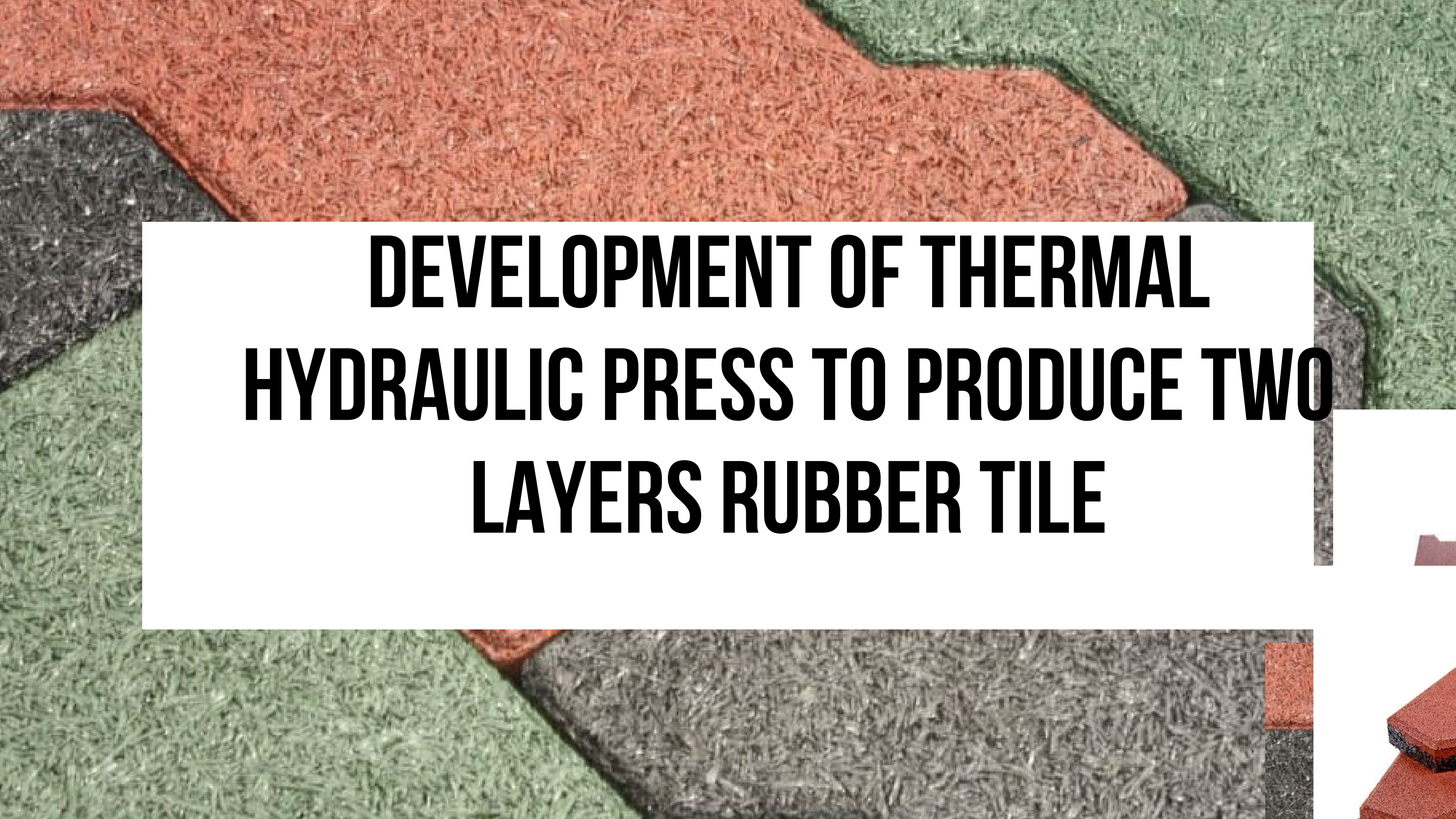




DEVELOPMENT OF THERMAL HYDRAULIC PRESS TO PRODUCE TWO LAYERS RUBBER TILE



Team



Mohamed Zaki
Ahmed



Mohamed
Sayed Abdel
Rahman



Mohamed
Khaled Fathy

Team



Mohamed
Saaed
Mahmoud



Ahmed Alaa
Aldin Hassan



Amr Hisham
Saad

Team



Badr Ragab
Madny



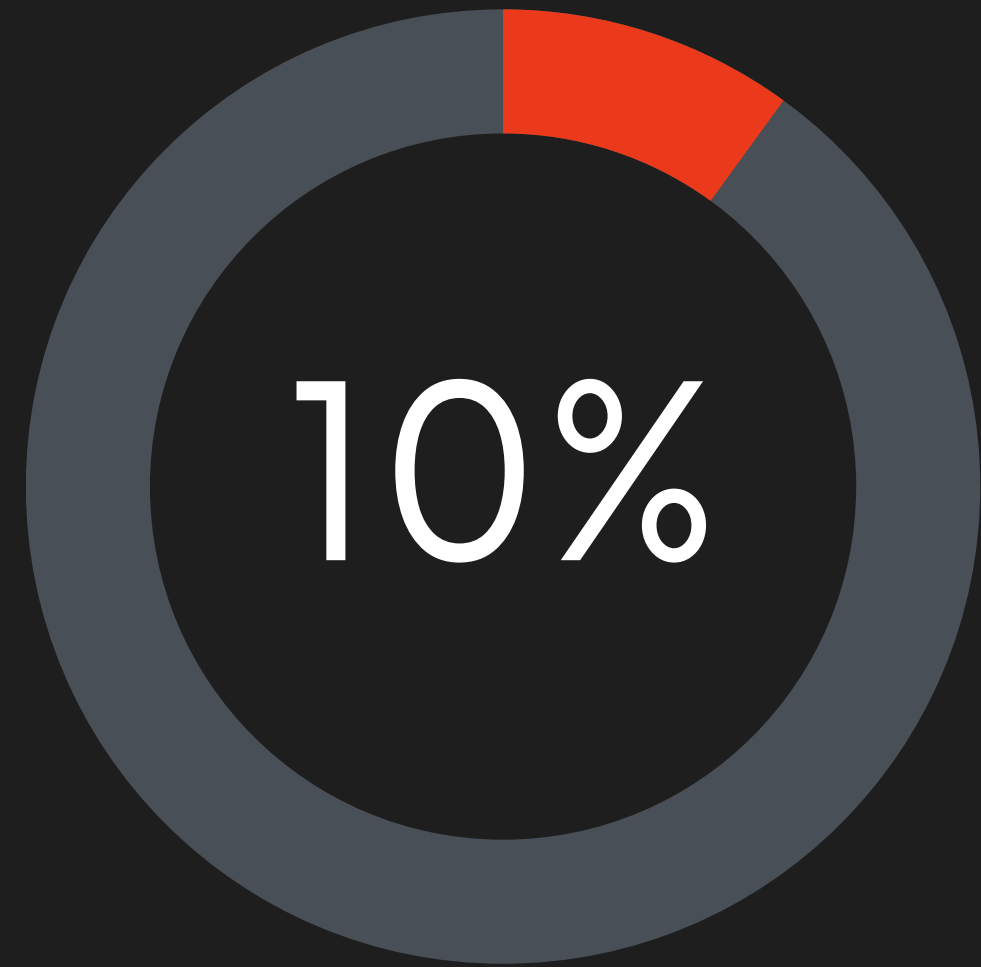
Osama Magdy
Diab



Problem

Egypt creates
20 million
waste tires
annually

According to Wamda



barely 10 percent
of those are
recycled



Waste tire Hazards

-Oil Leakage

-Fire



Solutions

Solutions

1

Cement Furnace Fuel

Used as a furnace fuel due to its high calorific value

2

Rubber Tile Production

Molding rubber powder for production of rubber tiles



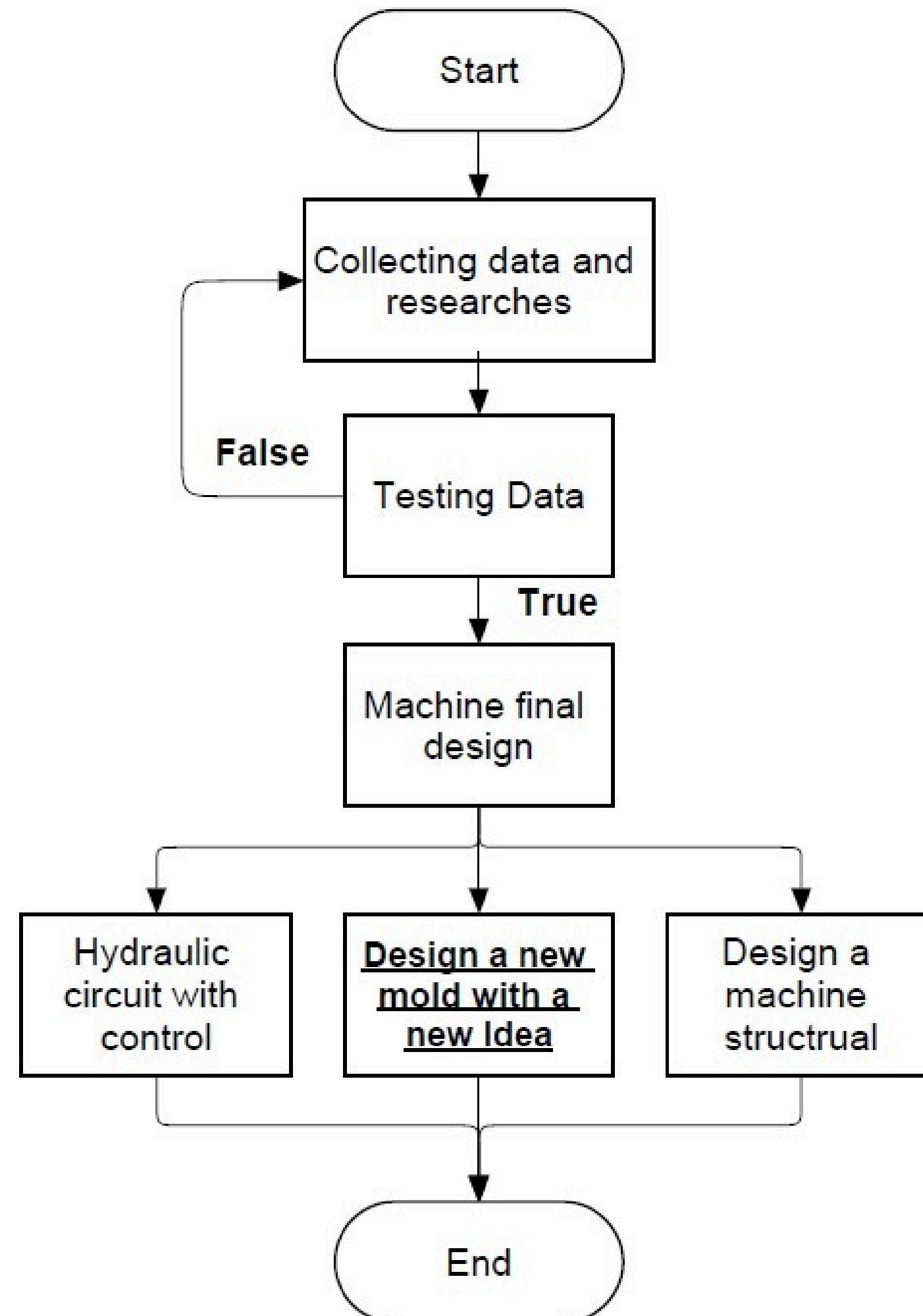
Rubber Tile Benefits



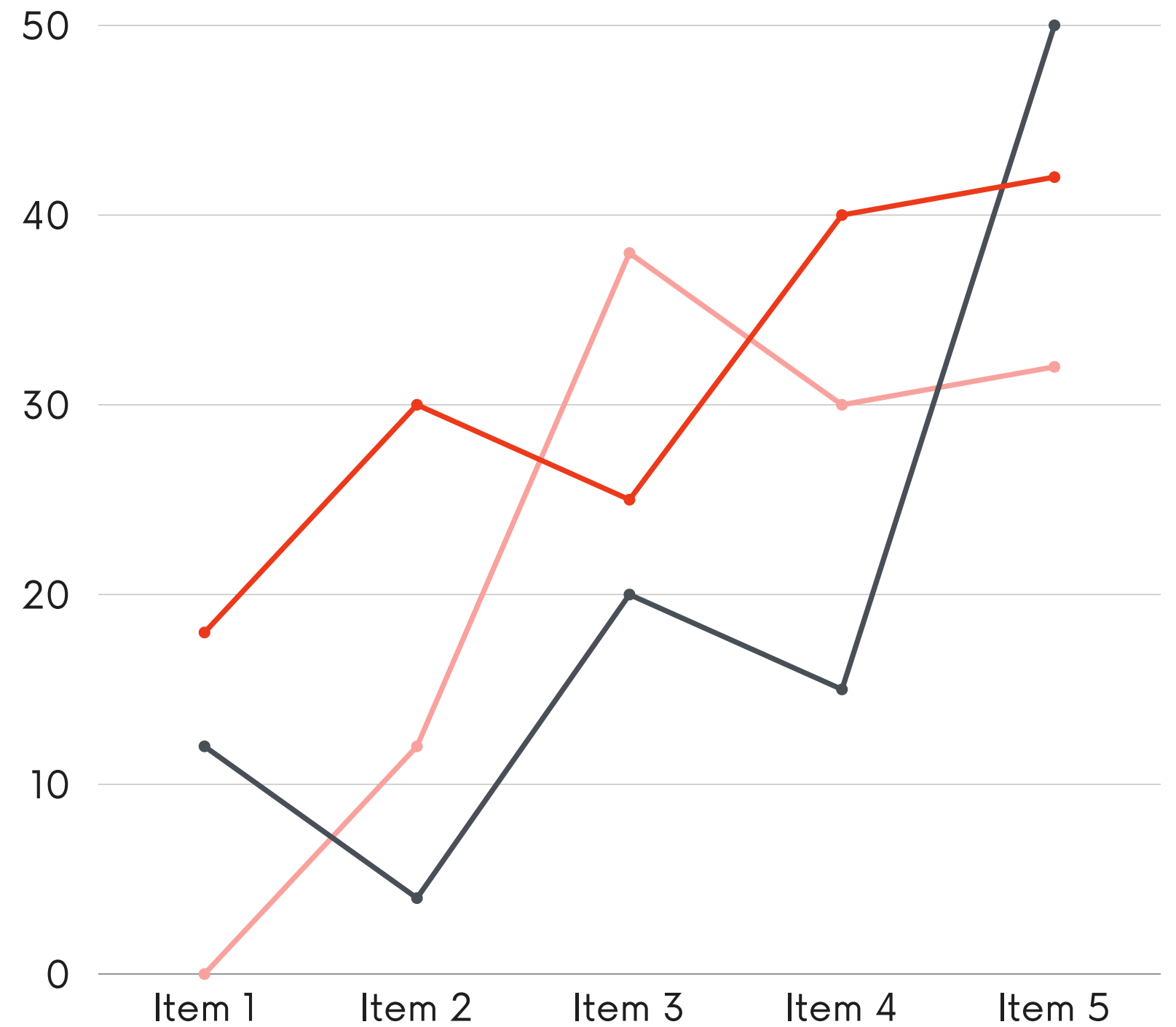
- Sound and shock absorbent
- Nonconductive
- Comfort
- Bacteria-resistant
- Slip-resistant
- Resilient in high-impact areas

Purposed Methodology

Stages of prolem solving



Collecting Data and Research



Critical Parameters

- Percentage of components
- Temperature
- Pressure

Rubber tile Components

Black rubber powder



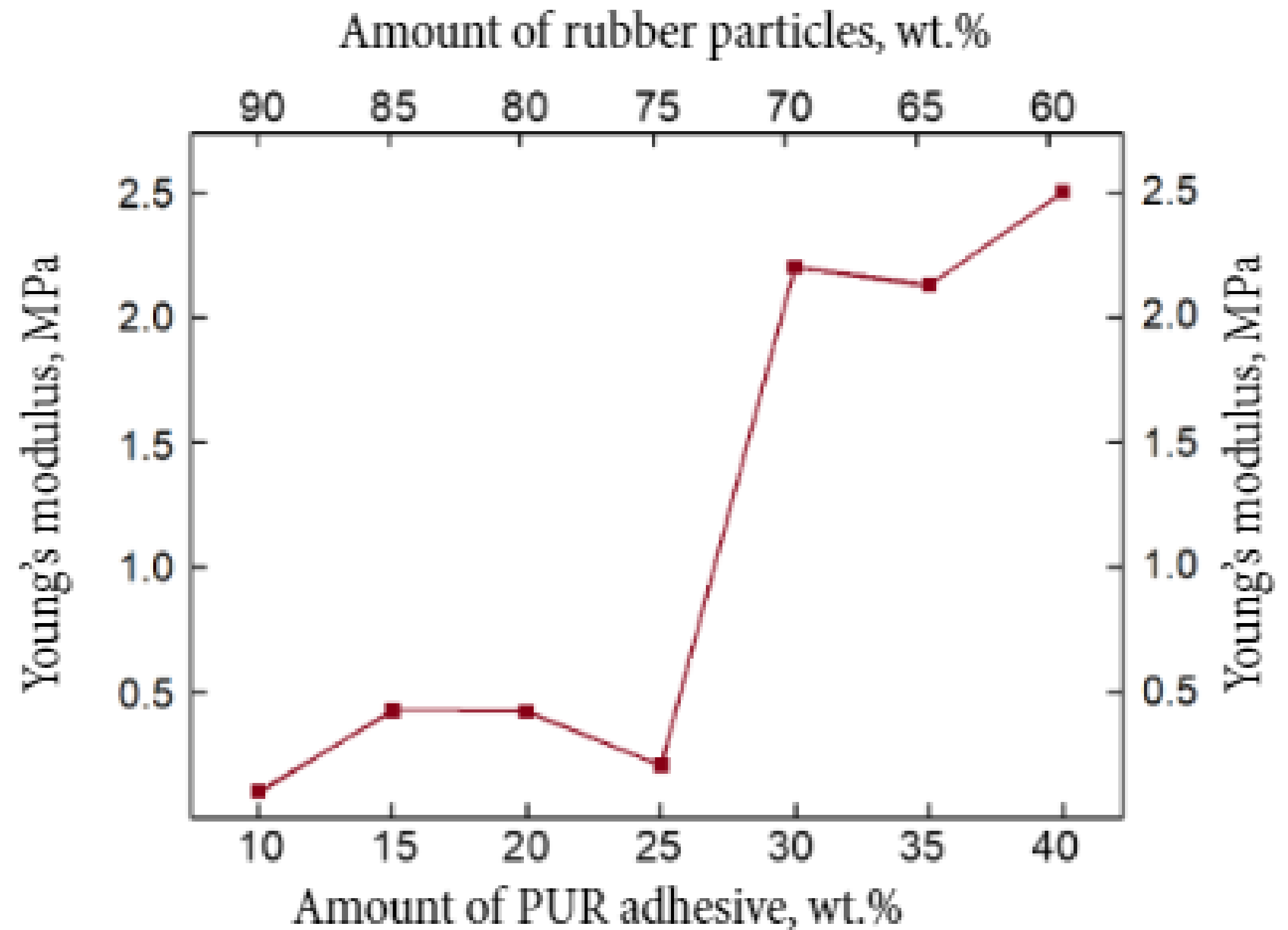
Colorful pigment (Iron oxide)



Poly urethane (PU) Glue

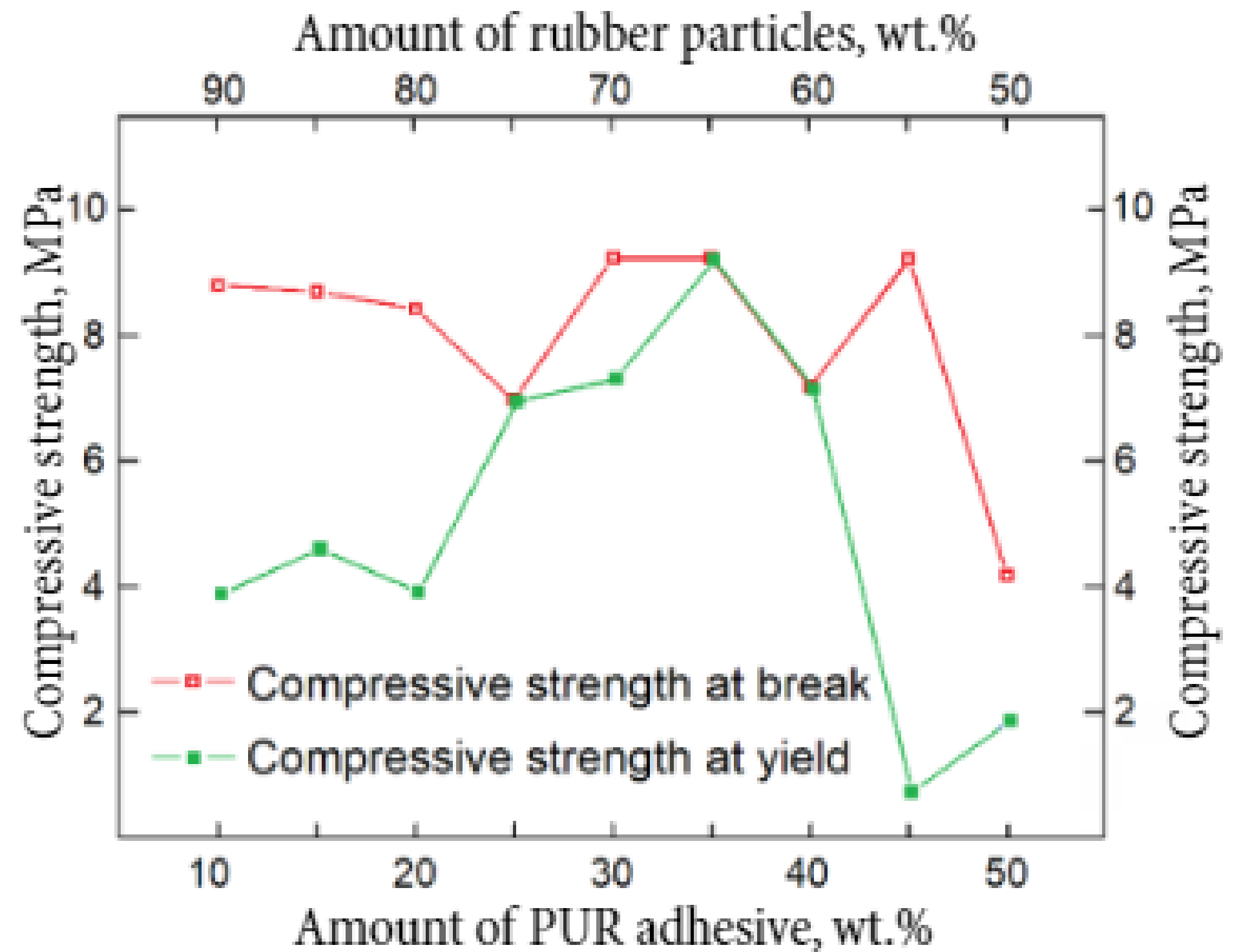
Relation between percentage of rubber to PU glue and young's modulus

60% rubber, 40% glue is perfect
percentage according to young's
modulus



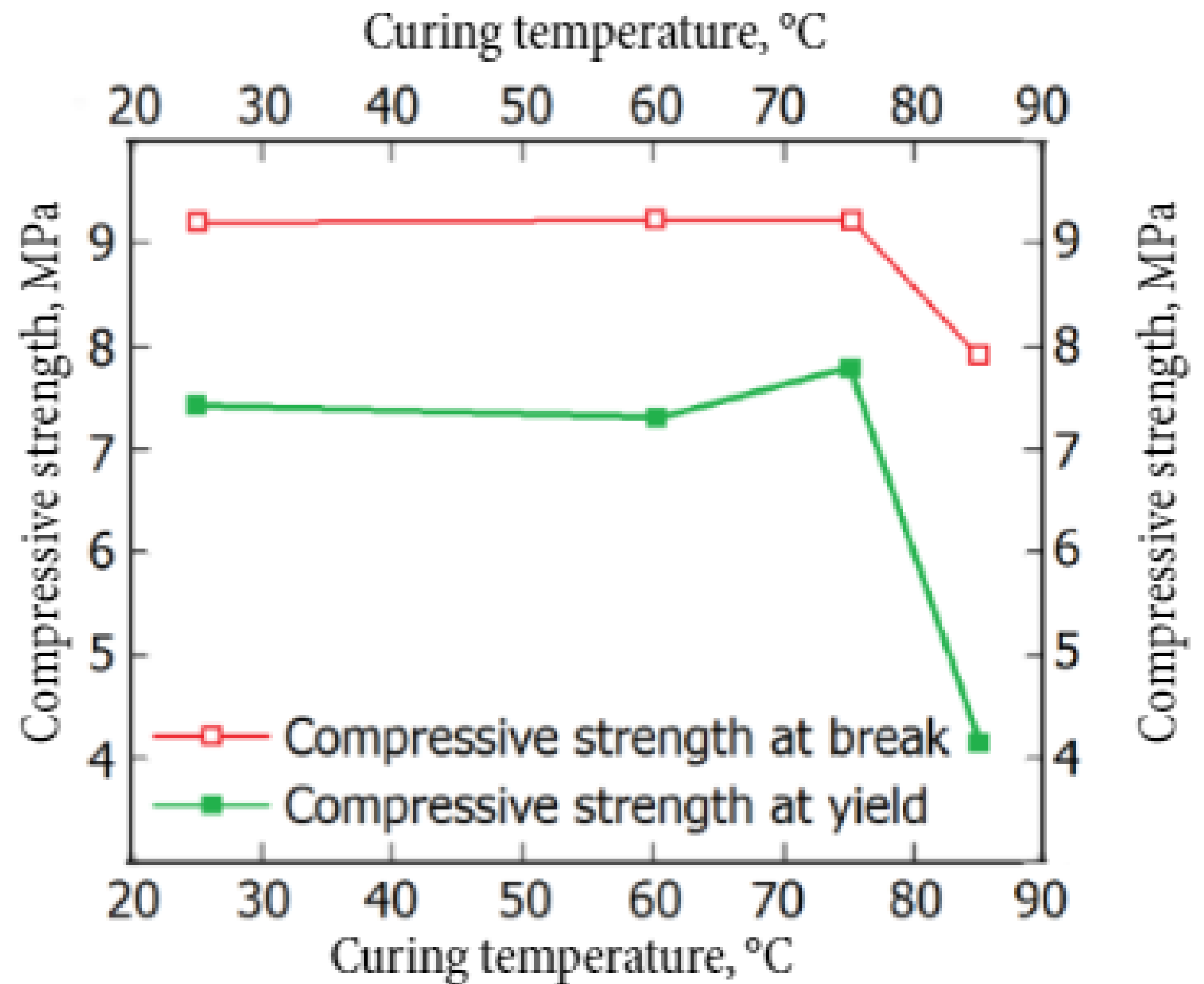
Relation between percentage of rubber to PU glue and compressive strength

65% rubber, 35% glue is perfect percentage according to Compressive strength



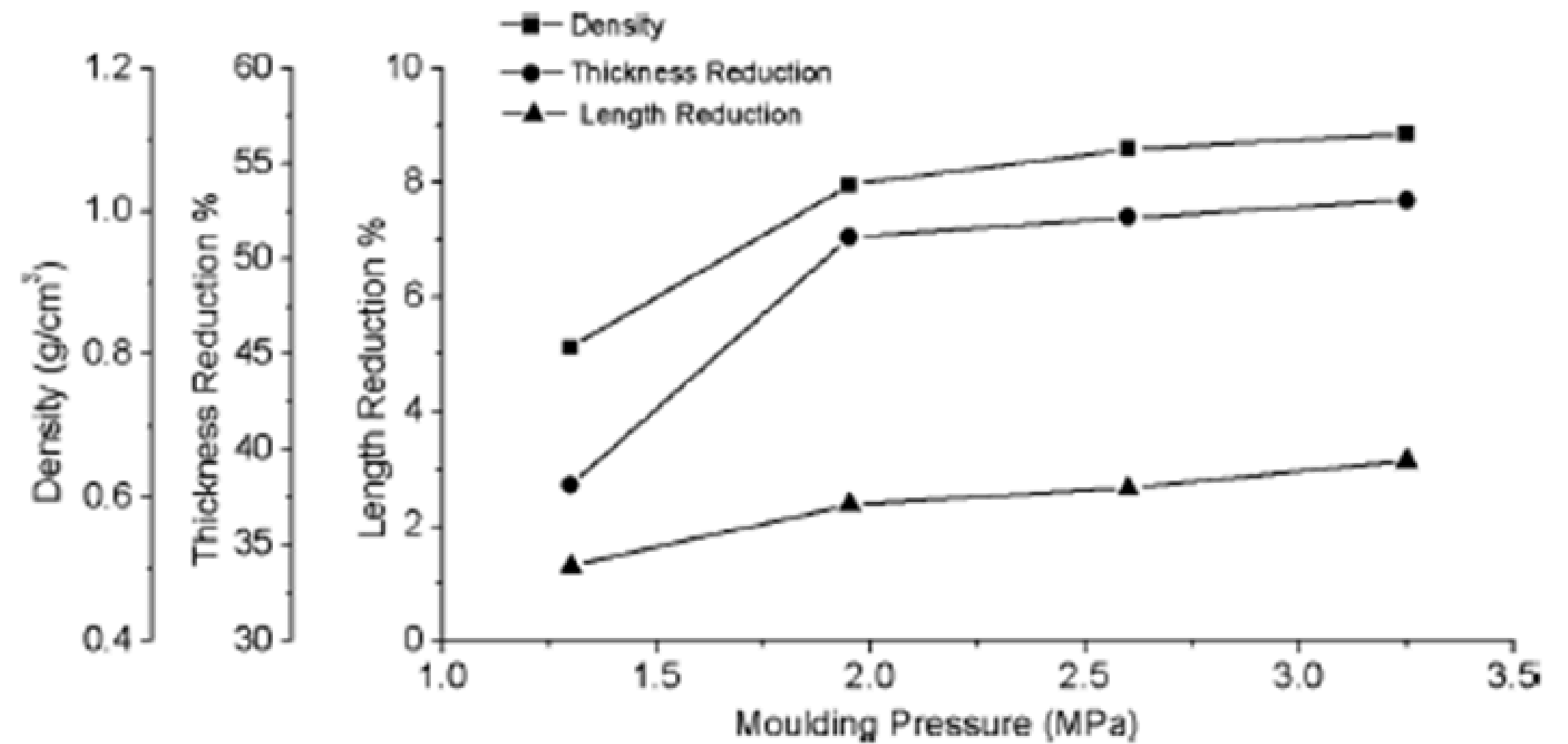
Relation between temperature and compressive strength

The best moulding temperature is about 75 °C, over that compressive strength decreases



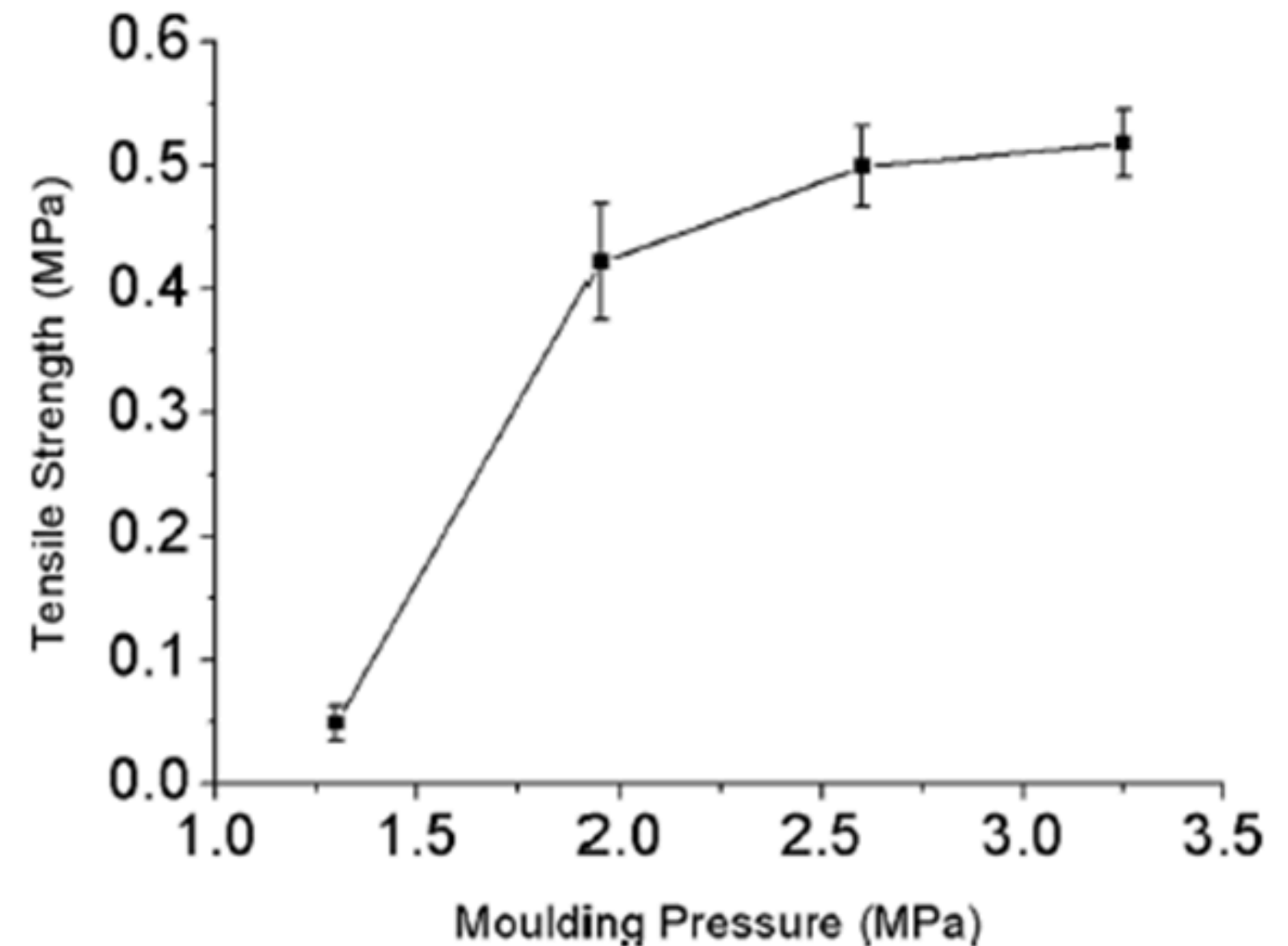
Relation between pressure, Density and thickness reduction

As pressure increase, Density increase and thickness decrease



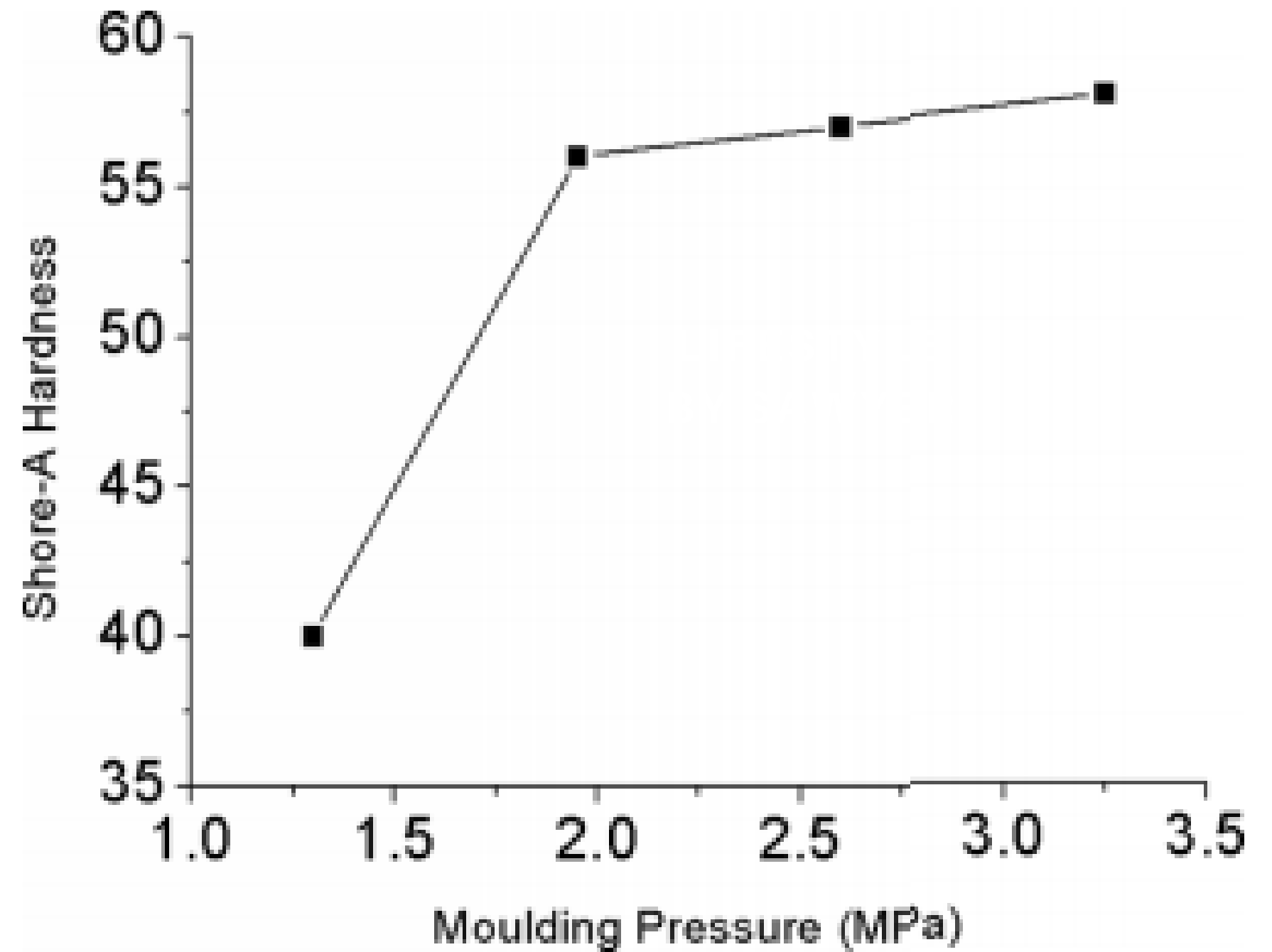
Relation between pressure and tensile strength

As Pressure increase, tensile strength increase, leading to good adhesion



Relation between pressure and Hardness

As Pressure increase, Hardness increase



Summary

- The Suitable pressure for molding tire is **3.5 Mpa**
 $F = PA = \mathbf{10.8 \text{ ton}}$

- The Suitable percentage of rubber is **60-65%**

- The Suitable molding temperature is **75 c**

- The Suitable percentage of glue is **35-40%**

Communication with chinese companies



According to
jucaimachine co.

The percentage of
PU glue : rubber
is
1:6 (17% : 83%)
It means one ton powder
need about 170 kg

The datasheet of the XLB-25T is as below table, from the datasheet you can see that this press is very small, normally for experiment use only. Not suitable to produce rubber tiles in bulk.

Clamping Pressure:	0.25MN(25Ton)
Unit Area Pressure:	20.41Kg/cm2
Daylight Opening:	220mm
Hydraulic Cylinder:	1pcs
Maximum Stroke of Plunger:	220mm
Working Layer Quantity:	1 Layer
Motor:	1pcs 2.2Kw Motor
Heating Available:	Type Electricity
Control Method:	Automatic Control Mold Open and Close,Manually Push and Pull Mold in and out
Temperature:	Max 200 ^o C for Electricity type
Weight:	About 800kgs
Production Time:	Lead 10-15Days

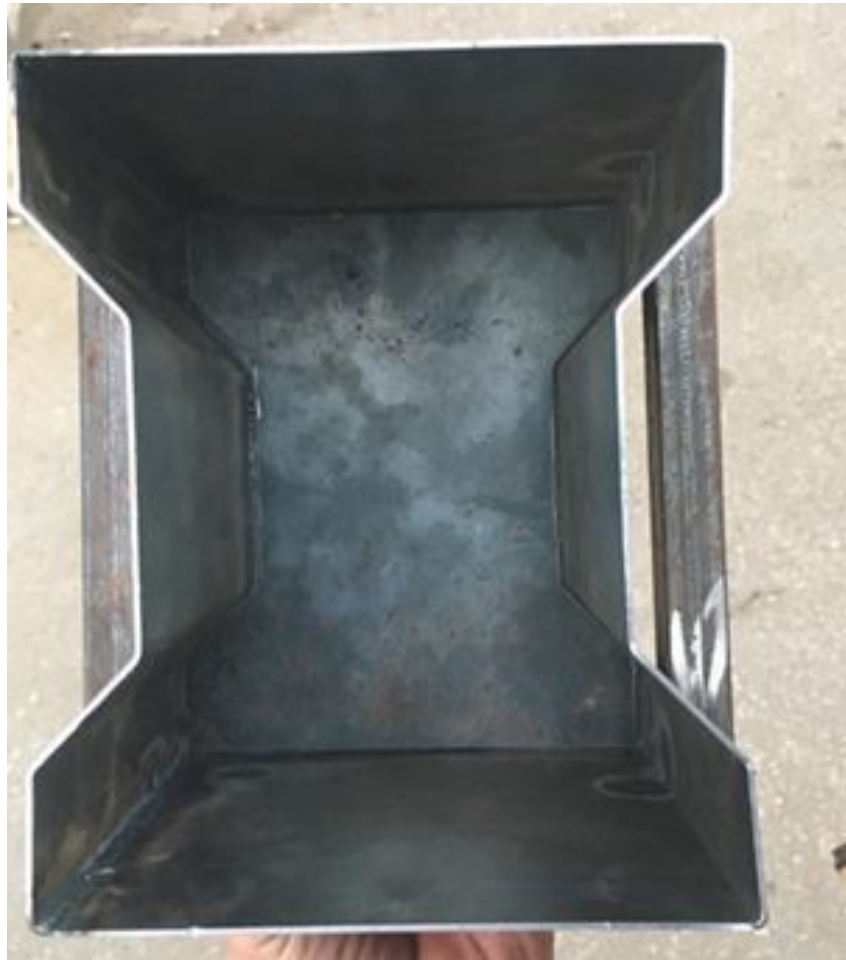
Datasheet of 25 ton machine from (JINGYUAN Group CO.,Limited)

From data sheet we
obtained unit Area
pressure=20.41
kg/square cm

$$F = f_s * A = 20.41 * 20 * 16.5 * 10 \\ = 67353 \text{ N} = 6.7 \text{ ton}$$

Due to conflict in components percentage
between research and manufacturing companies
and to ensure the validity of other parameters
we have to do **practical testing**

Design a Prototype Mold



1st Practical test

60% rubber- 40% glue



2nd Practical test

83% rubber - 17% glue

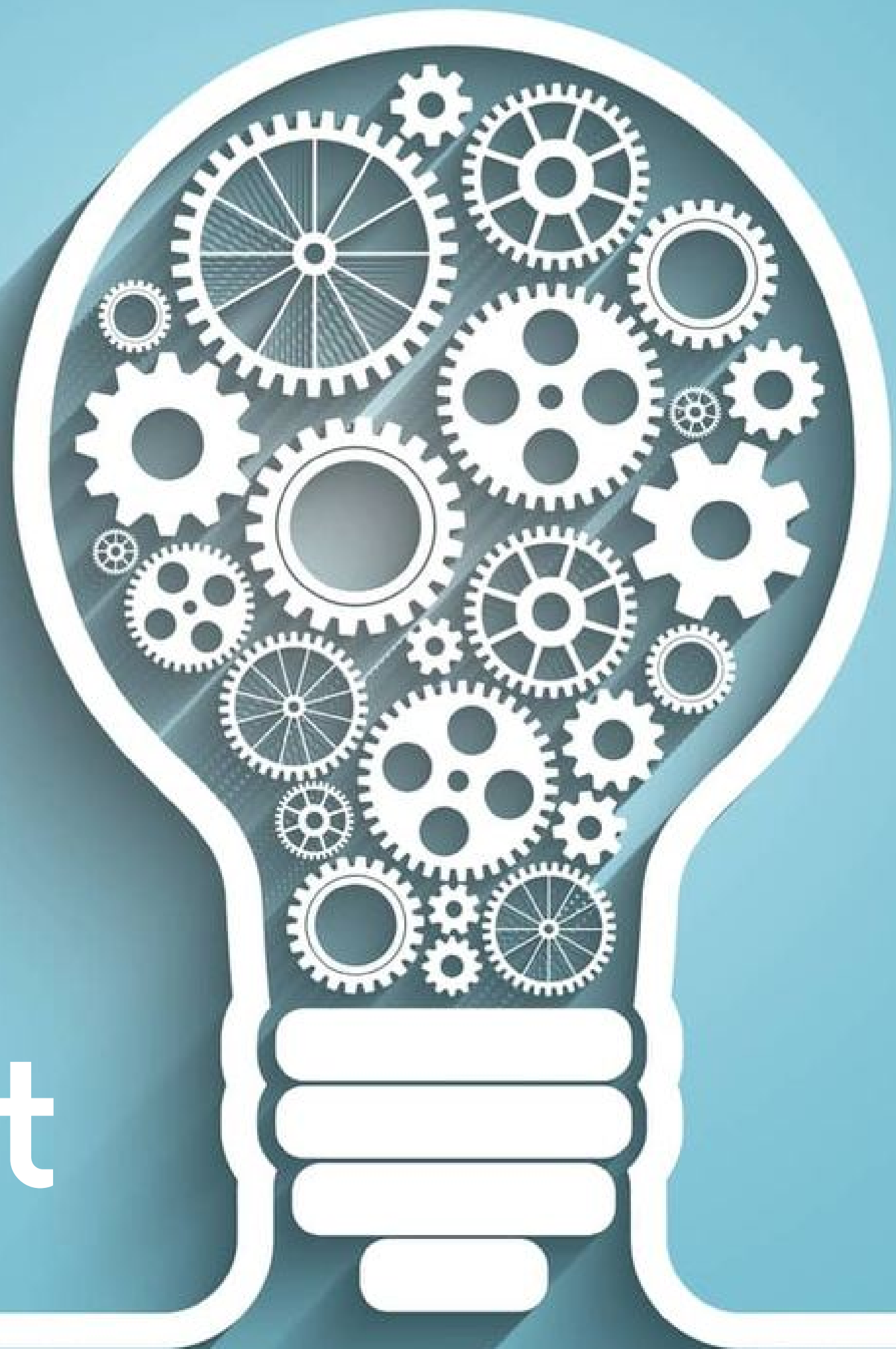


Conclusion

From tests

- Molding Force is 8 ton
- Molding temperature is 75 c
- Percentage of rubber to glue 6:1 (83% : 17%)

Mold Development



Mold Manufacturing



Steel block



Sheet metal

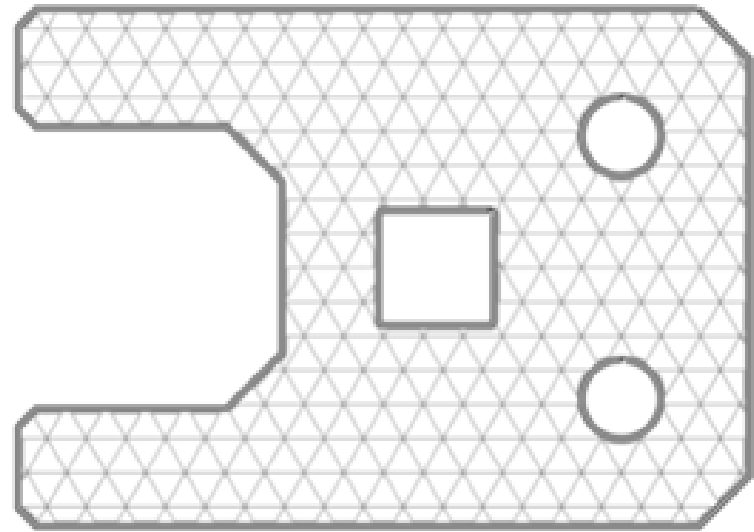
Mold Development

We have used the
3D printing technology

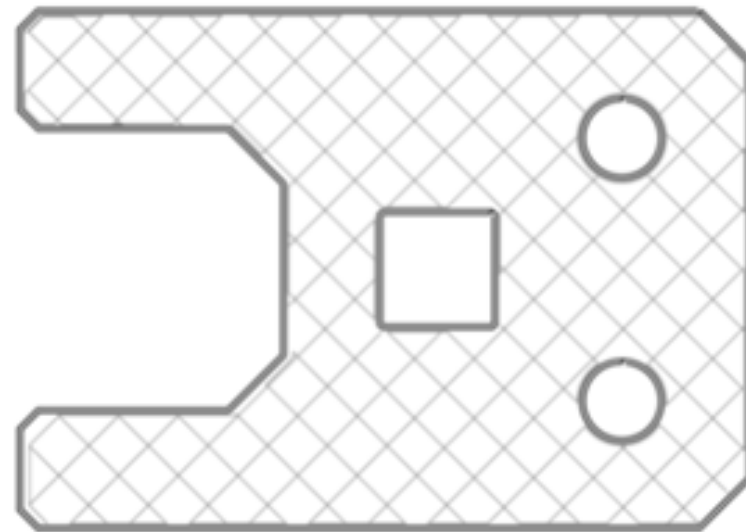
Mold Material

Material	Tensile strength (Mpa)	Bending stress (Mpa)	Melting Temperature (°C)	Heat Deflection Temperature (°C)
PLA	61-66	48-110	157-170	49-52 at 0.46 Mpa
Nylon	76	110	220	160 at 0.46 MPa
ABS	46	74	190-270	98 at 0.46 Mpa

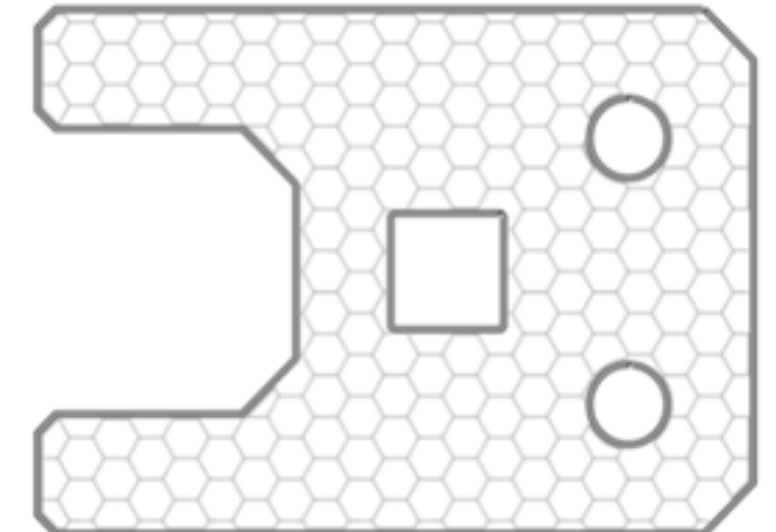
Mold infill types



Triangular infill

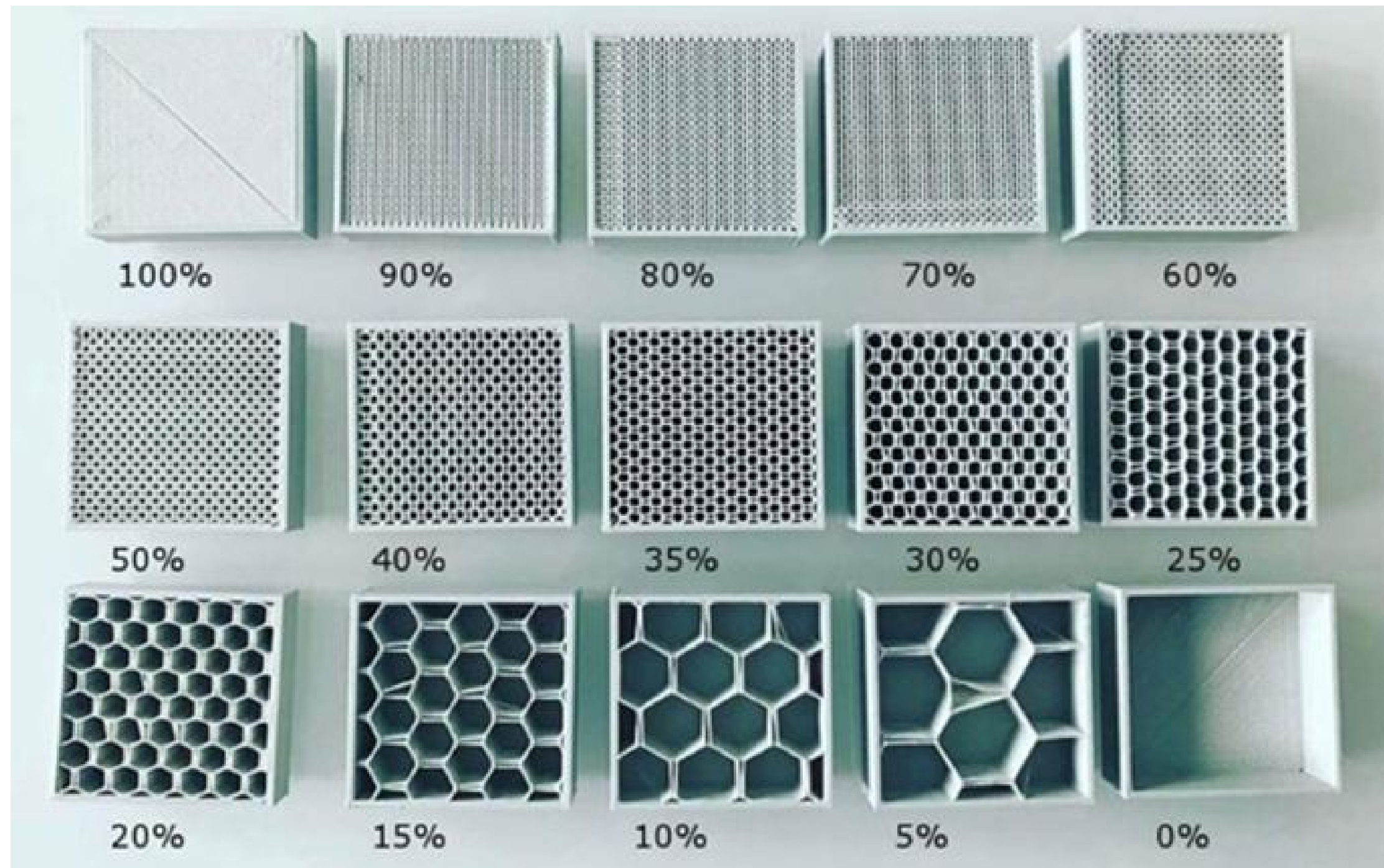


Rectangular infill

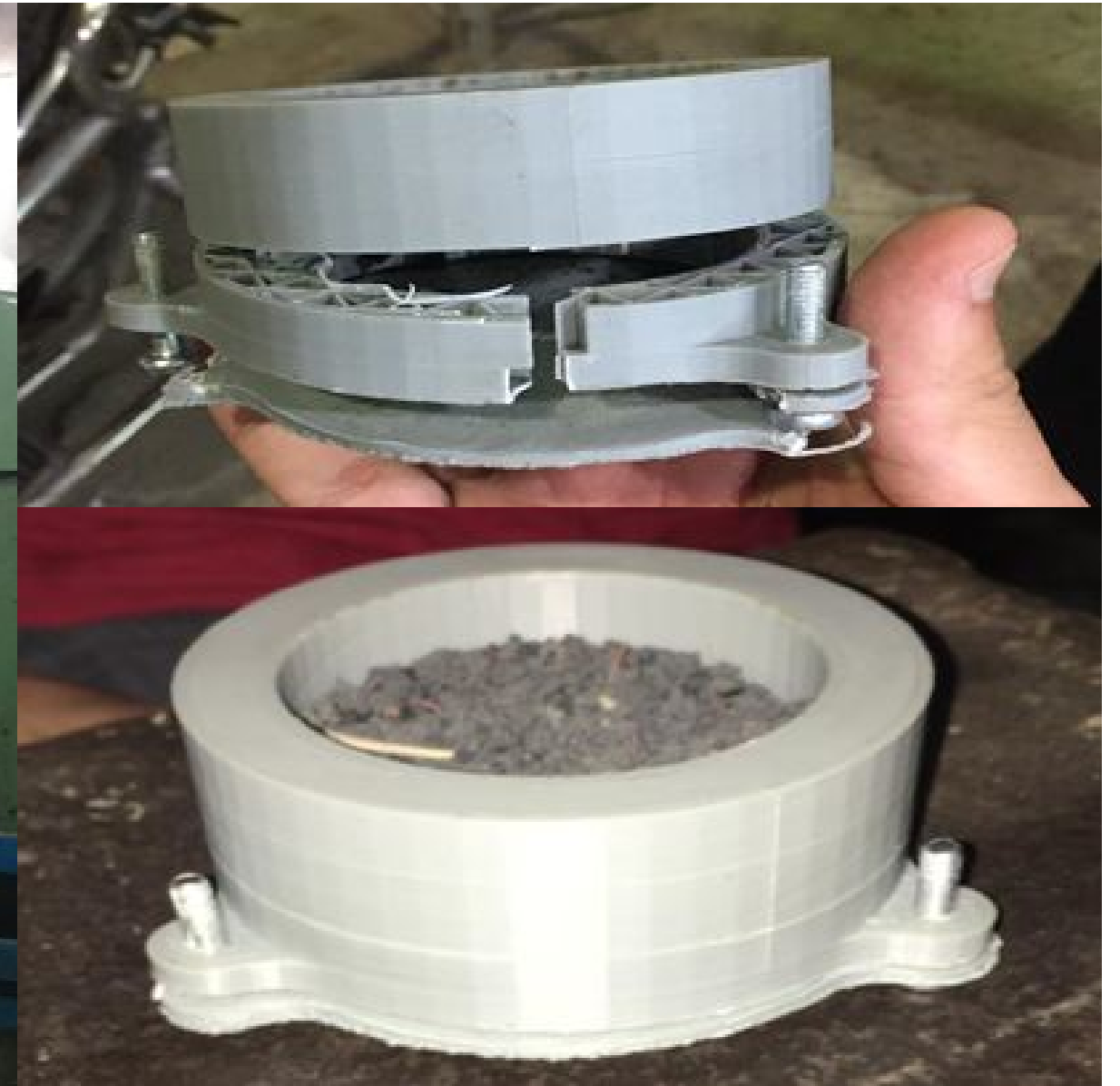


Hexagonal infill

Mold infill percentage



30% infill test

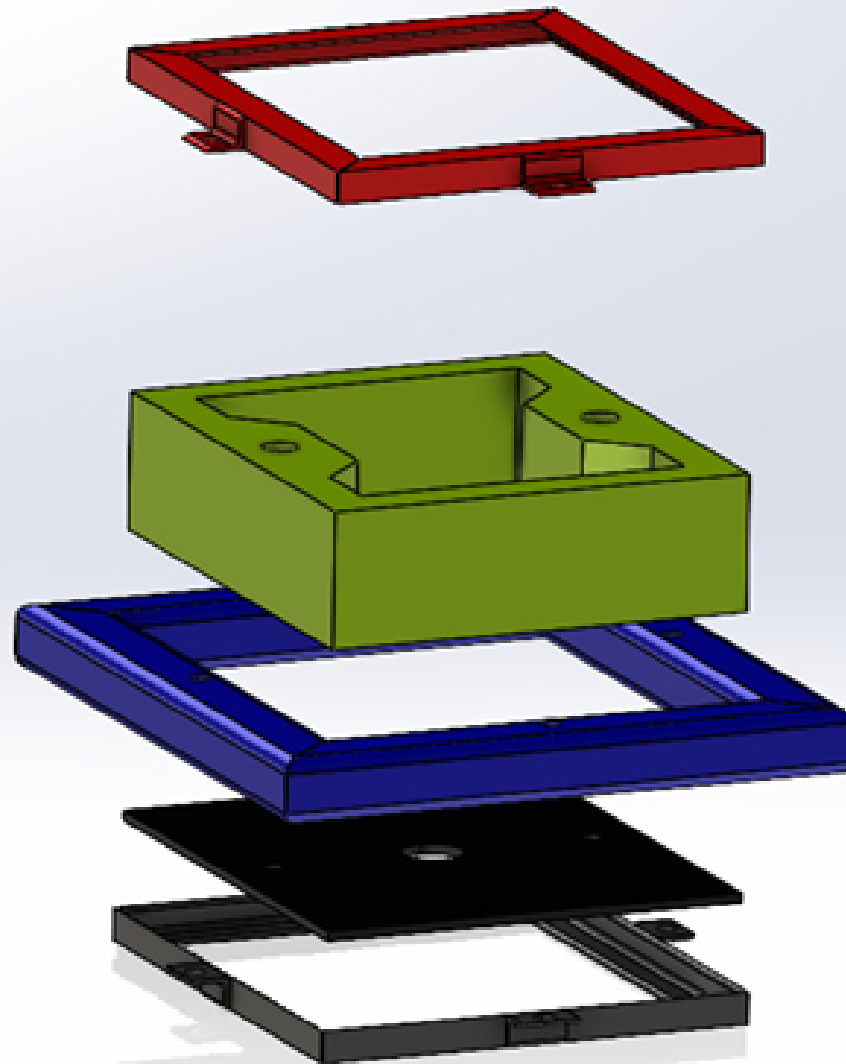
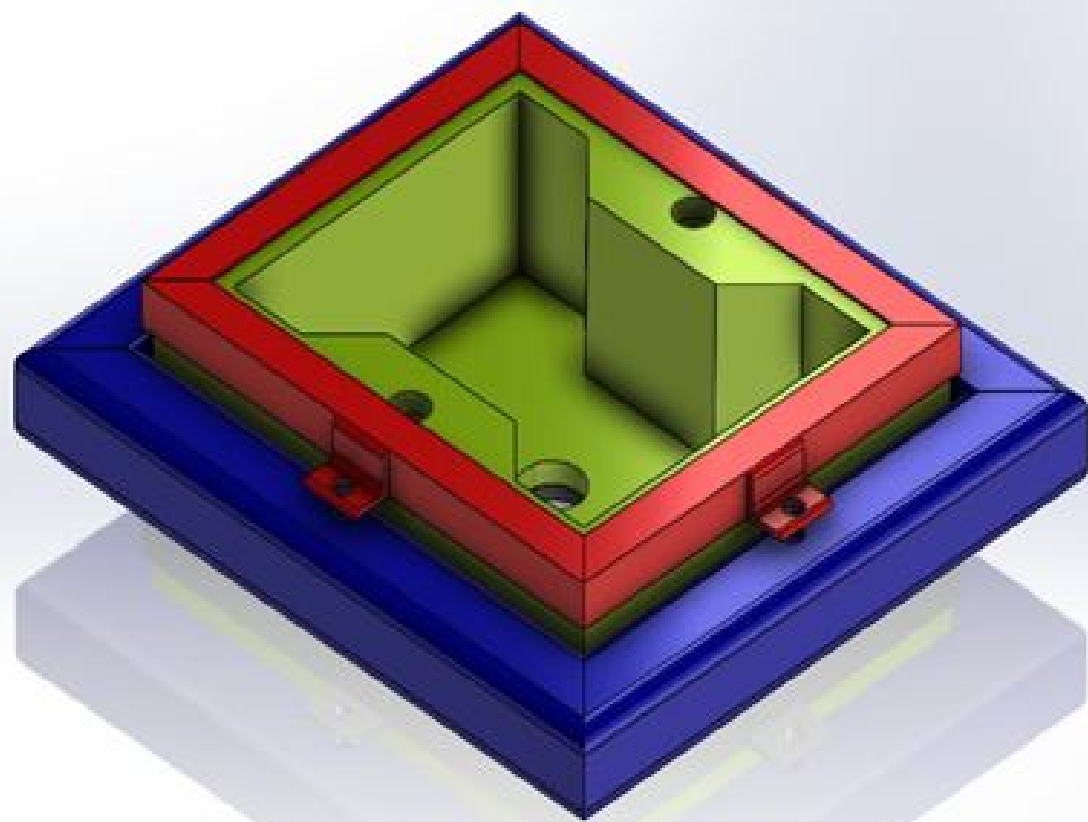


30% infill test



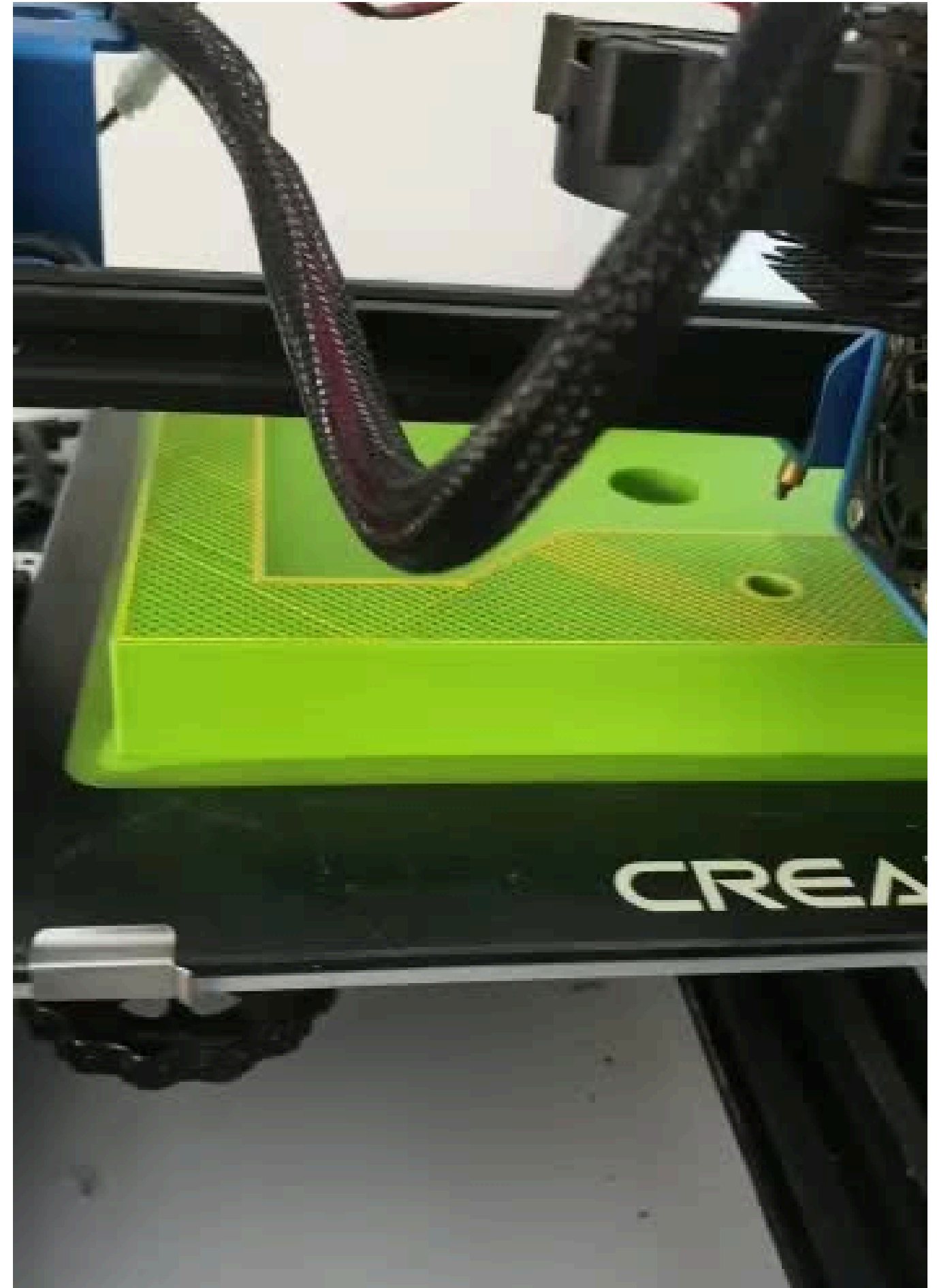
50% infill test

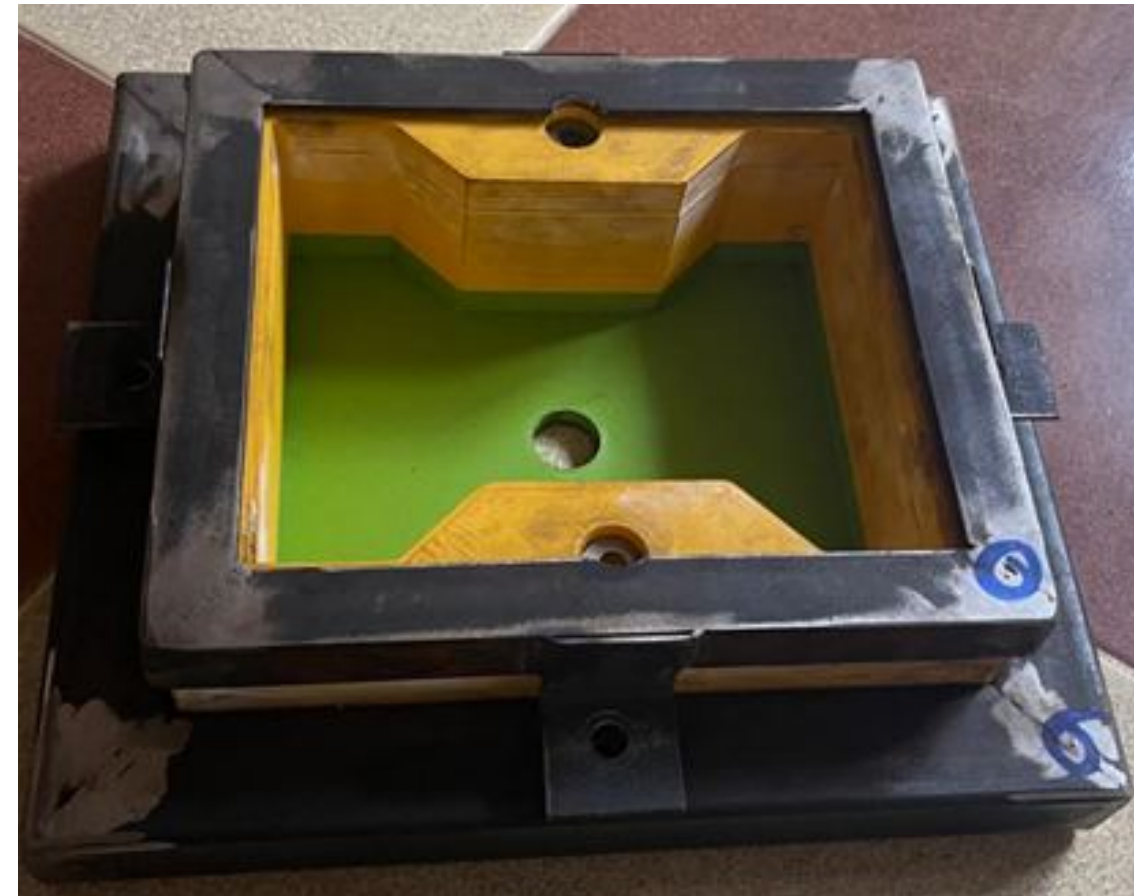
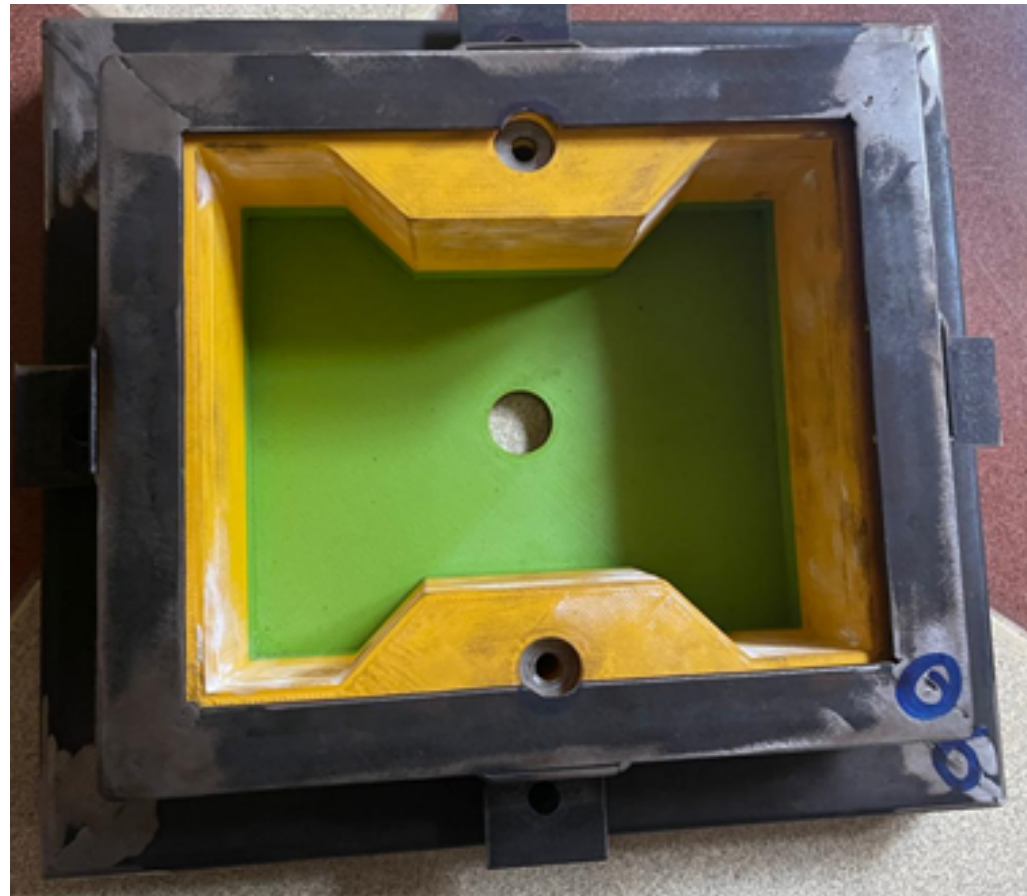




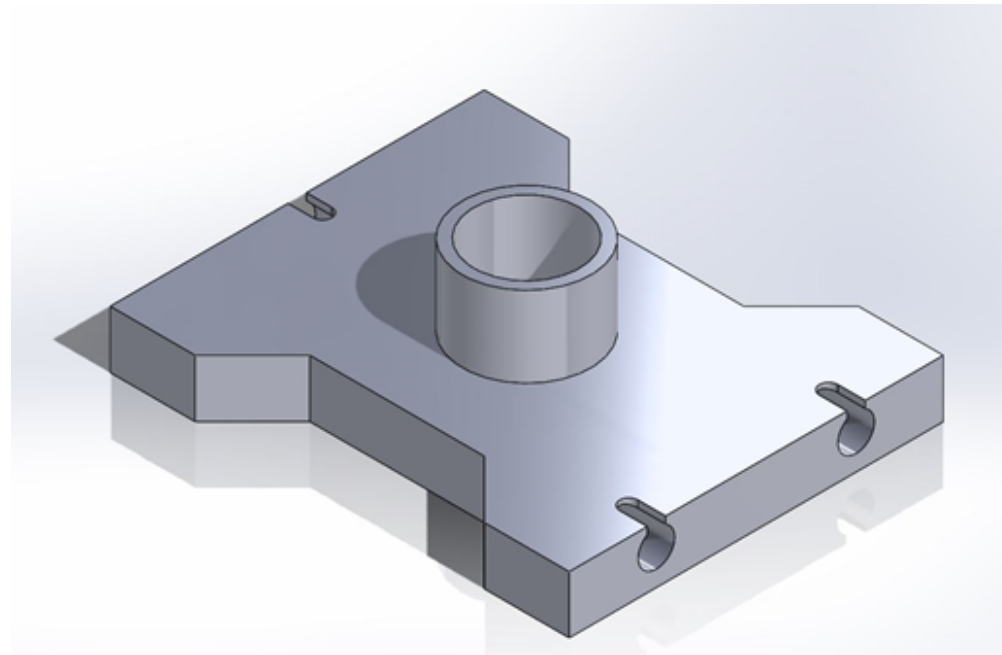
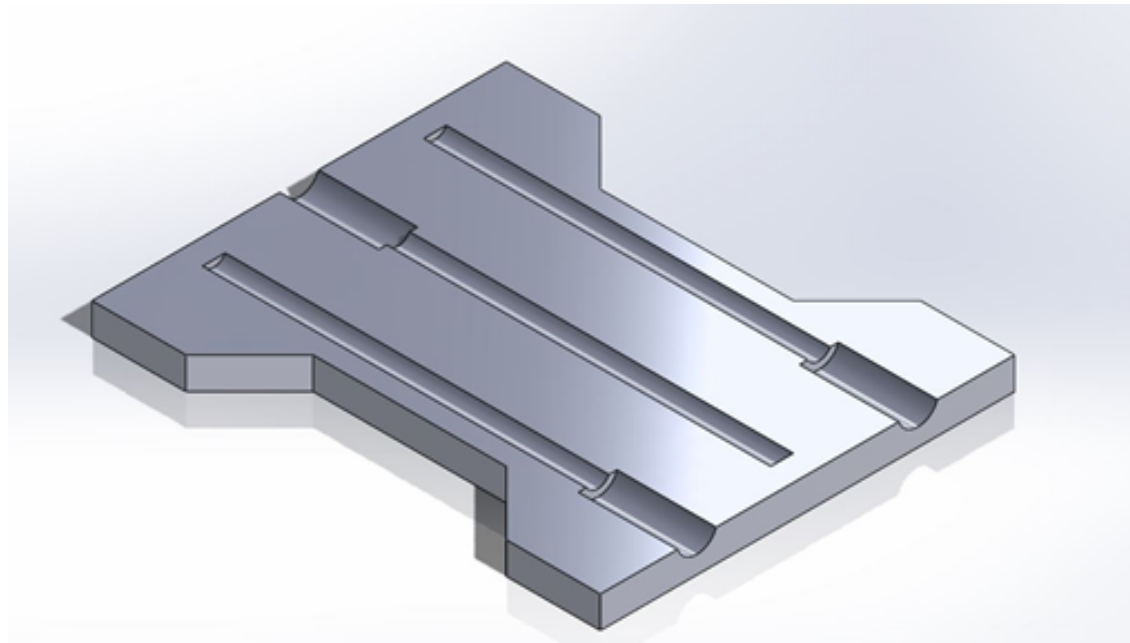
Final Mold Design

Mold Manufacturing





Final Mold
ABS Material
Triangular infill
60% infill



Final Mold
ST-37 Material
20mm Thickness
Laser cutting
3 heaters
400 Watt

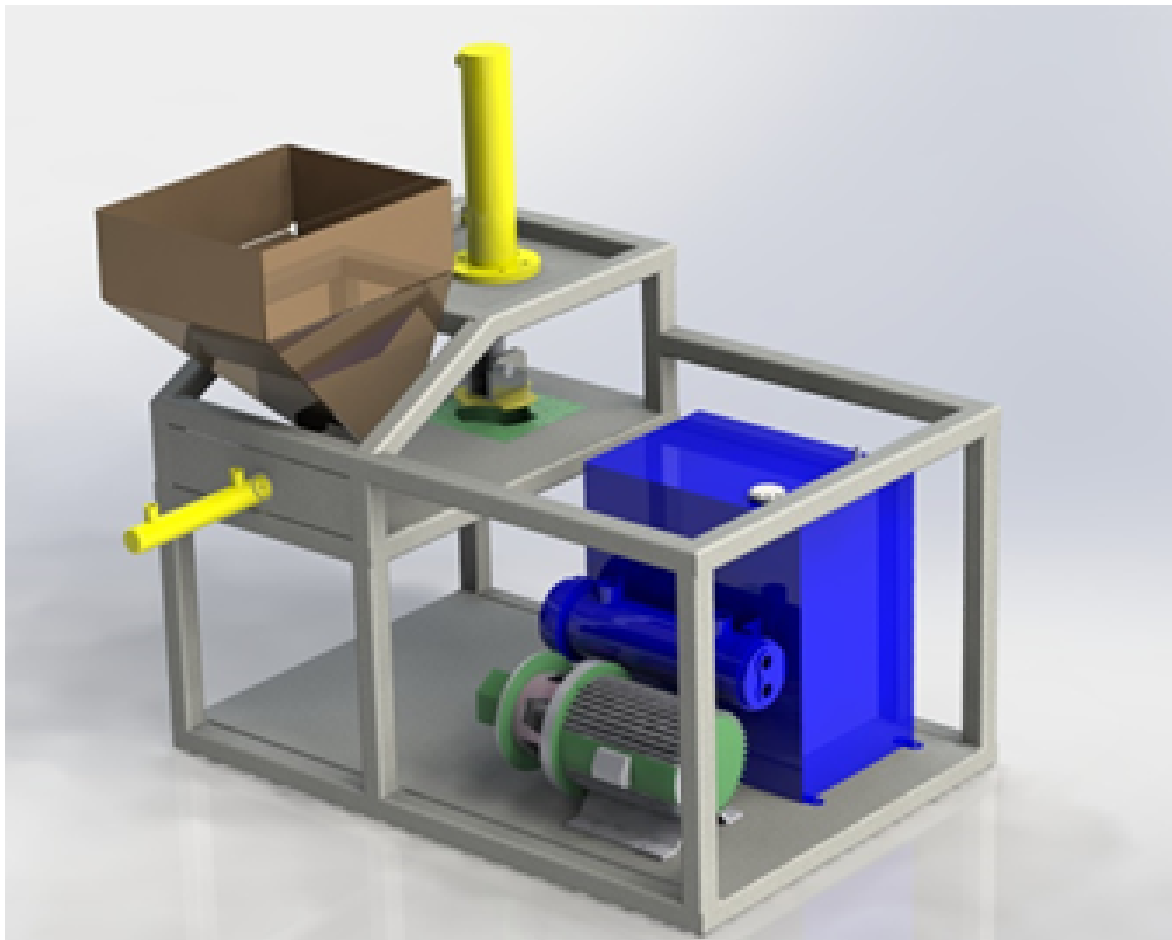
Machine Design



Design methodology

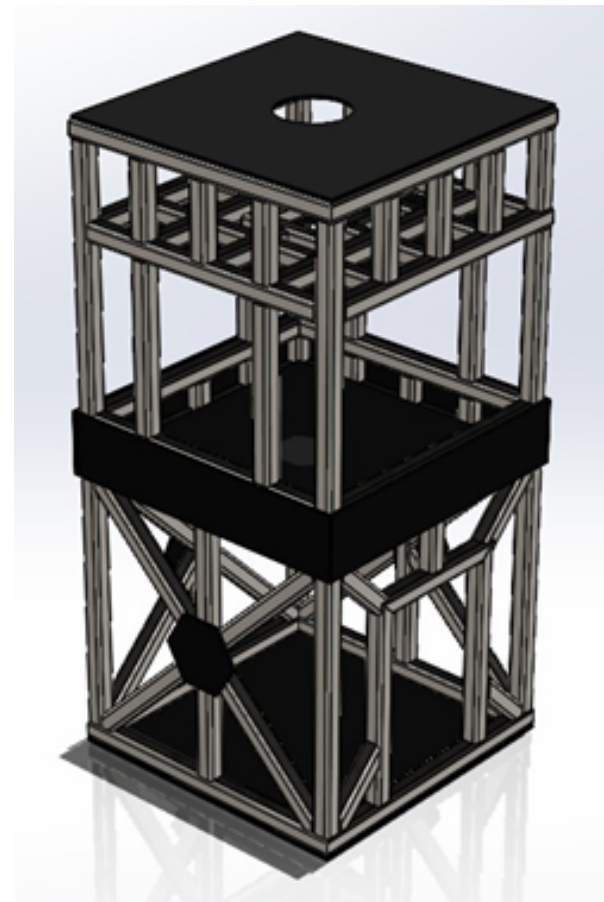
1. **Components Constrains**
2. **FEA**
3. **Empirical equations**
4. **Recommendations & Previous work**

Machine Versions



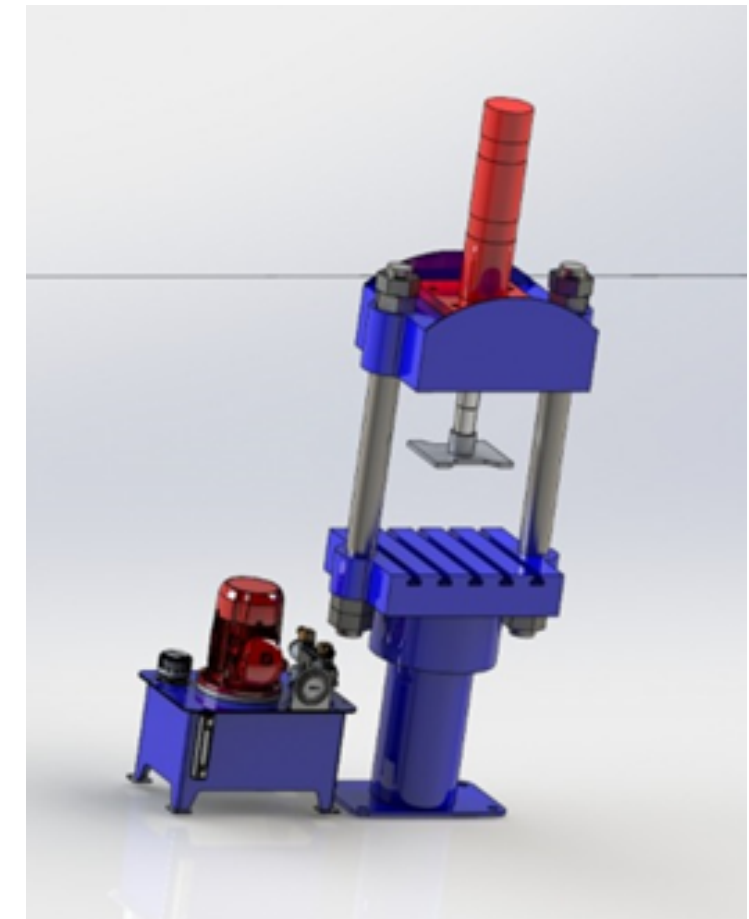
Version1

- High cost
- more options



Version 2

- low cost
- skill dependent



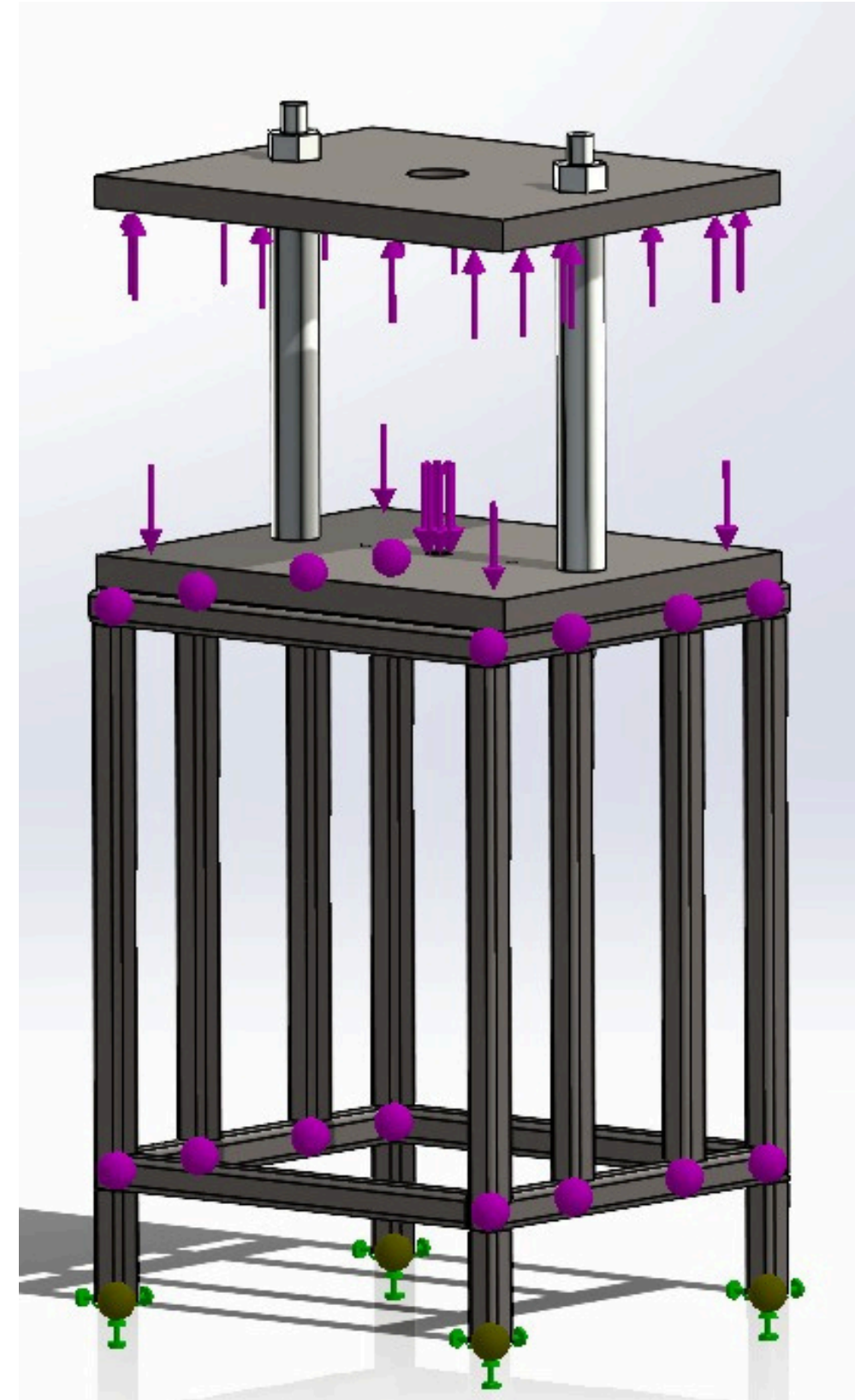
Version 3

- High cost
- reliable design

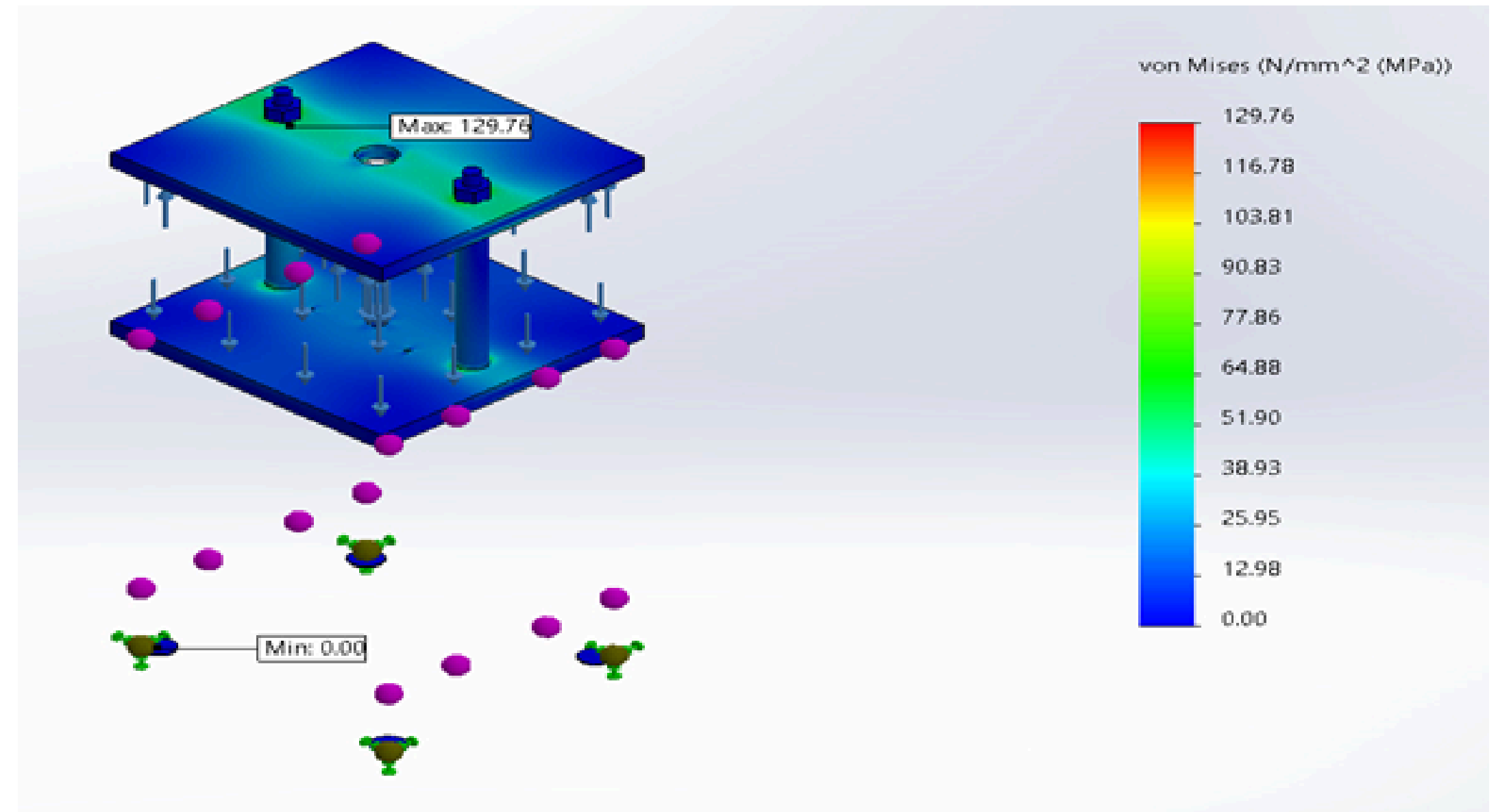


Final
Design

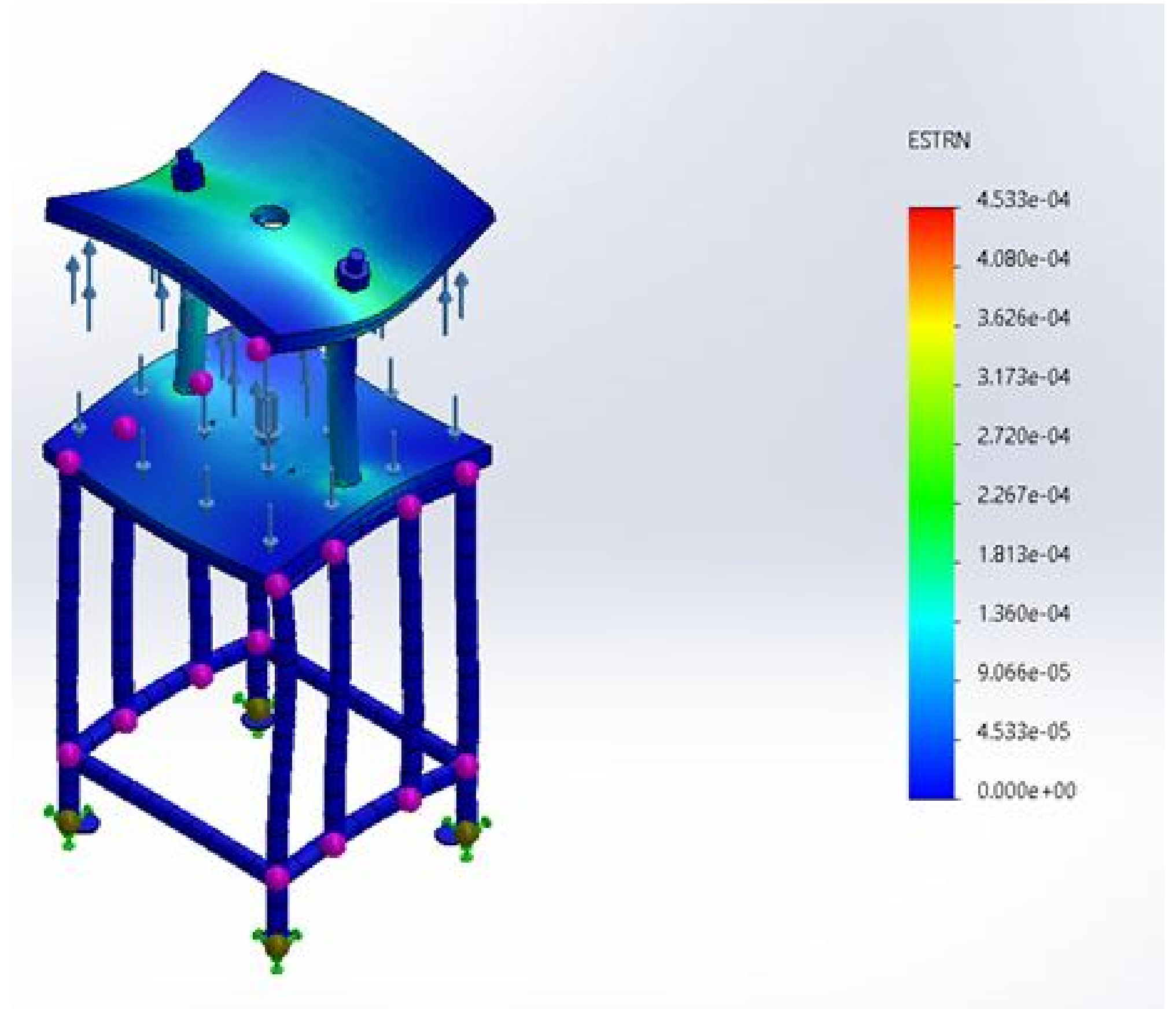
Stress Analysis



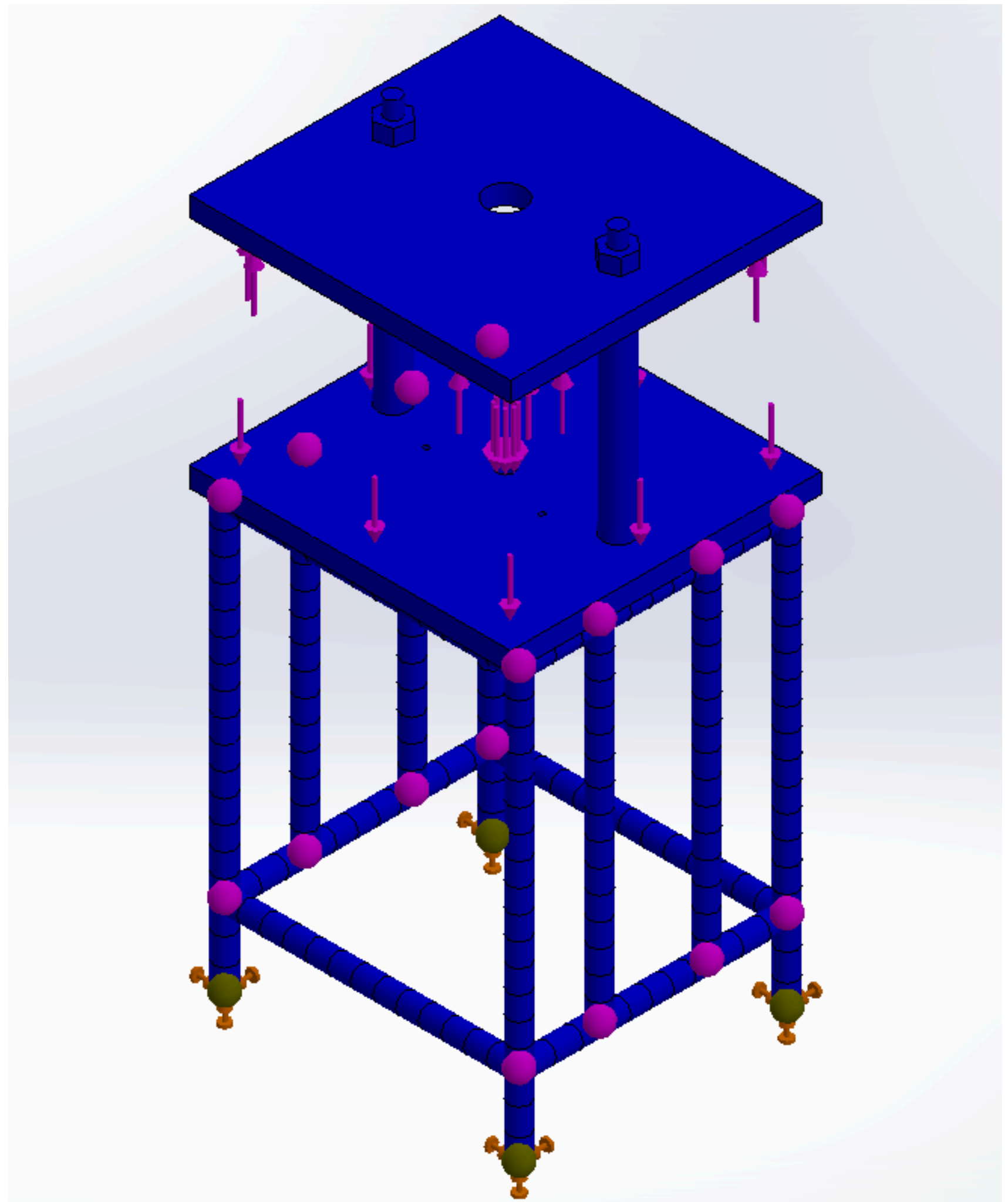
Maximum stress
acting on machine is
129.76 Mpa



Maximum Strain is
 $4.533\text{e-}04$



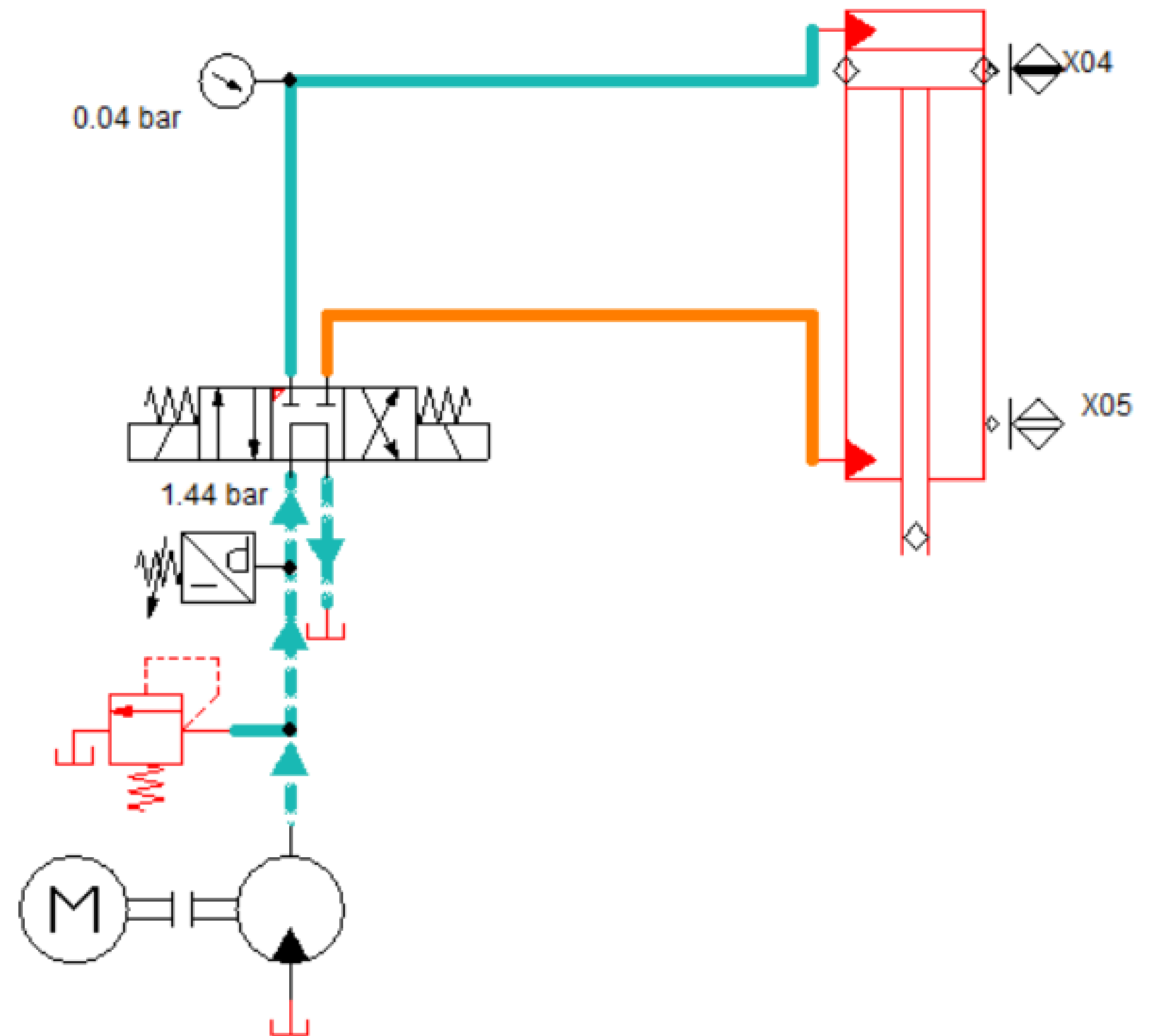
Factor of safety is
2.5



Hydraulic Design



Hydraulic Circuit Design

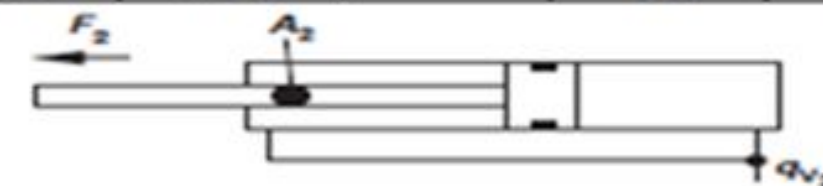
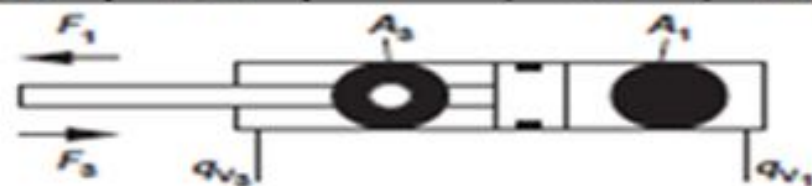


Hydraulic circuit design

Component	Equation	Selected Data
Cylinder	$F = P \cdot A_{\text{piston}}$	$P = 130 \text{ bar}$
		$A_{\text{piston}} = 78.54 \text{ cm}^2$
		$D_{\text{piston}} = 100\text{mm}$ $D_{\text{rod}} = 56\text{mm}$
Pump	$Q = V \cdot A_{\text{piston}}$	$V = 2 \text{ cm/sec}$
		$Q = 9 \text{ L/min}$ $V_g = 6.89 \text{ cm}^3$
		AZPW-1-008R
Electric motor	$P_{\text{electric}} = P \cdot Q \cdot F_s$	$P_{\text{electric}} = 3 \text{ KWatt} = 4\text{hp}$
Directional Control valve	4/3 DCV Type G	Size 6
Pressure relief valve	-	Set on 160 bar
Tank Volume	$\text{Volume} = (3:5) * Q$	Volume = 40 L

Cylinder selection

AL Ø mm	MM Ø mm	ϕ A_1/A_3	A_1 cm ²	A_2 cm ²	A_3 cm ²	F_1 kN	F_2 kN	F_3 kN	q_{v1} l/min	q_{v2} l/min	q_{v3} l/min
25	14	1,46	4,91	1,54	3,37	7,85	2,46	5,39	2,9	0,9	2,0
32	18	1,46	8,04	2,54	5,50	12,80	4,07	8,79	4,8	1,5	3,3
40	22	1,43	12,56	3,80	8,76	20,00	6,08	14,00	7,5	2,3	5,3
50	28	1,46	19,63	6,16	13,47	31,30	9,82	21,50	11,7	3,7	8,1
63	36	1,48	31,17	10,18	20,99	49,80	25,40	24,40	18,7	9,5	9,2
80	45	1,46	50,26	15,90	34,36	80,30	25,40	54,90	30,1	9,5	20,6
100	56	1,46	78,54	24,63	53,91	125,00	39,30	86,20	47,1	14,8	32,3
125	70	1,46	122,72	38,48	84,24	196,00	61,50	134,00	73,6	23,1	50,5
160	90	1,46	201,06	63,62	137,00	321,00	101,00	219,00	121,0	38,1	82,4
200	110	1,43	314,16	95,06	219,00	502,00	151,00	350,00	188,0	57,0	131,0
220	90	1,20	380,1	63,6	316	494 ³⁾	82,8 ³⁾	506	228	38,2	190
	100	1,26		78,5	301		102 ³⁾	482		47,1	181
	110	1,33		95,0	285		123 ³⁾	456		57,0	171
250	100	1,19	490,8	78,5	412	638 ³⁾	102 ³⁾	659	294	47,2	248
	110	1,24		95,0	396		123 ³⁾	633		57,0	238
	125	1,33		123	368		159 ³⁾	589		73,7	221
280	110	1,18	615,7	95,0	520	800 ³⁾	123 ³⁾	833	369	57,0	313
	125	1,25		123	493		159 ³⁾	788		73,7	296
	140	1,33		154	462		200 ³⁾	739		92,4	277
320	125	1,18	804,2	123	681	1045 ³⁾	159 ³⁾	1090	482	73,7	409
	140	1,24		154	650		200 ³⁾	1040		92,4	390
	160	1,33		201	603		261 ³⁾	965		121	362
360	140	1,18	1017,8	154	864	1323 ³⁾	200 ³⁾	1382	610	92,4	519
	160	1,25		201	816		261 ³⁾	1306		121	490
	180	1,33		254	763		330 ³⁾	1221		153	458
400	160	1,19	1256,6	201	1055	1633 ³⁾	261 ³⁾	1688	753	121	634
	180	1,25		254	1002		330 ³⁾	1603		153	602
	200	1,33		314	942		408 ³⁾	1507		188	566
450	180	1,19	1590,4	254	1335	2067 ³⁾	330 ³⁾	2136	954	153	801
	200	1,25		314	1276		408 ³⁾	2042		188	766
	220	1,33		380	1210		494 ³⁾	1936		228	726
500	200	1,19	1963,4	314	1649	2551 ³⁾	408 ³⁾	2639	1178	188	990
	220	1,24		380	1583		494 ³⁾	2533		228	950
	250	1,33		491	1472		638 ³⁾	2356		294	884



Rexroth

Pump selection

AZPW-1x				NG	004	005	008	011	014	016	019	022	
Displacement, geometric, per revolution				V_g	cm ³	4.0	5.5	8.0	11.0	14.0	16.0	19.0	22.5
Pressure in suction port		absolute	p_s	bar	0.7 to 3								
Maximum continuous pressure				p_1	bar	190	190	190	190	190	190	180	170
Maximum intermittent pressure				p_2	bar	210	210	210	210	210	210	200	190
Maximum pressure peak				p_3	bar	230	230	230	230	230	230	220	210
Minimum speed	at 12 mm ² /s and	< 100 bar	n_{min}	rpm	700	700	700	700	700	700	700	700	700
		100 to 180 bar		rpm	1200	1200	1000	1000	800	800	800	800	
		180 bar to p_2		rpm	1400	1400	1400	1200	1000	1000	1000	1000	
	at 25 mm ² /s and	p_2		rpm	700	700	700	700	700	700	700	700	
	Maximum speed	at p_2		n_{max}	rpm	3500	3500	3500	3500	3000	3000	3000	2500

Electric motor selection

TYPE	Rated Output		Full Load				Locked Current	Locked Torque	Max. Torque	Moment of Inertia	Weight kg
	Kw	Hp	Current in 400V A	Speed r/min	Eff %	Power Factor cos ϕ	Rated Current I_s/I_n	Rated Torque T_s/T_n	Rated Torque T_{max}/T_n	$J = 1/4GD^2$ kgm ²	
M 71 K 6	0.18	0.25	0.70	900	57	0.66	4.0	1.9	2.0	0.0011	14
M 71 G 6	0.25	0.33	0.90	900	60	0.68	4.0	1.9	2.0	0.0014	14.5
M 80 K 6	0.37	0.50	1.24	900	65.5	0.70	4.7	1.9	2.0	0.0016	15
M 80 G 6	0.55	0.75	1.70	900	68.2	0.66	4.7	1.9	2.1	0.0019	16
M 90 S 6	0.75	1	2.12	910	71	0.72	5.5	2.0	2.1	0.0033	19
M 90 L 6	1.1	1.5	2.98	910	73	0.73	5.5	2.0	2.1	0.0040	22
M 100 L 6	1.5	2	3.85	920	76	0.75	5.5	2.0	2.1	0.0082	32
M 112 M 6	2.2	3	5.36	935	79	0.76	6.5	2.0	2.1	0.0147	41
M 132 S 6	3	4	6.7	960	81	0.76	6.5	2.1	2.1	0.0343	53
M 132 M 6	4	5.5	8.8	960	82	0.76	6.5	2.1	2.1	0.0429	61
M 132 MX 6	5.5	7.5	11.7	960	84	0.77	6.5	2.1	2.1	0.0543	70
M 160 M 6	7.5	10	15.9	970	86	0.77	6.5	2.0	2.1	0.1003	101
M 160 L 6	11	15	22.4	970	87.5	0.78	6.5	2.0	2.1	0.1336	120
M 180 L 6	15	20	29.2	970	89	0.81	7.0	2.0	2.1	0.2332	170
M 200 L 6	18.5	25	35.8	970	90.0	0.81	7.0	2.1	2.1	0.3532	187
M 200 LX 6	22	30	41.90	970	90.1	0.83	7.0	2.1	2.1	0.3401	210
M 225 M 6	30	40	55.50	980	91.5	0.84	7.0	2.0	2.1	0.5793	288
M 250 M 6	37	50	66.90	980	92.0	0.86	7.0	2.1	2.1	0.9524	367
M 280 S 6	45	60	81.10	980	92.5	0.86	7.0	2.1	2.0	1.31	483
M 280 M 6	55	75	98.10	980	92.8	0.86	7.0	2.1	2.0	1.54	550
M 315 S 6	75	100	133.2	990	93.5	0.86	7.0	2.0	2.0	3.55	930
M 315 M 6	90	125	158.70	990	93.8	0.86	7.0	2.0	2.0	4.17	950
M 315 L 6	110	150	192.2	990	94.0	0.86	6.7	2.0	2.0	5.10	1092
M 315 LX 6	132	180	230.2	990	94.2	0.87	6.7	2.0	2.0	6.17	1150
M 355 M 6	160	220	276.5	990	94.9	0.88	6.7	1.9	2.0	7.29	1550
M 355 MX 6	200	270	346.4	990	94.7	0.88	6.7	1.9	2.0	8.67	1600

M Motor

Direction control valve selection

RE 23 163/09.99

Replaces: 02.99



4/3, 4/2 and 3/2 directional valves
with wet pin DC solenoids,
Type WE 6 ../.S

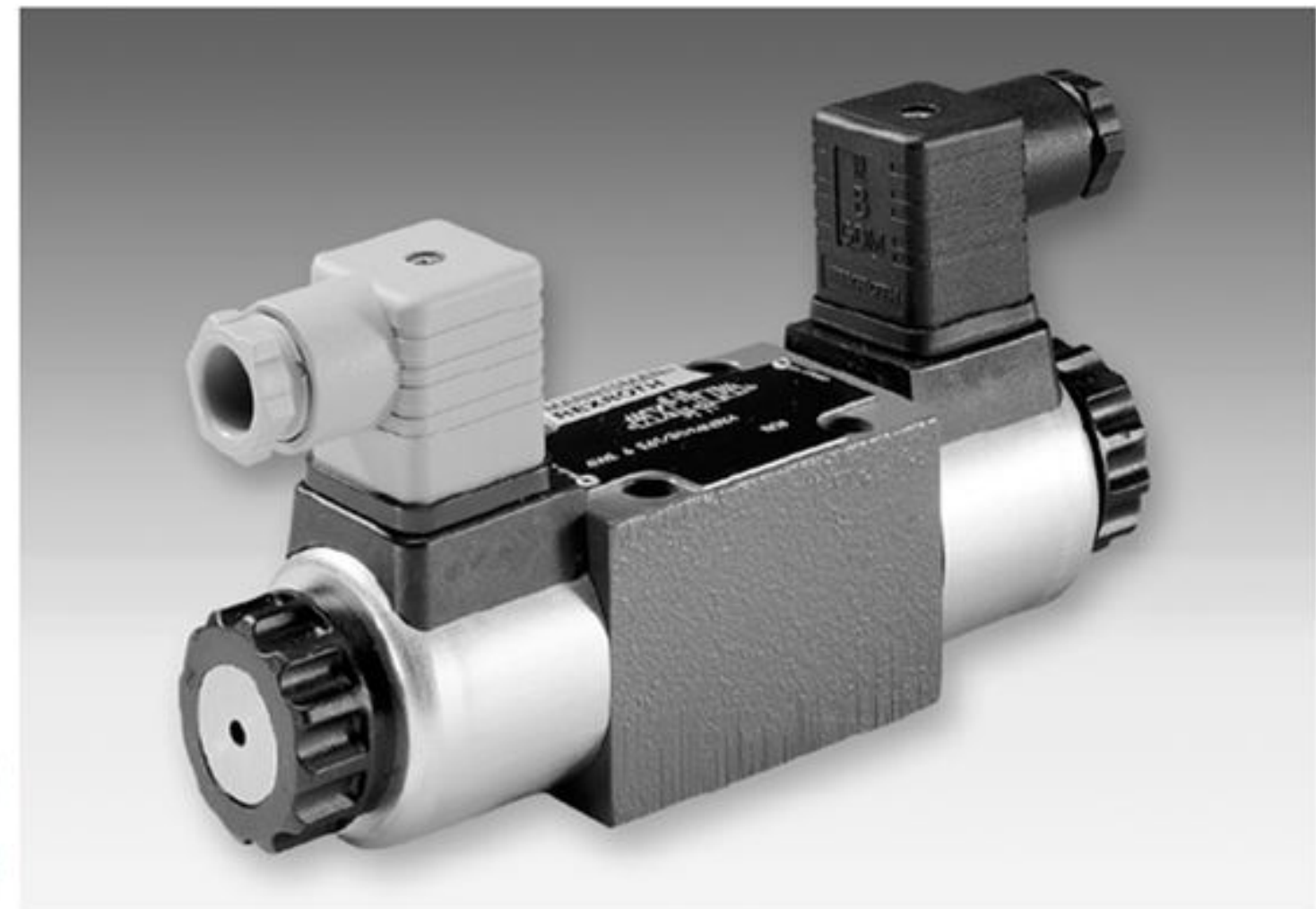
Nominal size 6

Series 6X

Maximum operating pressure 315 bar

Maximum flow 60 L/min

Standard industrial valve



H5911/98

Type 4WE 6 E6X/SG24N9K4/V with plug-in connector

Rexroth

Relief valve selection

RE 25 402/03.98

Replaces: 08.97



**Pressure relief valve,
direct operated,
Type DBD**

Nominal sizes 6 to 30

Series 1X

Maximum operating pressure 630 bar

Maximum flow 330 L/min

H/A 5585/96 •



Type DBD...1X/...

Rexroth

Tiles Tests



Pill Flammability Test

This test detect the affect of spreading flame from a small ignition source such as a dropped match



Pill Flammability Test

Method:

Taking 8 samples each sample subjected to source of ignition such as electrically heated nut then detect the diameter of nut effect which must be less than 25mm to pass this test



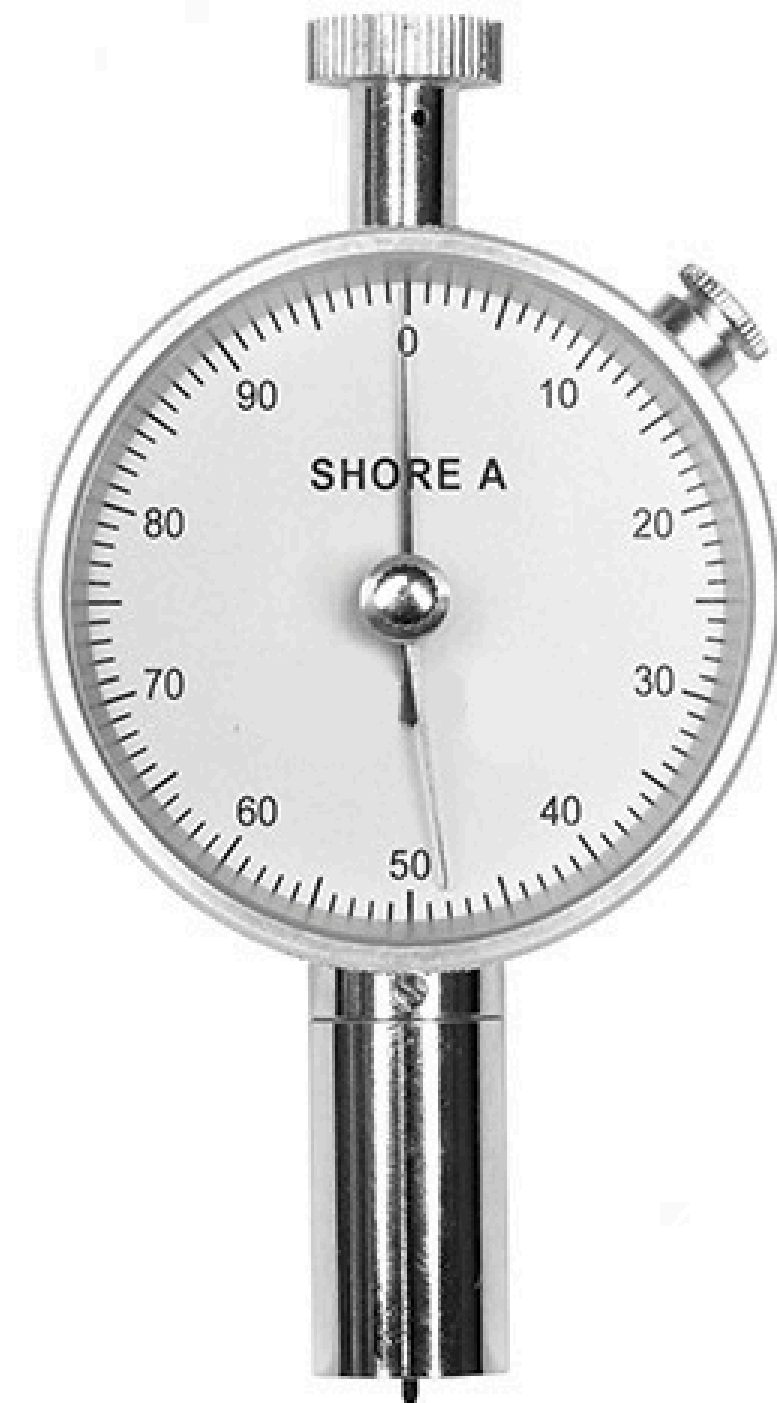
Skid Resistance Test

Check skid resistance under variable condition such as wet or dry floor using British pendulum device to determine the coefficient of friction



Hardness Shore Test

This test used to detect the hardness of tile using durometer which have range from 0-100 SHORE A



Compression Test

This test is done to know the maximum load applied that our tile cannot stand against it

Cost Estimation



Productive Machine

Productivity= 16tile/operation

1 operation take 8 minute

ABS Mold



Hydraulic system cost

Hydraulic cylinder cost

Cylinder (double acting)		
Diameter	160mm (less cost)	200mm (more safety)
Cost (\$)	382.9	510.5

Hydraulic system cost

Hydraulic equipment cost

Equipment	Cost (\$)	
	Made in china (<u>yuken</u>)	Made in Germany (Rexroth)
Hydraulic unit	1062.8	1758.7

Mold cost

Equipment	Fixed cost (\$)	Material cost (\$)
3-D printing Machine	1500	480

Frame cost

Equipment	Cost (\$)
Frame 2.3*1.81*1.96m	3829

Total Cost

(7254.7\$ - 8078.2\$).

References

- <https://www.wamda.com/memakersge/2016/06/rubber-a-hot-commodity-for-egypt-startup-retyres#:~:text=Egypt%20creates%2020%20million%20waste,most%2010%20percent%20is%20recycled>.
- **Chang, L.T., Tsai, K.H. and Shiau, J.S., 2004.** Experimental Evaluation of The Impactabsorption Properties of Rubber Tiles for The Playground. Biomedical Engineering: Applications, Basis and Communications, 16(05), pp.244-250.
- **Strøbech, C., 1990.** Polyurethane adhesives. International Journal of Adhesion and Adhesives, 10(3), p.127
- **Strakšys, A., Valsiūnas, I., Stalnionis, G., Eicher-Lorka, O., Kuodis, Z., Bražinskienė, D., Jukna, A. and Asadauskas, S., 2018.** Influence of polyurethane adhesives on tensile and compressive properties of ground rubber composites. Chemija, 29(2).
- **Lucignano, C., Gugliemotti, A. and Quadrini, F., 2012.** Compression moulding of rubber powder from exhausted tyres. Polymer-Plastics Technology and Engineering, 51(4), pp.340-344.

References

- https://jucaimachine.en.alibaba.com/company_profile.htmlspm=a2700.galleryofferlist.normal_offer.3.45ba429cpW1syz
- <https://shanzhongcgf.en.ecplaza.net>
- **Manufacturing, S.D., 2016.** 3D Printing Materials: Choosing the Right Material for Your Application. Resource URL: https://www.stratasysdirect.com/content/white_papers/S TR_7463_15_SDM_WP_3D_MATERIALS.PDF.
- <https://markforged.com/resources/learn/design-for-additive-manufacturing-plastics-composites/understanding-3d-printing-strength/3d-printing-settings-impacting-part-strength>
- <https://knowledgebank.materialbank.com/terms/astm-d2859-flammability/>

Thank you!

Any Questions ?