Machine Design

Project

FLY PRESS

Submitted To: Dr. Aya Elhabak
Eng. Ahmed Hamed

15/5/2024

<u>Team Members</u>

Ahmed Mostafa Elsayed	1210126
Khaled Ayman	1210099
Omar Sobhy Ellethy	1210066
Waleed Ashraf	4220147

LIST OF CONTENT

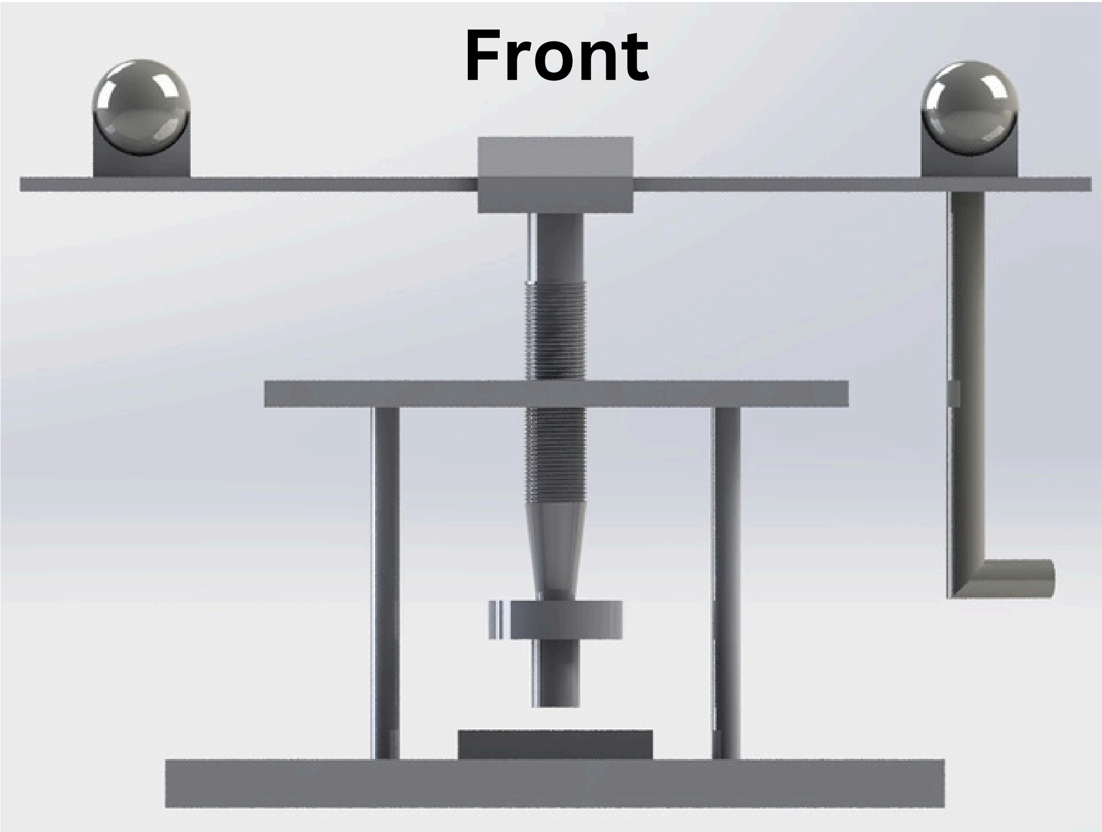
Fly Press

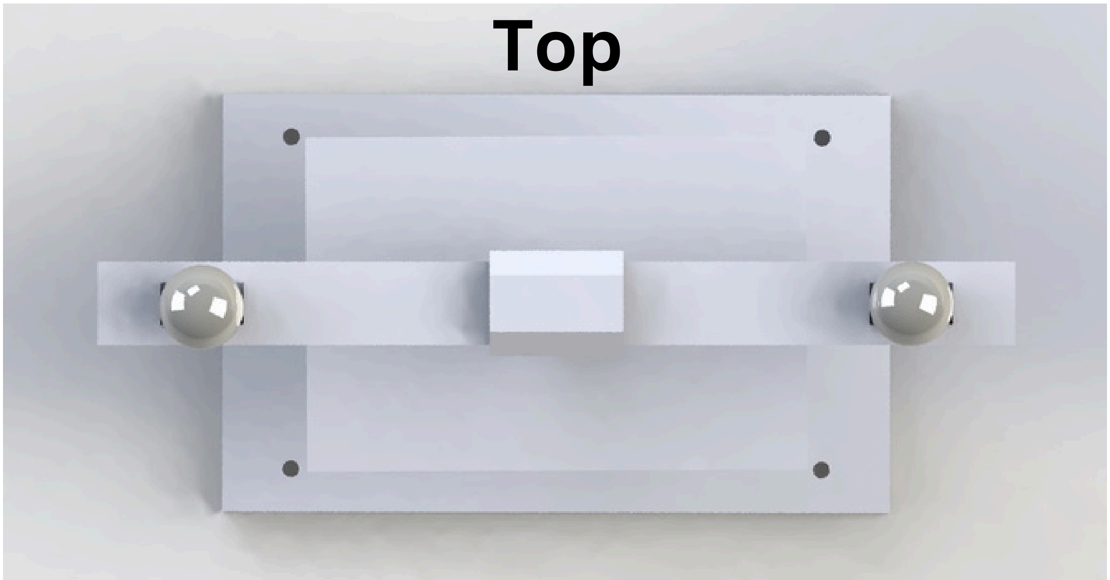
A manual fly press is a metalworking machine with a cast iron frame and lever mechanism. The lever applies force to a ram, which contacts the workpiece on an anvil. A vertical guide post ensures the ram moves accurately. Adjustments allow for varying workpiece sizes and precise operations. Operators control force by adjusting leverage or workpiece position. Commonly used in workshops and manufacturing for punching, bending, and forming metal. Valued for simplicity, reliability, and versatility in small-scale operations. Enables precise shaping of metal components with manual control.

Fly Press

Kindly here is a drive of all the parts & and assemble drawings: **Click here** “100% our design”

Our assembly

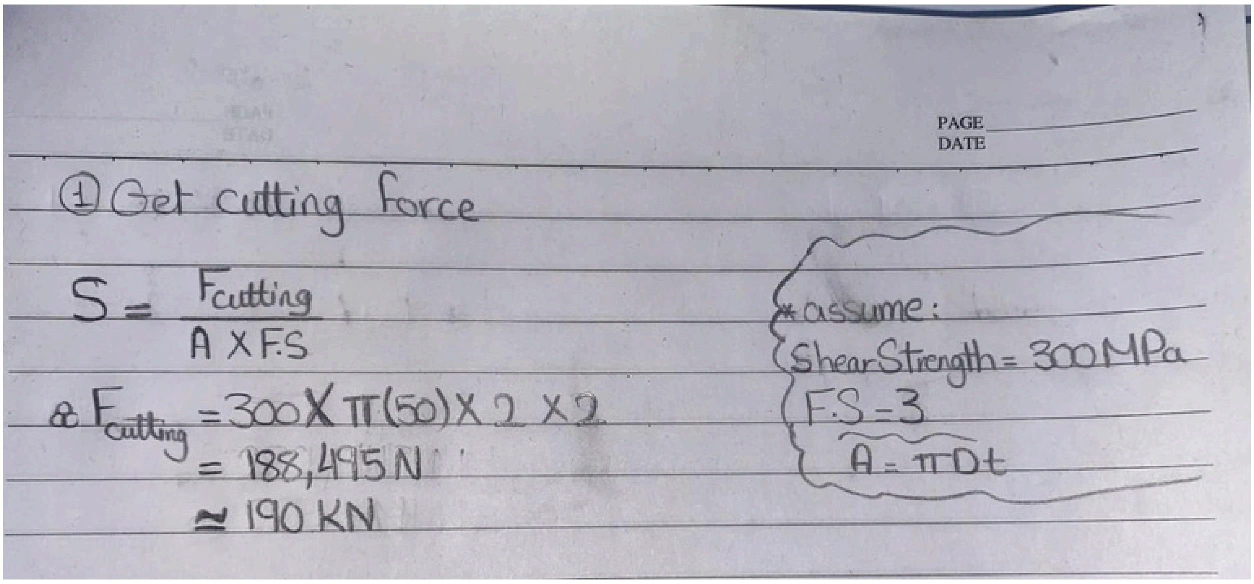




How we made our design?

First, the main objective was to cut a punch of 50 mm diameter from a mild steel sheet of thickness 3mm

So we had to find the force needed to cut the punch through dividing the shear strength over the length of cut (circumference) multiplied by thickness of metal sheet .



PAGE
DATE

① Get cutting force

$$S = \frac{F_{cutting}}{A \times F.S}$$

$$\therefore F_{cutting} = 300 \times \pi(50) \times 2 \times 2$$

$$= 188{,}495\,N$$

$$\simeq 190\,KN$$

*assume:
Shear Strength = 300 MPa
F.S = 3
$A = \pi D t$

Second, We are willing to design the power screw for the axial linear movement and to transmit power to cut the punch.

We've chosen the type of the thread to be square thread as the square shape of the thread reduces the friction between the mating parts, leading to smoother operation. This is particularly useful in mechanisms where precise movement and minimal resistance are required.

So we have to choose the pitch and its type from being fine or coarse and after doing research we found that for a manual press, there are some factors to be taken into account:

1. User Strength and Comfort: Since manual presses rely on human power to operate, the pitch type should be chosen to match the strength and comfort level of the operator. Coarser pitches may require less effort to operate but might sacrifice precision, while finer pitches offer more control but may require more effort to turn.

2. Intended Application: Consider the specific tasks the manual press will be used for. If precision is paramount, such as in jewelry making or small-scale metalworking, a fine pitch screw may be preferable. Conversely, for tasks where speed and ease of operation are more important, such as manual assembly or light pressing operations, a coarse pitch screw might be more suitable.

Due to high productivity needed for the worker and considering that the machine is manual so, we preferred coarse pitch.

So, based on the area subjected to the tensile strength we have chosen our pitch diameter and major diameter

Table 8–1 Diameters and Areas of Coarse-Pitch and Fine-Pitch Metric Threads*

	Coarse-Pitch Series			Fine-Pitch Series		
Nominal Major Diameter d mm	Pitch p mm	Tensile-Stress Area A_t mm^2	Minor-Diameter Area A_r mm^2	Pitch p mm	Tensile-Stress Area A_t mm^2	Minor-Diameter Area A_r mm^2
1.6	0.35	1.27	1.07			
2	0.40	2.07	1.79			
2.5	0.45	3.39	2.98			
3	0.5	5.03	4.47			
3.5	0.6	6.78	6.00			
4	0.7	8.78	7.75			
5	0.8	14.2	12.7			
6	1	20.1	17.9			
8	1.25	36.6	32.8	1	39.2	36.0
10	1.5	58.0	52.3	1.25	61.2	56.3
12	1.75	84.3	76.3	1.25	92.1	86.0
14	2	115	104	1.5	125	116
16	2	157	144	1.5	167	157
20	2.5	245	225	1.5	272	259
24	3	353	324	2	384	365
30	3.5	561	519	2	621	596
36	4	817	759	2	915	884
42	4.5	1120	1050	2	1260	1230
48	5	1470	1380	2	1670	1630
56	5.5	2030	1910	2	2300	2250
64	6	2680	2520	2	3030	2980
72	6	3460	3280	2	3860	3800
80	6	4340	4140	1.5	4850	4800
90	6	5590	5360	2	6100	6020
100	6	6990	6740	2	7560	7470
110				2	9180	9080

*The equations and data used to develop this table have been obtained from ANSI B1.1-1974 and B18.3.1-1978. The minor diameter was found from the equation $d_r = d - 1.226\ 869p$, and the pitch diameter from $d_p = d - 0.649\ 519p$. The mean of the pitch diameter and the minor diameter was used to compute the tensile-stress area.

Third, we are going for material selection for the punch itself, the most important property of this metal is to have a yield strength greater than the ultimate strength of the required sheet metal to be cut from. so, we chose carbon steel
AISI 1030 quenched at 315 C

1 AISI No.	2 Treatment	3 Temperature °C (°F)	4 Tensile Strength MPa (kpsi)	5 Yield Strength, MPa (kpsi)
1030	Q&T*	205 (400)	848 (123)	648 (94)
	Q&T*	315 (600)	800 (116)	621 (90)
	Q&T*	425 (800)	731 (106)	579 (84)
	Q&T*	540 (1000)	669 (97)	517 (75)
	Q&T*	650 (1200)	586 (85)	441 (64)
	Normalized	925 (1700)	521 (75)	345 (50)
	Annealed	870 (1600)	430 (62)	317 (46)

Force amplification:
Now, the force needed to cut is much greater than man effort and definitely we need to amplify so here comes the role of the two balls which gives the mechanical advantage to the system
The mechanical advantage of a fly press with two balls can be calculated based on the geometry and the principles of leverage in the mechanism. In a fly press, the balls act as a linkage between the operator's hand force and the punch, amplifying it to provide the necessary force for punching through the material, we’ll talk later more specific about the balls.

By using the formula for mechanical advantage (*MA*), which is the ratio of output distance to input distance:
$MA = D\text{output}/D\text{input}$
The mechanical advantage represents how much the force applied by the operator's hand is amplified to produce the force applied to the punch.

By Assuming: length of power screw = 1m
length of Rm = 0.5 m
length of handle = 0.4 m

$$D_{in} = 1+0.5+0.4 = 1.9\,m$$

length of D_{out} = 2 mm (thickness of metal sheet)

By using Mechanical advantage ratio: $MA = \frac{D_{output}}{D_{in}} = \frac{2\times10^{-3}}{1.9} = 1.05 \times 10^{-3}$

$$\therefore F_{operator} = MA * F_{punch} = [1.05\times10^{-3}] * [192 \times 10^{3}]$$

$$= 200\ N$$ (input force by worker)

So as we see, by applying these assumptions, the worker's force has been amplified from 200N which seems a very reasonable number as the average of human pushing force is 300N and we meant to make the distance ratio smaller to amplify this force with the least effort for the worker,

to achieve highest productivity while working sitting.

Welding and fixation

We will need welding in many parts of our machine as

- Pillars
- Ball holders
- Housing

We decided to use GMAW with CO_2 as a shielding gas with the following specifications:

- Electrode: E71T-9
- Voltage: 17~22 volts
- Current Intensity: 100~200 A
- Shield gas: CO_2
- Wire diameter: 1.1 mm
- Wire exit speed: 6 mm/min.

Manufacturing Processes

Machining:

- We will use the center lathe to make the power screw
- To make the internal thread and external thread for screw and punch fixed inside it.

Drilling:

- To make the holes of the base for fixation
- To make the hole of the power screw for punch fixation

Grinding:

- For surface finishing

Designation of the Punch

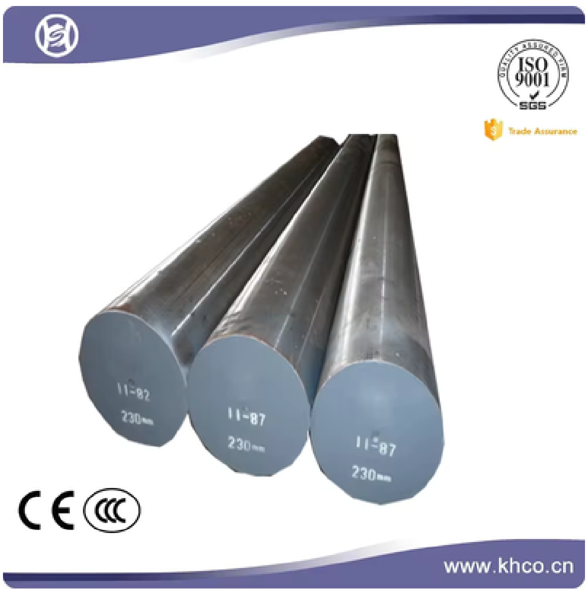
● Brief about punch

The punch in a manual fly press shapes and cuts materials precisely, driven by applied force. It's essential for forming and slicing through various materials. Operators adjust force for accurate results, making it vital in metalworking and crafting tasks.

Material selection

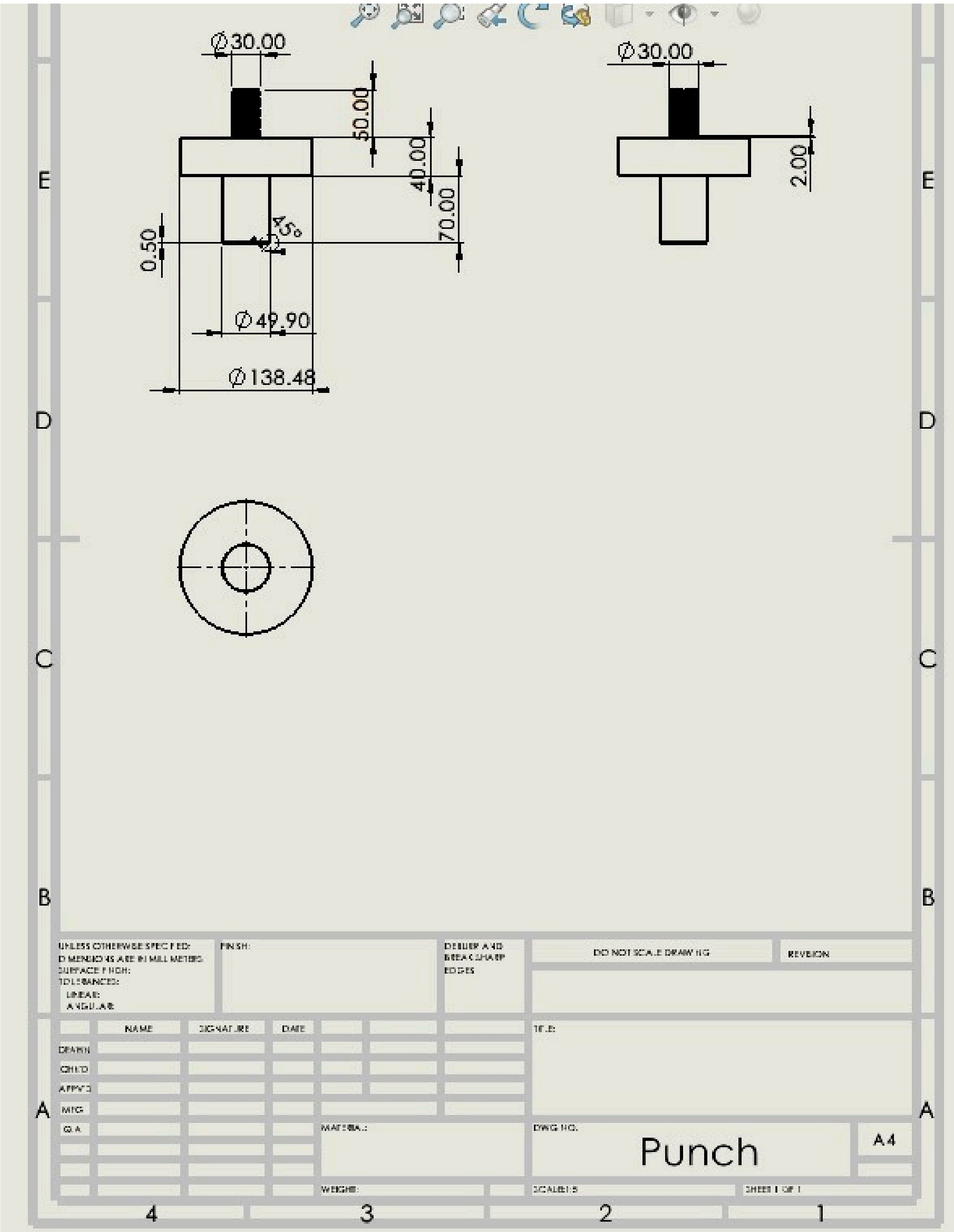
K100 Steel

- Using K100 Steel as a die material for the punch as it has high hardness and suitable for the usage as a die cut object and a punch
- Our goal of selection to have the yield strength of the punch to be more than the ultimate strength of the required material to be cut (mild steel)



Designation of the Punch

Working Drawing



Designation of the Power Screw

• Brief about power screw

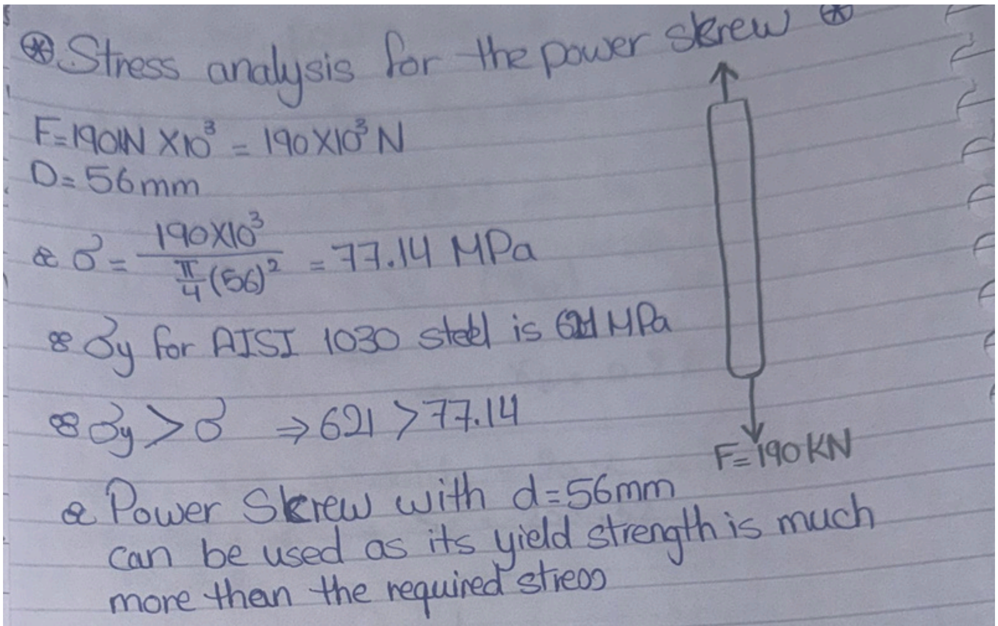
A power screw roll on a manual fly press facilitates controlled vertical movement. It converts rotational motion into linear force, adjusting the press's ram height. This mechanism enhances precision in shaping and cutting tasks, offering versatility in various manual operations.

• Material selection

AISI 1030 (Annealed at 315 C):

- To have a yield strength more than the ultimate strength of the material to be punched
- AISI 1030 steel was chosen for the power screw due to its balanced strength, machinability, and cost-effectiveness. Its moderate carbon content ensures adequate hardness for power transmission while being easy to machine. This material choice optimizes performance and simplifies manufacturing, making it suitable for student projects or small-scale production.

• *Stress analysis*



Stress analysis for the power skrew

$F = 190\,kN \times 10^3 = 190 \times 10^3\,N$

$D = 56\,mm$

$\sigma = \dfrac{190 \times 10^3}{\frac{\pi}{4}(56)^2} = 77.14\ MPa$

σ_y for AISI 1030 steel is 621 MPa

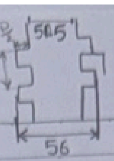
$\sigma_y > \sigma \Rightarrow 621 > 77.14$

F= 190 KN

Power Skrew with d=56mm can be used as its yield strength is much more than the required stress

Designation of the Power Screw

• Fatigue



$P = 5.5\ mm$

PAGE
DATE

Fatigue for power screw

$F = 190\ KN$, $S_u = 800\ MPa$, $S_y = 621\ MPa$

$S_e' = 0.45\ S_u = 0.45\ (800) \rightarrow S_e' = 360$

$* K_a = A\ (S_u)^b = 4.51 \cdot (800)^{-0.265} \rightarrow K_a = 0.767$

$* K_b = 1.189 \times (56)^{-0.097} \rightarrow K_b = 0.81$

$*$ assume that reliability $= 90\% \rightarrow K_c = 0.897$

$\rightarrow S_e = K_a K_b K_c S_e' \rightarrow S_e = 200.62$

At thread :

Get K_t using Figure A-15-13 : $(r/d = 0.046)$, $(D/d = 1.11)$

$* K_t = 2.63$

$(F_{max} = 190\ KN ,\ F_{min} = 94\ KN)$, $A = 2002.96\ mm^2$

$* \sigma_{max} = \frac{F_{max}}{A} = \frac{190 \times 10^3}{2002.96} \rightarrow \sigma_{max} = 94.86\ MPa$

$* \sigma_{min} = \frac{F_{min}}{A} = \frac{94 \times 10^{-3}}{2002.96} \rightarrow \sigma_{min} = 46.93\ MPa$

$* \sigma_m = 70.895\ MPa$, $* \sigma_a = 23.965\ MPa$

Get q using Figure 6-20 : $(r = 2.25\ mm ,\ S_u = 116\ kpsi)$

$q = 0.82$, $K_f = 1 + q\ (K_t - 1) \rightarrow K_f = 2.337$

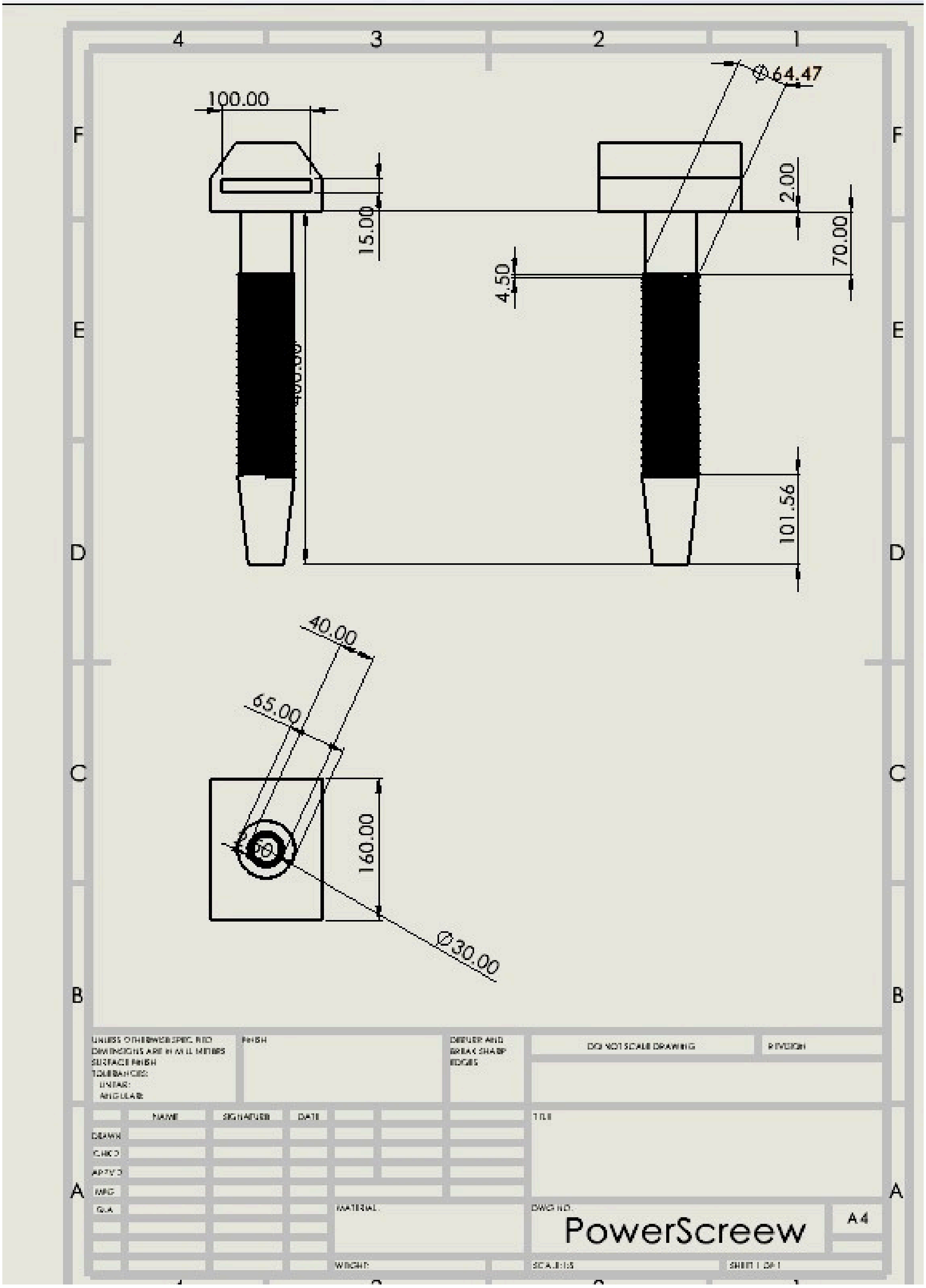
$\rightarrow$ Goodman : $\frac{K_f \sigma_a}{S_e} + \frac{\sigma_m}{S_u} = \frac{1}{n}$

$\hookrightarrow n = 2.72$

As n > 1 then the power screw will have infinite life and will can be used for mass production

Designation of the Power Screw

- Working Drawing



Designation of the nut

Assumptions:

Assume the nut material to be **bronze** (Sall = 300 N/m^2) to act as a **mechanical fuse** for the Power Screw which will be made of AISI 1030 (Sall = 650 N/m^2) that will be very expensive.

Zn (no. of teeth of the nut)=5 teeth

P(Pitch of the Power Screw) = 5.5 mm

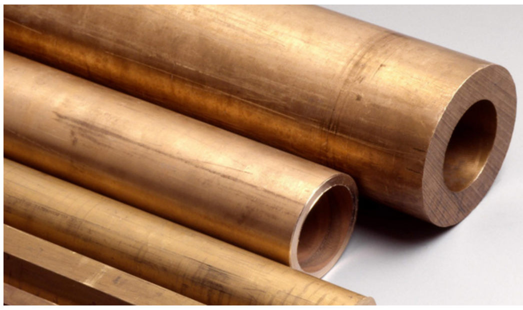
Then:

Height of the nut = Zn X P

= 5 X 5.5 = 27.5 mm

Height of nut = Nut Housing (Bracket)

- ## Material selection: BRONZE



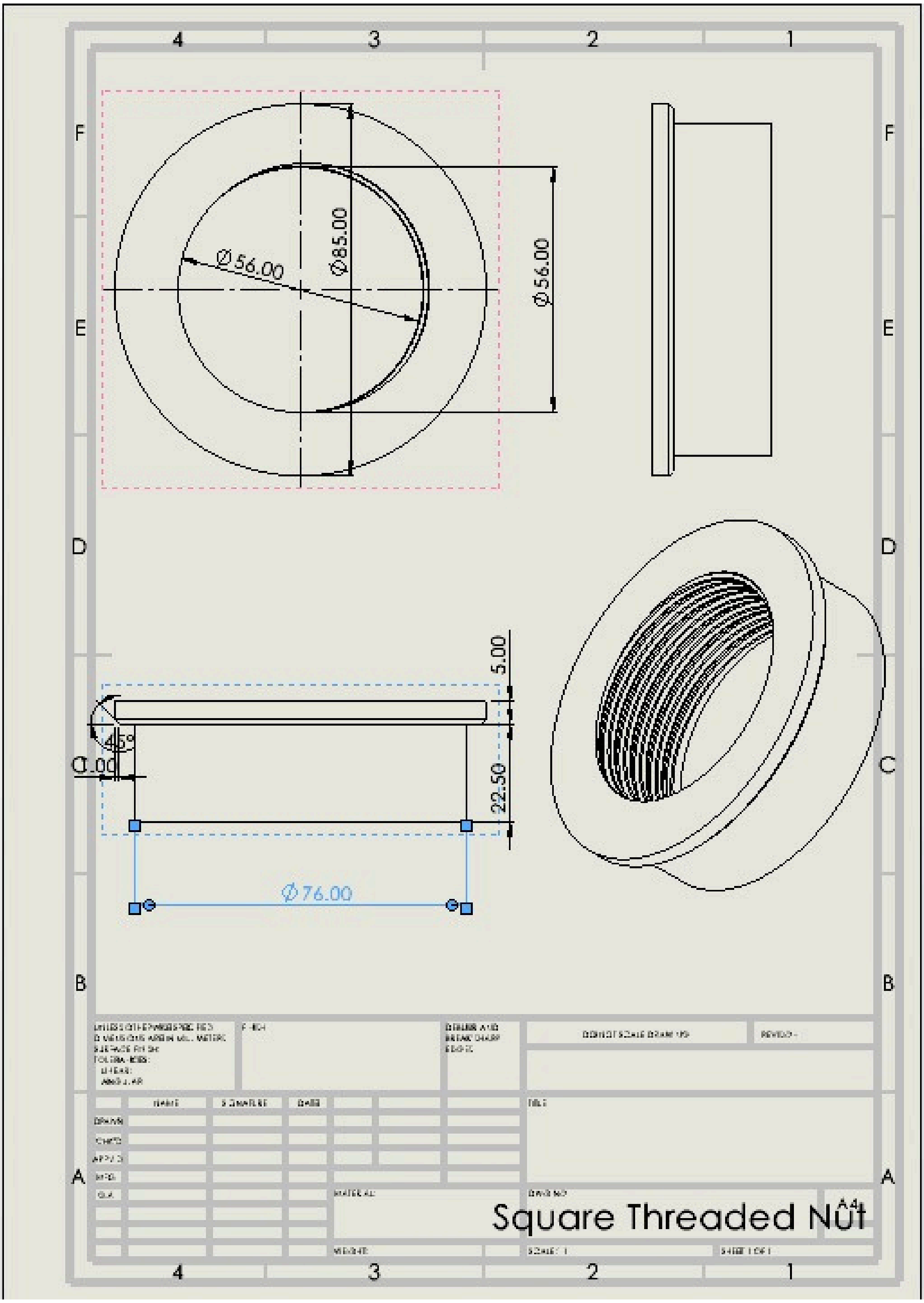
Using bronze for the nut in a power screw assembly offers self-lubricating properties, corrosion resistance, high load-bearing capacity, and minimal galling. These qualities ensure smooth operation, durability, and reliability in various applications like fly presses.

Although on the cost factor it do its work safely and cost less

The fitting that is used between the housing and the nut is **TRANSITION FIT** to ease the maintenance for the nut also if we need to change it.

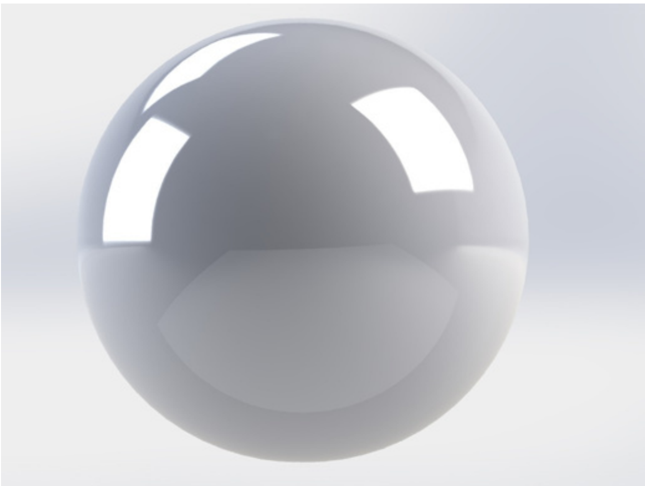
Designation of the nut

- Working Drawing



Designation of the balls

In a fly press mechanism, the balls typically act as a linkage between the operator's hand force and the punch.
The balls transmit the force applied by the operator to the punch, amplifying it to provide the necessary force for punching through the material.
They serve as part of the mechanism for converting the linear motion of the operator's hand into the rotational motion required for punching.



Let's assume a reasonable radius for example, Rm=50 mm=0.05 Rm=50mm=0.05m.
Volume:
V=(4/3)π(0.05 m)^3,
V≈(4/3)π(1.25×10−4 m3)V≈34π(1.25×10−4m3) V≈5.24×10−4 m3V≈5.24×10−4m3
Mass=7280 kg/m3 · 5.24×10−4 m3
Mass=7280kg/m3 · 5.24×10−4m3 ,
Mass≈3.81kg
The mass of each cast iron ball is approximately 3.81 kg.

Designation of the balls

- **Material selection:**

Given den. =7320kg/m3

- Cast iron

Mild steel, a widely used carbon steel variant, exhibits moderate strength and ductility. Its versatility in fabrication and affordability make it a popular choice in construction, automotive, and manufacturing industries.

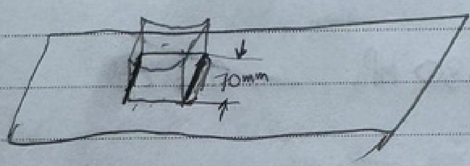
Welding of Ball Holders

Welding of ball holders (x2)

weight of ball : $50 * 9.81 = 490\ N$

$\sigma_{ut} = 430$ MPa

Assume Fillet width = 5 mm , $\eta = 4$



$A_{weld} = 0.707 * 5(70+70)$

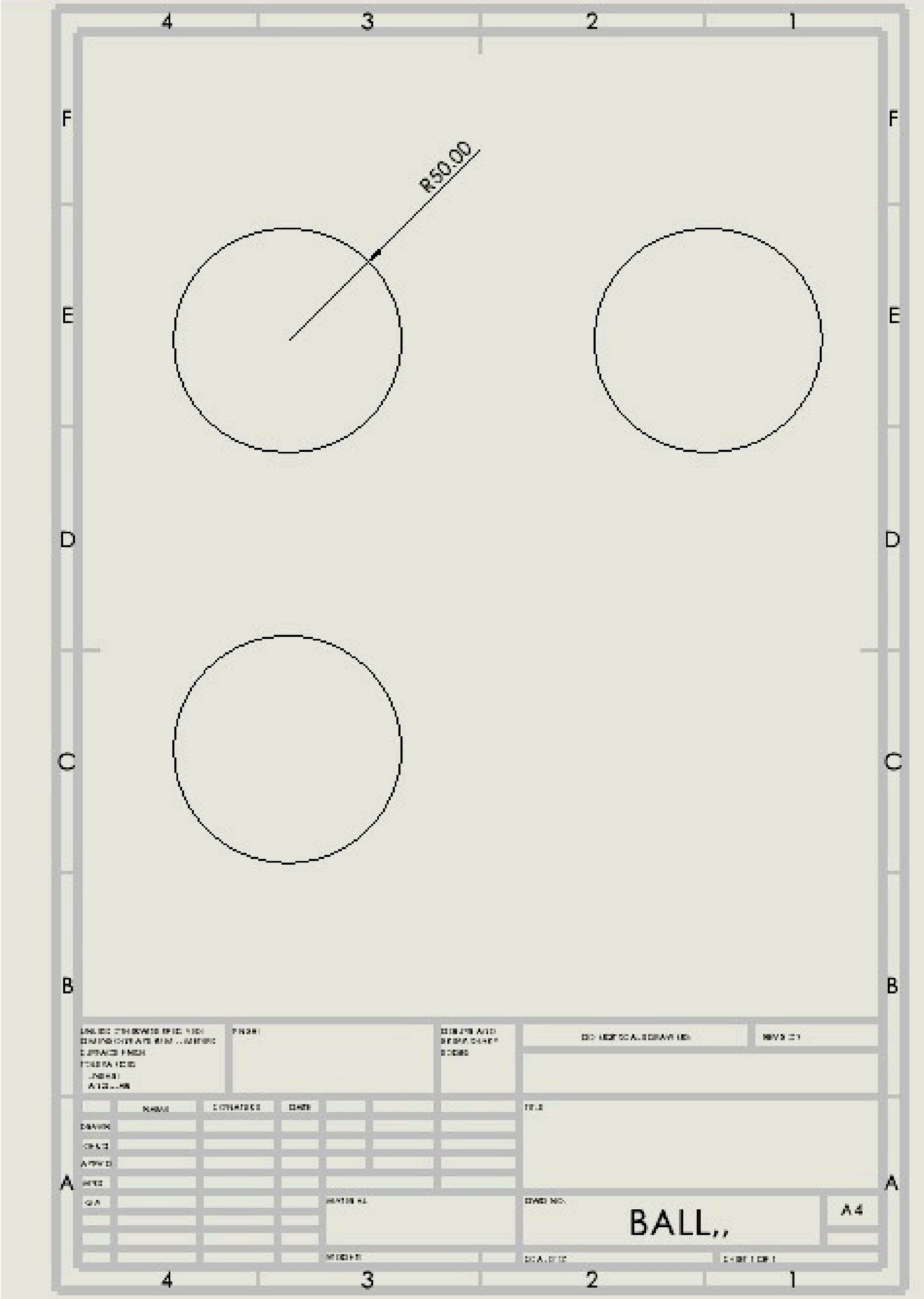
$= 495\ mm^2$

$F_{all} = \tau_{all} * A_{weld} = 107 * 495 = 52\ kN$

$\therefore$ Weld is Safe

Designation of the balls

Working Drawing



Design of the Housing

Hosing in a fly press facilitates fluid transmission, enabling hydraulic or systems to exert force for pressing operations. It channels and regulates pressure to control the movement of the press components efficiently.

MATERIAL SELECTION:

AISI 1030 (Annealed at 315 C):

- To have a yield strength more than the yield strength of the material of the nut also to make the nut act as mechanical fuse for the object

Design of the Housing

Stress analysis

⊛ Stress analysis for housing ⊛

* Housing Material: AISI 1030 annealed

$S_y = 317$ MPa , $S_{ut} = 430$ MPa , $\rho = 7870$ Kg/m^3

volume of housing $= (600 \times 400 \times 27.5) - \left(\frac{\pi}{4}(76)^2 \times 27.5\right)$

$= 6,475,247$ mm^3

$= 6.475 \times 10^{-3}$ m^3

$m = 7870 \times 6.475 \times 10^{-3}$

$= 50.95 \simeq 51$ Kg

$F = 51 \times 9.81 = 500$ Newton

To calc the force on each pillar & $F_{1pillar} = 250$ N

Pillar material AISI 1030

$S_y = 317$ MPa $\Rightarrow S_y = \frac{F}{A \times FS} \Rightarrow 317 = \frac{250}{A \times 2}$ { F.S = 2

& $A_{pillar} =$

$= 706.85$ mm^2 & $A = \left(\frac{\pi}{4}\right) d^2_{pillar}$ & $d_{pillar} = 30$ mm

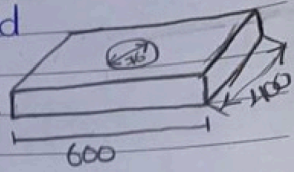
Design of the Housing

Fatigue Calculations

PAGE
DATE

⊛ Fatigue for housing ⊛

Housing Material: AISI 1030 annealed



$S_y = 317$ MPa, $S_{ut} = 430$ MPa

$S_e' = 0.45(430) = 193.5$ MPa

$K_a = A(S_{ut})^b$, assume housing is machined

& $A = 4.51$ $b = -0.265$

& $K_a = 4.51(430)^{-0.265} = 0.904$

$K_b = 1.189 (76)^{-0.097} = 0.7811$

$K_c = 0.897$, assume reliability = 90%

$S_e = K_a K_b K_c S_e'$

$= 0.904 \times 0.7811 \times 0.897 (193.5) = 122.5$ MPa

$M = 250 \times 300 = 75000$ Nmm

$= 75$ Nm

getting K_t : $\frac{d}{w} = \frac{76}{400} = 0.19 \simeq 0.2$, $\frac{d}{h} = \frac{76}{27.5} = 2.76$

& $K_t = 1.5$, $q = 0.8$ & $K_f = 1.4$

$\sigma_{o\,(min)} = \frac{75 \times 10^3}{I} = \frac{75 \times 10^3}{561515.625} = 0.1335$ MPa

$\left\{ I = \left((400-76)(27.5)^3\right)/12 = 561515.625 \right.$

$\sigma_{max} = \frac{150 \times 10^3}{I} = 0.267$ MPa

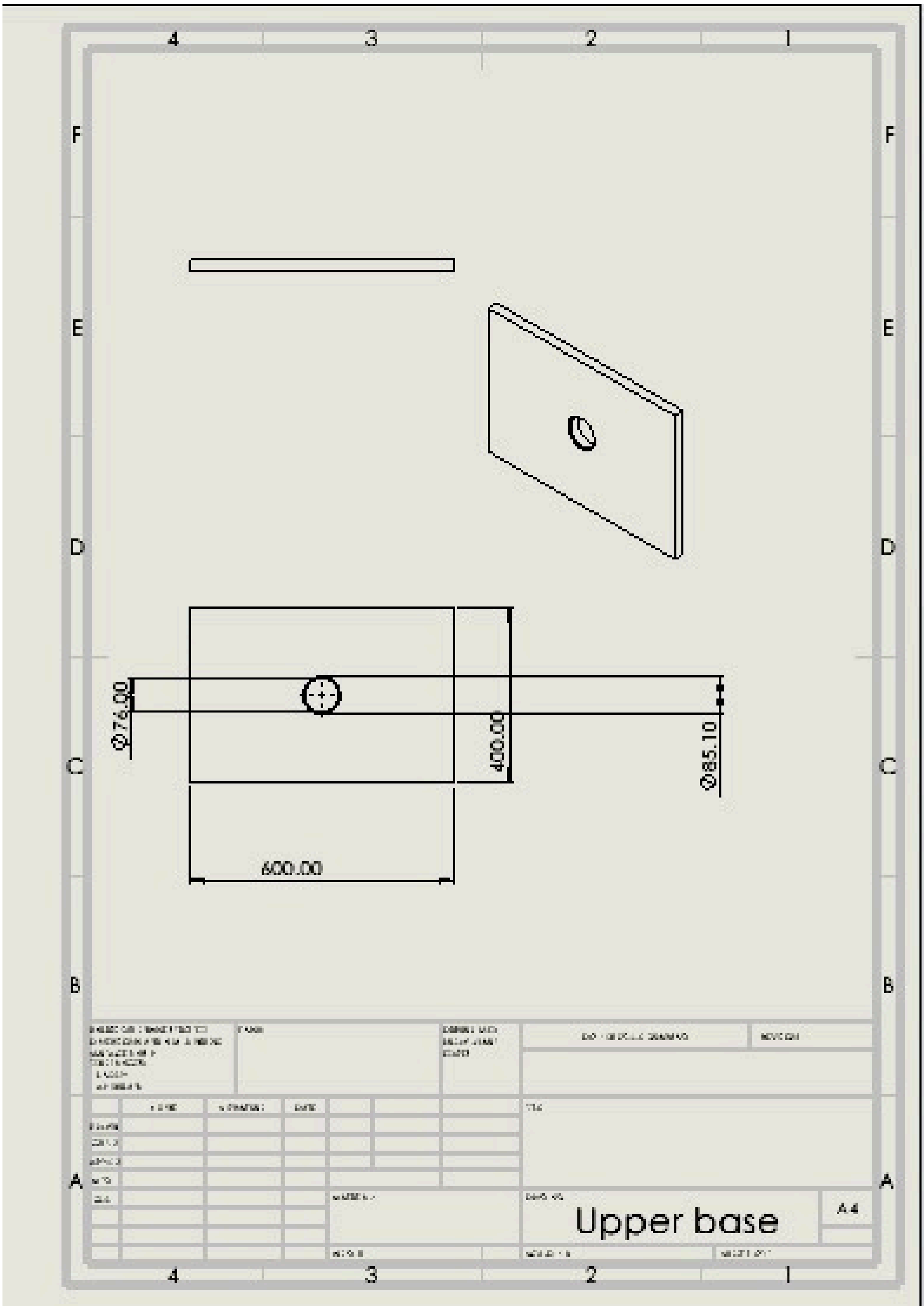
& $\sigma_a = \frac{0.267 - 0.1335}{2} = 0.06675$ MPa & $\sigma_m = 0.20025$ MPa

$\frac{1.4(0.06675)}{122.5} + \frac{0.20025}{430} = \frac{1}{n}$ & $n = 12.4$

& infinite life for the housing (accepted)

Design of the Housing

Working Drawing



Design of the Pillars

Pillars in a fly press provide structural support and alignment for the moving parts, ensuring stability and precision during pressing operations. They absorb and distribute forces, maintaining the integrity of the machine.

Material Selection

AISI 1030 (Annealed at 315 C):

- To have a yield strength as the hosing as the are the same material to avoid buckling for the pillars due to force from housing

Design of the Pillars

Stress Analysis

⊛ Stress analysis for housing ⊛

* Housing Material: AISI 1030 annealed

$S_y = 317$ MPa , $S_{ut} = 430$ MPa , $\rho = 7870\ Kg/m^3$

volume of housing $= (600 \times 400 \times 27.5) - \left(\frac{\pi}{4}(76)^2 \times 27.5\right)$

$= 6{,}475{,}247\ mm^3$

$= 6.475 \times 10^{-3}\ m^3$

$m = 7870 \times 6.475 \times 10^{-3}$

$= 50.95 \simeq 51$ Kg

$F = 51 \times 9.81 = 500$ Newton

To calc the force on each pillar & $F_{1pillar} = 250$ N

Pillar material AISI 1030

$S_y = 317$ MPa $\Rightarrow S_y = \frac{F}{A \times FS} \Rightarrow 317 = \frac{250}{A \times 2}$ { $\underline{F.S = 2}$ }

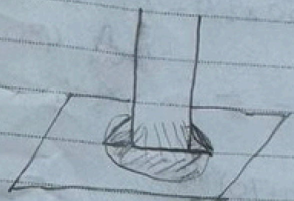
& $A_{pillar} =$
$= 706.85\ mm^2$

& $A = \left(\frac{\pi}{4}\right) d_{pillar}^2$ & $d_{pillar} = 30$ mm

Design of the Pillars

Welding

Welding of pillars (x4)



- Fillet welding

σ_{ut} of pillar $= 430$ MPa , $n_s = 4$

$$\tau_{all} = \frac{\sigma_{ut}}{n_s} \qquad \tau_{all} = \frac{430}{4} = 107 \text{ MPa}$$

$$\tau_{all} = \frac{F_{allow}}{A_{weld}} \; , \quad F_{allow} = \tau_{all} * A_{weld}$$

Let the fillet weld diameter = 5 mm

$$A_{weld} = \frac{\pi}{4} d^2 = \frac{\pi}{4}(40^2 - 30^2) = 550 \text{ mm}^2$$

$$F_{allow} = 107 * 20 = 58 \text{ kN}$$

And,

pillar is subjected to weight of housing which is

$$F_{housing} = \frac{50}{2} * 9.8 = 245 \text{ N} < 2140 \text{ N}$$

So, the weld is SAFE.

and No Failure will happen

Type of welding: GMAW

wire (electrode): E71T-9

Voltage : 17~22 V

Current intensity: 100~200 A

Shielding gas : CO_2

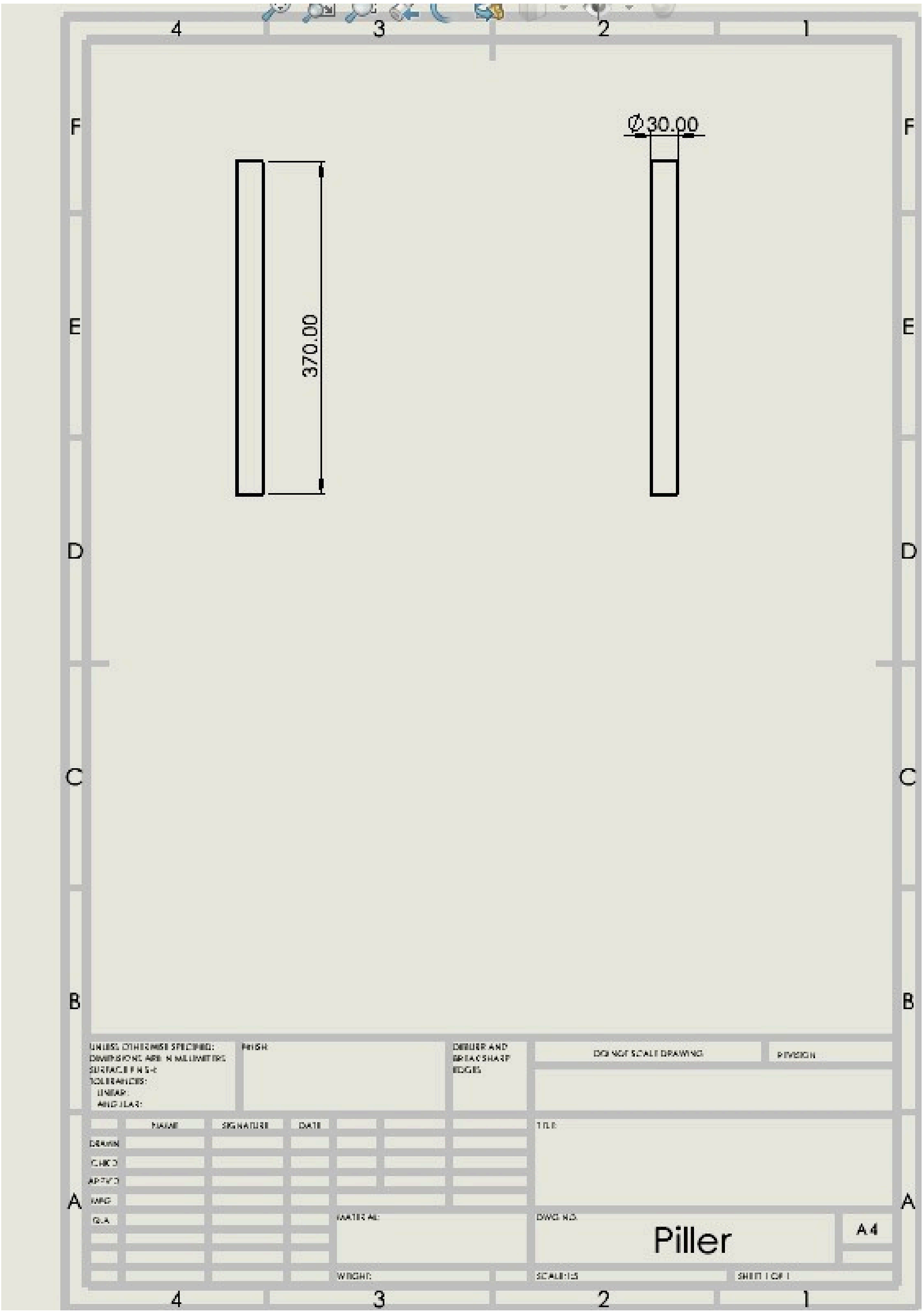
wire : 1.1 mm (diameter)

Speed : 60 mm/s

ALADIB

Design of the Pillars

Working Drawing



Design of the Upper Case

The upper case in a fly press houses the ram and serves as a platform for mounting tooling. It provides support and guides the downward movement of the ram during pressing operations.

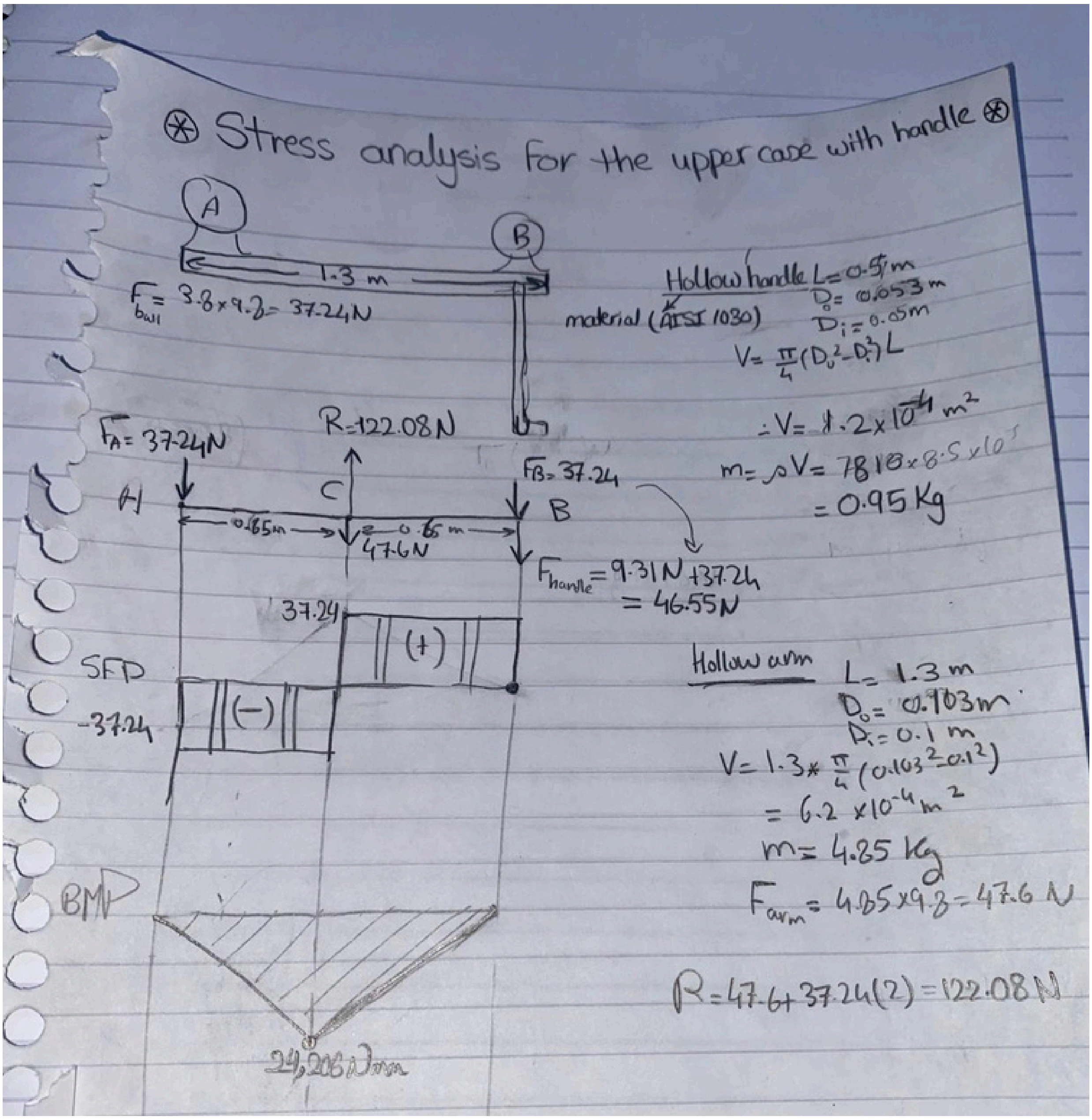
Material Selection

AISI 1030 (Annealed at 315 C):

- To have a yield strength equal to that of the power screw to prevent any failure in the two parts

Design of the Upper Case

Stress Analysis



Design of the Upper Case

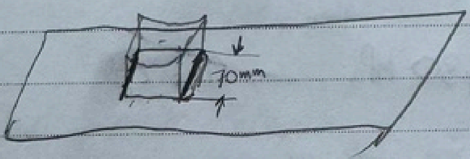
Welding of Ball Holders

Welding of ball holders (x2)

weight of ball : $50 * 9.81 = 490\ N$

$\sigma_{ult} = 430\ MPa$

Assume fillet width $= 5\ mm$, $\eta = 4$



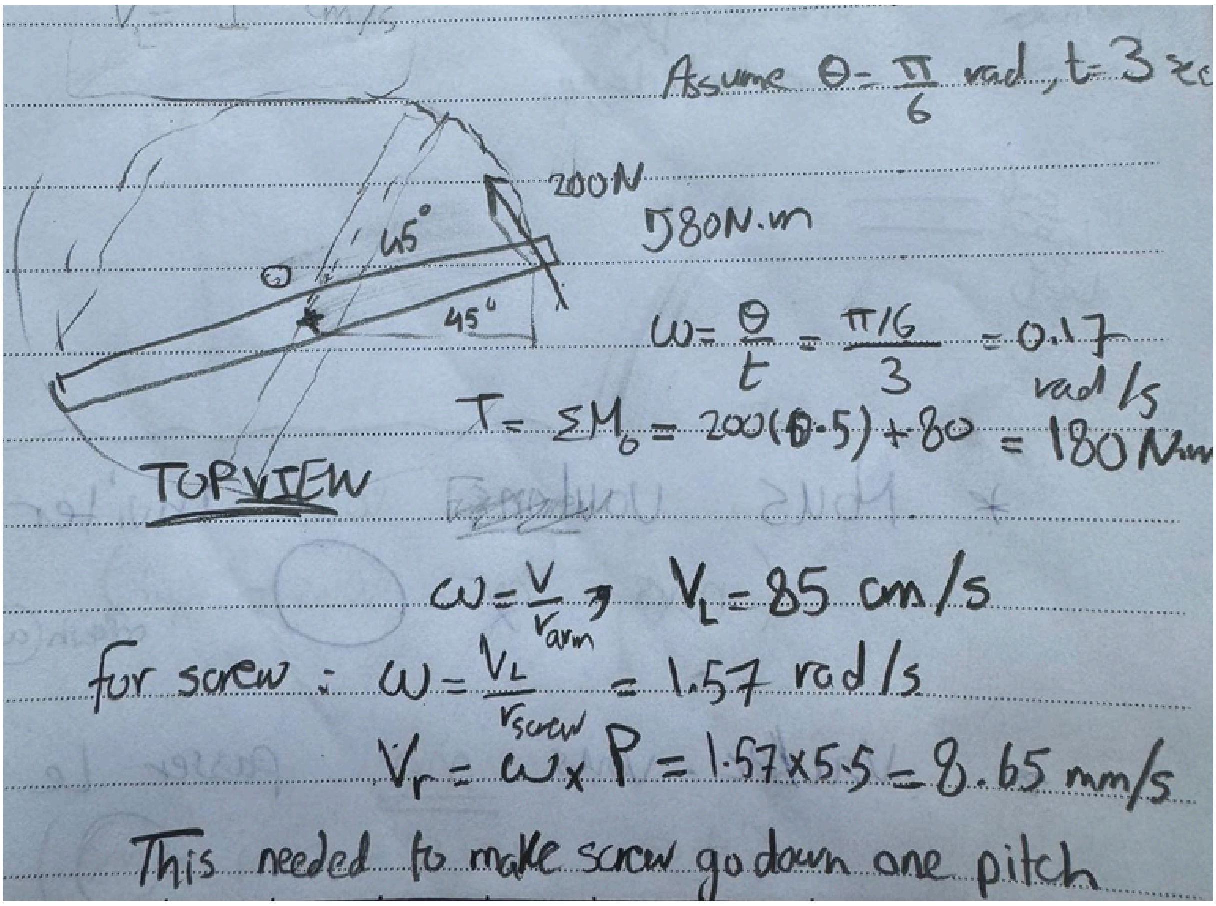
$$A_{weld} = 0.707 * 5(70+70)$$
$$= 495\ mm^2$$

$$F_{all} = \tau_{all} * A_{weld} = 107 * 495 = 52\ kN$$

$\therefore$ Weld is safe

Design of the Upper Case

Rotation of Upper Case



Assume $\theta = \frac{\pi}{6}$ rad, $t = 3$ s

200N

580N.m

45°

45°

θ

TOP VIEW

$\omega = \frac{\theta}{t} = \frac{\pi/6}{3} = 0.17$ rad/s

$T = \Sigma M_0 = 200(0.5) + 80 = 180$ Nm

$\omega = \frac{V}{r_{arm}} \rightarrow V_L = 85$ cm/s

for screw : $\omega = \frac{V_L}{r_{screw}} = 1.57$ rad/s

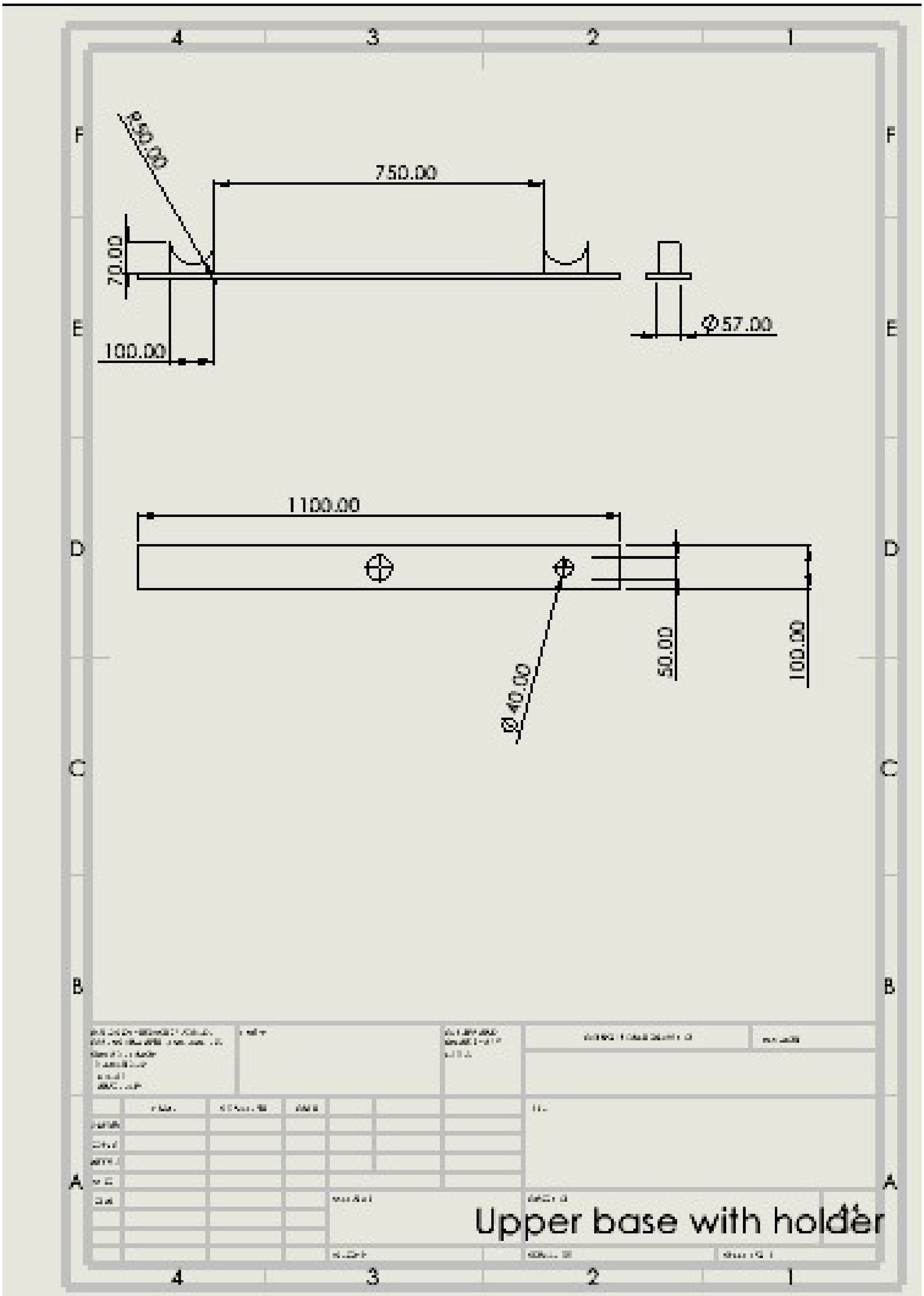
$V_r = \omega \times P = 1.57 \times 5.5 = 8.65$ mm/s

This needed to make screw go down one pitch

- **Total Linear Displacement=(Linear Displacement per Revolution)×(Total Number of Rotations) = 5.5 mm**

Design of the Upper Case

Working Drawing



References

- Mechanics of Materials" by Ferdinand P. Beer, E. Russell Johnston Jr., and John T. DeWolf

- Shigley's Mechanical Engineering Design" by Richard G. Budynas and Keith J. Nisbett

- Manufacturing Technology- foundry, Forming and Welding, PN Rao, volum1 1, 4th edition, McGraw Hill Education, 2014.