pressure (Bar)	Temp. (°c)	Speed (m/s)
NBR-Polyester-POM	350	-30 +120	0.5

- Good sealing effect, also suitable for holding cylinders.
- Capable of installation in closed grooves.
- Economic and efficient sealing solution.
- Simple snap installation.
- High resistance to gap extrusion.

Installation Recommendation



Surface roughness	Ra	Rt
Sliding surface	≤ 0.3 µm	≤ 4 µm
Surface of housing	≤ 1.8 µm	≤ 10 µm
Sides of housing	≤ 3.0 µm	≤ 16 µm

Chamfers

D	C
< 60	4.0
60-120	5.0
120-180	6.5
180-250	7.5
250-320	10.0

12

SPEC SEAL
Seals & Orings Specialist

Compact Seal

(Metric Size)

Bore Dia.	Groove Dimensions						Reference	Reference	Reference
D	d	L1	L2	d1	d2	r max			
50.00	34.00	20.50	3.10	46.00	49.00	0.40	KGD 050-034/A	DAS 050-034/1	TPL 050-034
50.00	35.00	20.00	5.00	46.00	48.50	0.40			TPM 196-137/SK-ISO
50.00	38.00	20.50	4.20	46.00	49.40	0.40	KGD 050-038	DAS 050-038	TPS/G 050-038
50.00	40.00	11.30	4.00	45.40	49.00	0.40			TPM 196-157
50.00	40.00	12.50	4.00	47.00	49.00	0.40			TPM 196-157-ISO
55.00	39.00	18.40	6.35	50.36	53.50	0.40	KGD 055-039	DAS 055-039	TPM 216-153
55.00	39.00	20.50	3.10	51.00	54.00	0.40	KGD 055-039/A	DAS 055-039/1	TPL 055-039
55.00	43.00	20.50	4.20	51.00	54.40	0.40			TPS/G 055-043
55.00	45.00	11.30	4.00	50.50	54.00	0.40			SPS 216-177
55.00	45.00	12.50	4.00	52.00	54.00	0.40			TPM 216-177-ISO
56.00	40.00	20.50	3.10	52.00	55.00	0.40		DAS 056-040	TPL 056-040
60.00	44.00	18.40	6.35	55.40	58.50	0.40	KGD 060-044	DAS 060-044	TPM 236-173
60.00	44.00	20.50	3.10	56.00	59.00	0.40	KGD 060-044/A	DAS 060-044/1	TPL 060-044
60.00	45.00	23.00	-	-	-	0.40			MHM 236-177 P
60.00	48.00	20.50	4.20	56.00	59.40	0.40	KGD 060-048	DAS 060-048	TPS/G 060-048
63.00	47.00	18.40	6.35	58.40	61.50	0.40	KGD 063-047	DAS 063-047	TPM 248-185
63.00	47.00	19.40	6.35	58.40	61.50	0.40	KGD 063-047/B	DAS 063-047/2	TPM 248-185/2S
63.00	47.00	20.50	3.10	59.00	62.00	0.40	KGD 063-047/A	DAS 063-047/1	TPL 063-047
63.00	48.00	20.00	5.00	59.00	61.50	0.40			TPM 248-188-ISO
63.00	51.00	20.50	4.20	59.00	62.40	0.40	KGD 063-051	DAS 063-051	TPS/G 063-051
63.00	53.00	11.40	4.00	58.50	61.50	0.40			SPS 248-208
63.00	53.00	12.50	4.00	60.00	62.00	0.40			TPM 248-208-ISO
65.00	49.00	20.50	3.10	61.00	64.00	0.40	KGD 065-049	DAS 065-049	TPL 065-049
65.00	50.00	18.40	6.35	60.40	63.50	0.40	KGD 065-050	DAS 065-050	TPM 255-196
65.00	53.00	20.50	4.20	61.00	64.40	0.40			TPS/G 065-053
70.00	50.00	22.00	10.00	64.00	68.00	0.40			H53-0075112
70.00	50.00	22.40	6.35	64.20	68.30	0.40	KGD 070-050	DAS 070-050	TPM 275-196
70.00	54.00	20.50	3.10	66.00	69.00	0.40	KGD 070-054	DAS 070-054	TPL 070-054
70.00	55.00	20.00	5.00	66.00	69.00	0.40			TPM 275-216-ISO
70.00	55.00	23.00	-	-	-	0.40			MHM 275-216 P
70.00	58.00	20.50	4.20	66.00	69.40	0.40	KGD 070-058	DAS 070-058	TPS/G 070-058
75.00	55.00	22.00	10.00	69.00	73.00	0.40			H53-0075612
75.00	55.00	22.40	6.35	69.20	73.30	0.40	KGD 075-055	DAS 075-055	TPM 295-216
75.00	59.00	20.50	3.10	71.00	74.00	0.40		DAS 075-059	TPL 075-059
75.00	63.00	20.50	4.20	71.00	74.40	0.40			TPS/G 075-063
80.00	60.00	22.40	6.35	74.15	78.30	0.40	KGD 080-060	DAS 080-060	TPM 314-236
80.00	60.00	25.00	6.30	75.00	78.00	0.40			TPM 314-236-ISO
80.00	62.00	22.50	3.60	76.00	79.00	0.40	KGD 080-062	DAS 080-062	TPL 080-062
80.00	65.00	20.00	5.00	76.00	78.50	0.40			TPM 314-255-ISO
80.00	65.00	23.00	-	-	-	0.40			MHM 314-255 P

* For order processing, the computer code will be
e.g. CS 020-011 KGD, CS 020-011 DAS, CS 020-011 TPL

U Cup Seal

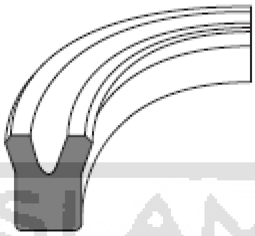
U-Cup

SPEC SEAL
Seals & O-rings Specialist

Piston & Rod Seals

H-601 (Metric Size)

(Size list on page 111-121)

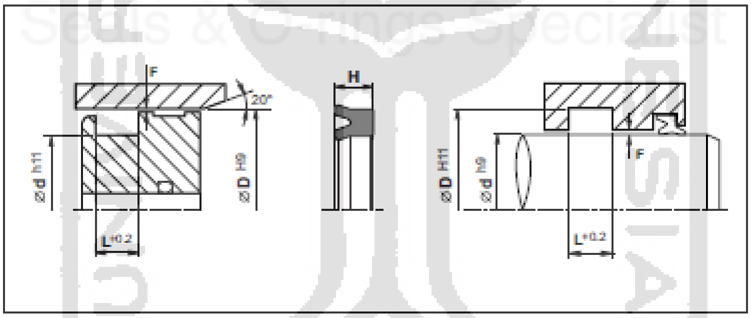


H-601

Material	Pressure (Bar)	Temp. (°c)	Speed (m/s)
PU	400	45 +110	1

- General purpose seal.
- Excellent temperature resistance.
- Ease of installation.

Installation Recommendation



Surface roughness	Ra	Rt
Sliding surface	≤ 0.3 µm	≤ 4 µm
Surface of housing	≤ 1.8 µm	≤ 10 µm
Sides of housing	≤ 3.0 µm	≤ 16 µm

Pressure	Clearance F Max	
Bar	d <60 mm	d >60 mm
50	0.40	0.50
100	0.30	0.40
200	0.20	0.30
300	0.15	0.20
400	0.10	0.15

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U-Cup

SPEC SEAL
Seals & O-rings Specialist

(Metric Size)

Rod/ Groove Dia.	Bore/ Groove Dia.	Seal Height	Groove Width	Reference	Reference	Reference	Reference
d	D	H	L				
35.0	55.0	12.0	13.0	UPN 035-055			
35.5	45.0	6.0	7.0		UC 035.5-045-06 H601	4605100	UHS-035.5
35.5	50.5	10.2	11.0				UNS-035.5
36.0	46.0	5.6	6.3		UC 036-046-05.6 H601	4183701	
36.0	46.0	7.0	8.0	UPN 036-046			
36.0	70.0	10.0	11.0	UPN 036-070			
38.0	45.0	5.0	5.5	UPN 038-045			
38.0	46.0	6.5	7.5	UPN 038-046			
38.0	48.0	6.0	7.0		UC 038-048-06 H601	4605200	UHS-038
38.0	50.0	9.0	10.0	UPN 038-050			
38.0	55.0	9.7	11.0		UC 038-055-09.7 H601	4366000	
38.0	55.0	10.0	11.0	UPN 038-055			
38.0	58.0	9.7	11.0		UC 038-058-09.7 H601	4560100	
38.0	58.0	10.0	11.0	UPN 038-058			
40.0	48.0	11.0	12.0	UPN 040-048			
40.0	50.0	5.6	6.3		UC 040-050-05.6 H601	4183801	
40.0	50.0	6.0	7.0		UC 040-050-06 H601	4605300	UHS-040
40.0	50.0	5.6	6.3		UC 040-050-05.6 H601	4183801	
40.0	50.0	6.5	7.5	UPN 040-050/A			
40.0	50.0	8.0	9.0	UPN 040-050/B			
40.0	50.0	10.0	11.0	UPN 040-050	UC 040-050-10 H601	4362900	
40.0	55.0	9.9	11.0		UC 040-055-09.9 H601	4388500	
40.0	55.0	10.0	11.0	UPN 040-055	UC 040-055-10 H601	4601600	UNS-040
40.0	56.0	10.0	11.0	UPN 040-056			
40.0	60.0	10.0	11.0	UPN 040-060/A			
40.0	60.0	12.0	13.0		UC 040-060-12 H601	4601700	
40.0	60.0	13.0	14.0	UPN 040-060			
40.0	60.0	18.0	19.0	UPN 040-060/B			
40.0	65.0	12.0	13.0	UPN 040-065			
40.0	70.0	15.0	16.0	UPN 040-070			
40.0	75.0	10.0	11.0	UPN 040-075			
42.0	50.0	8.0	9.0	UPN 042-050			
42.0	52.0	9.0	10.0	UPN 042-052			
42.0	62.0	12.0	13.0	UPN 042-062			
45.0	55.0	5.6	6.3		UC 045-055-05.6 H601	4183901	
45.0	55.0	6.0	7.0		UC 045-055-06 H601	4605400	UHS-045A
45.0	55.0	6.5	7.5	UPN 045-055/A			
45.0	55.0	10.0	11.0	UPN 045-055	UC 045-055-10 H601	4363000	
45.0	56.0	7.0	8.0		UC 045-056-07 H601	4605500	UHS-045
45.0	60.0	10.0	11.0	UPN 045-060	UC 045-060-10 H601	4601800	UNS-045

* For order processing, the computer code will be
e.g. UC 003-009-04.5 UPN, UC 004.5-012.5-04.4 H601

115

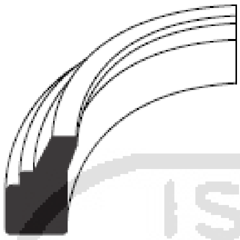
Wiper Seal

SPEC SEAL
Seals & O-rings Specialist

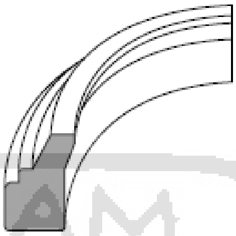
Wiper - A1

Wipers

A1 (Metric Size)



A1 (NBR)

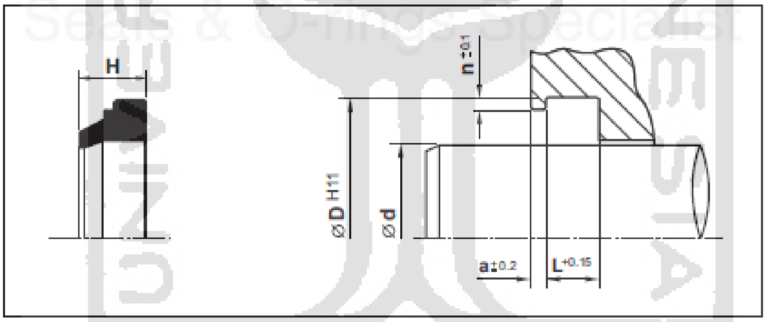


A1 (PU)

Material	Temp. (°c)	Speed (m/s)
NBR, PU	-35 +100	2

- Simple groove design.
- Very good scraping effect.
- Simple installation.
- Oversized diameters ensure a tight fit in the groove.

Installation Recommendation



Surface roughness	Ra	Rt
Sliding surface	≤ 0.3 μm	≤ 4 μm
Surface of housing	≤ 1.8 μm	≤ 10 μm
Sides of housing	≤ 3.0 μm	≤ 16 μm

Wiper - A1

(Metric Size)

Rod Dia. d	Groove Dia. D	Groove Width. L	Seal Height H	Distance a	Distance n	Prefix No.	Reference (For order processing)
4.0	12.0	4.0	7.0	1.0	1.0	0015	A1 004-012-4/7
5.0	8.0	2.2	4.0	1.0	0.5	0025	A1 005-008-2.2/4
6.0	10.0	2.2	4.0	1.0	0.5	0035	A1 006-010-2.2/4
8.0	14.0	2.6	5.0	1.0	1.0	0042	A1 008-014-2.6/5
8.0	16.0	4.0	7.0	1.0	1.0	0045	A1 008-016-4/7
10.0	16.0	2.6	5.0	1.0	1.0	1002	A1 010-016-2.6/5
10.0	18.0	4.0	7.0	1.0	1.0	1005	A1 010-018-4/7
12.0	18.0	2.6	5.0	1.0	1.0	1009	A1 012-018-2.6/5
12.0	20.0	4.0	7.0	1.0	1.0	1010	A1 012-020-4/7
14.0	20.0	3.1	5.0	1.0	1.0	1014	A1 014-020-3.1/5
14.0	22.0	4.0	7.0	1.0	1.0	1015	A1 014-022-4/7
15.0	23.0	4.0	7.0	1.0	1.0	1020	A1 015-023-4/7
16.0	22.0	3.1	5.0	1.0	1.0	1016	A1 016-022-3.1/5
16.0	24.0	4.0	7.0	1.0	1.0	1025	A1 016-024-4/7
17.0	25.0	4.0	7.0	1.0	1.0	1030	A1 017-025-4/7
18.0	24.0	3.1	5.0	1.0	1.0	1034	A1 018-024-3.1/5
18.0	26.0	4.0	7.0	1.0	1.0	1035	A1 018-026-4/7
20.0	26.0	3.1	5.0	1.0	1.0	2026	A1 020-026-3.1/5
20.0	28.0	4.0	7.0	1.0	1.0	2005	A1 020-028-4/7
22.0	30.0	4.0	7.0	1.0	1.0	2010	A1 022-030-4/7
23.0	31.0	4.0	7.0	1.0	1.0	2015	A1 023-031-4/7
24.0	32.0	4.0	7.0	1.0	1.0	2020	A1 024-032-4/7
25.0	33.0	4.0	7.0	1.0	1.0	2025	A1 025-033-4/7
26.0	34.0	4.0	7.0	1.0	1.0	2030	A1 026-034-4/7
28.0	36.0	4.0	7.0	1.0	1.0	2035	A1 028-036-4/7
30.0	38.0	4.0	7.0	1.0	1.0	3005	A1 030-038-4/7
32.0	40.0	4.0	7.0	1.0	1.0	3010	A1 032-040-4/7
33.0	41.0	4.0	7.0	1.0	1.0	3015	A1 033-041-4/7
34.0	42.0	4.0	7.0	1.0	1.0	3020	A1 034-042-4/7
35.0	43.0	4.0	7.0	1.0	1.0	3025	A1 035-043-4/7
36.0	44.0	4.0	7.0	1.0	1.0	3030	A1 036-044-4/7
38.0	46.0	4.0	7.0	1.0	1.0	3035	A1 038-046-4/7
40.0	48.0	4.0	7.0	1.0	1.0	4005	A1 040-048-4/7
41.0	49.0	4.0	7.0	1.0	1.0	4010	A1 041-049-4/7
42.0	50.0	4.0	7.0	1.0	1.0	4015	A1 042-050-4/7
44.0	52.0	4.0	7.0	1.0	1.0	4025	A1 044-052-4/7
45.0	53.0	4.0	7.0	1.0	1.0	4030	A1 045-053-4/7
45.0	57.0	5.5	10.0	1.5	1.5	4035	A1 045-057-5.5/10
46.0	54.0	4.0	7.0	1.0	1.0	4040	A1 046-054-4/7
47.0	55.0	4.0	7.0	1.0	1.0	4045	A1 047-055-4/7
48.0	56.0	4.0	7.0	1.0	1.0	4050	A1 048-056-4/7
50.0	58.0	4.0	7.0	1.0	1.0	5005	A1 050-058-4/7
50.0	62.0	5.5	10.0	1.5	1.5	5010	A1 050-062-5.5/10
51.0	59.0	4.0	7.0	1.0	1.0	5015	A1 051-059-4/7
52.0	60.0	4.0	7.0	1.0	1.0	5020	A1 052-060-4/7