Design And Fabrication of Economical Plastic Injection Molding Machine

Under The Valuable Guidance of
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Group No:-27

Team No:-24255

OUTLINE

- Project definition
- Purpose of project
- Project background
- Working principle
- Plastic materials
- Work flow and plan work
- Literature review
- Required parts
- Design calculation of parts

- Part drawing
- Various problems and solutions
- ANSYS analysis
- Advantages
- Future scope
- Conclusion
- References

PROJECT DEFINITION

- For small scale industry the requirement of semiautomatic plastic injection machine demand with low cost day by day increasing so there is need of solution so our project is based on design and development of economical plastic injection molding machine for small industry.

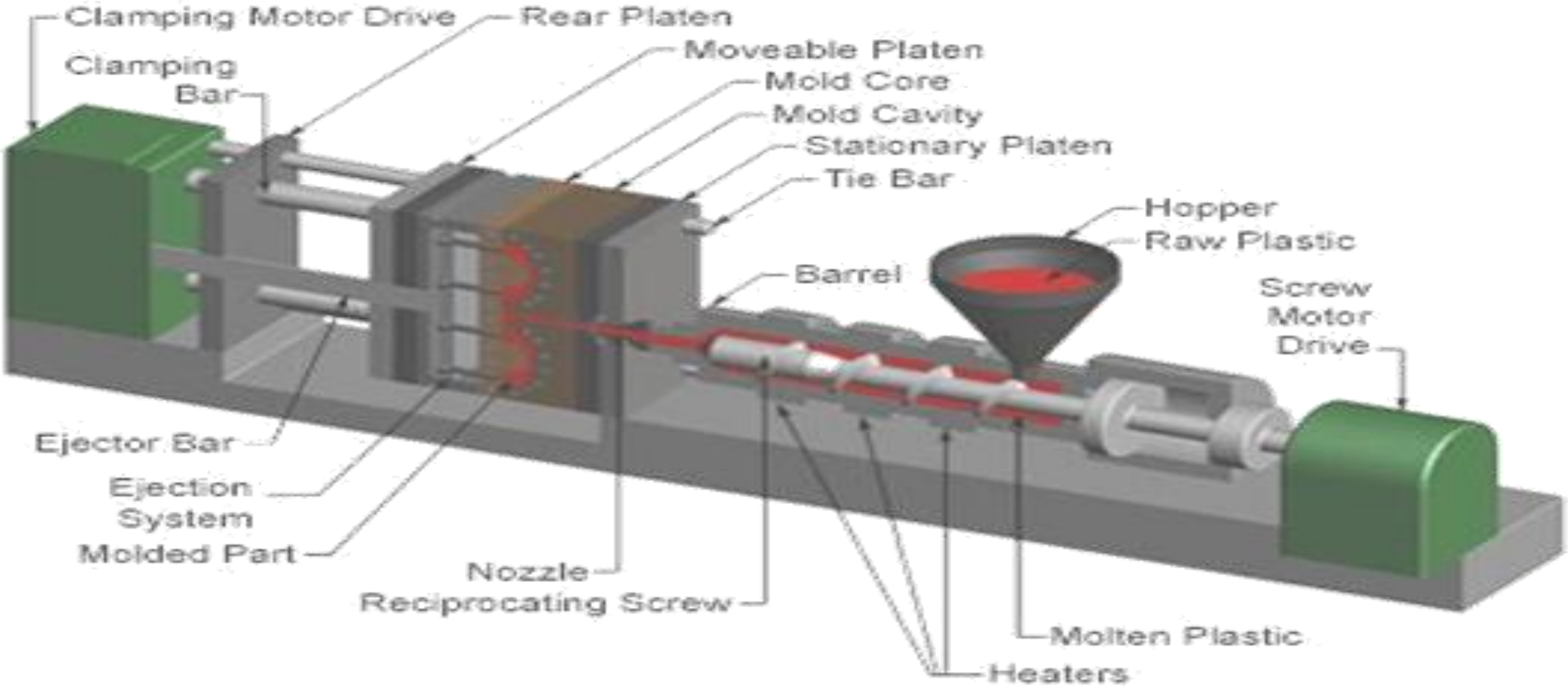
WHY WE HAVE CHOOSEN THIS PROJET

- High cost of machine for small scale industries
- Use for small scale industries
- Small and complex part produce
- Less electricity consumption
- Less space requirement
- Improve production rate
- Competitively less operation cost

PROJECT BACKGROUND

- Now a days there are many methods to develop plastic parts like bottle caps, mobile phone parts, electronic housings, containers, automotive interiors and most other plastic products.
- Molding process are industrial process in which plastic parts are created by injection of molten metal in mould.
- In the study of molding process the output quality is rather important. A significant improvement in output quality may be obtained by machine which we are going to be develop.
- We reduce the machine cost by developing this machine. In project we gather lots of important information from research papers and patents. According to that research we design different components of machine.

WORKING PRINCIPLE

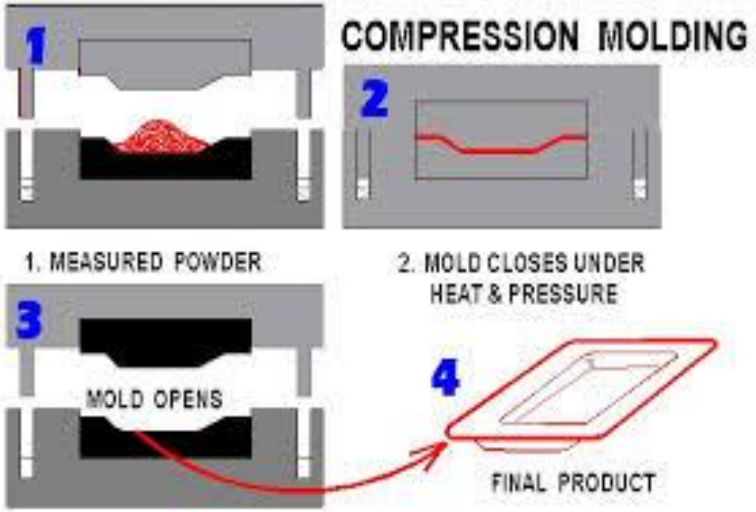


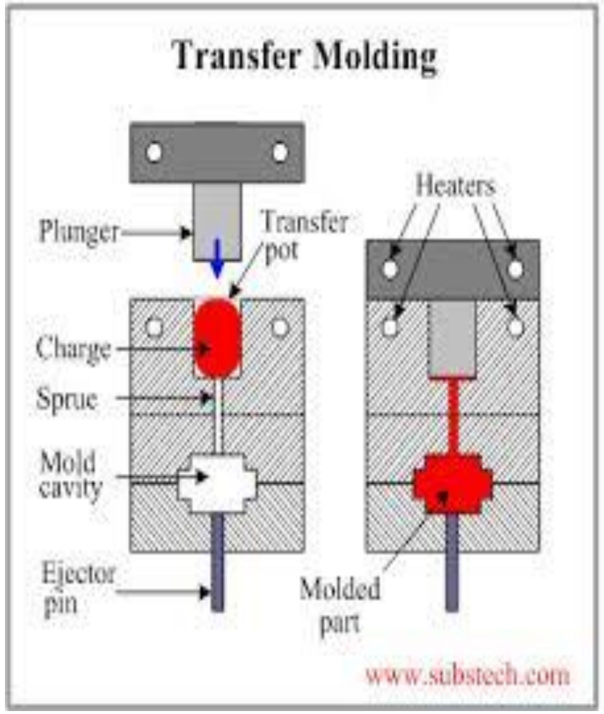
- The injection unit is responsible for both heating and injecting the material into the mould. The first part of this unit is the hopper, a large container into which the raw plastic is poured. The hopper has an open bottom, which allows the material to feed into the barrel. The barrel contains the mechanism for heating and injecting the material into the mould. This mechanism is usually a ram injector or a reciprocating screw. A ram injector forces the material forward through a heated section with a ram or plunger that is usually hydraulically powered. Today, the more common technique is the use of a reciprocating screw.
- A reciprocating screw moves the material forward by both rotating and sliding axially, being powered by either a hydraulic or electric motor. Injection moulding is an economical and very efficient method of producing injection moulded parts. It can produce millions of parts with exactly the same shape, dimension, and quality. Some examples of injection moulded parts are the mobile phones, mouse, keyboard, and many components found inside the automobile.

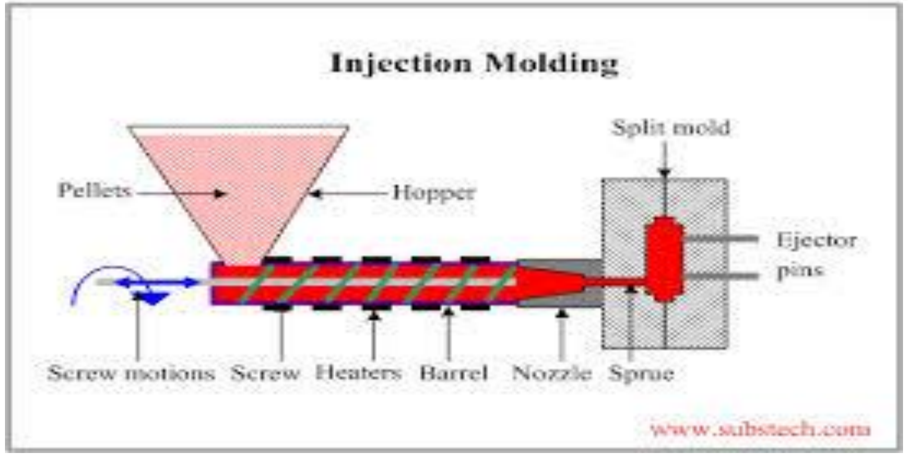
- As the molten resin is being injected into the mould, it enters the mould opening called the sprue. From the sprue this molten material will then be distributed to the runners then it will be forced into the gate and then into the cavity. The cavity must be filled precisely to avoid short shots but it must not be over packed (over packing is forcing more than enough pressure to the resin and it can damage the mould).
- The molten resin will stay in the cavity for 30 seconds to 1 minute or more until it cools down and solidify. When the resins solidify a moulded part is formed. The mould will open and then the moulded part will be ejected. The mould closes and its ready for another shot.

PROCESSING METHODS

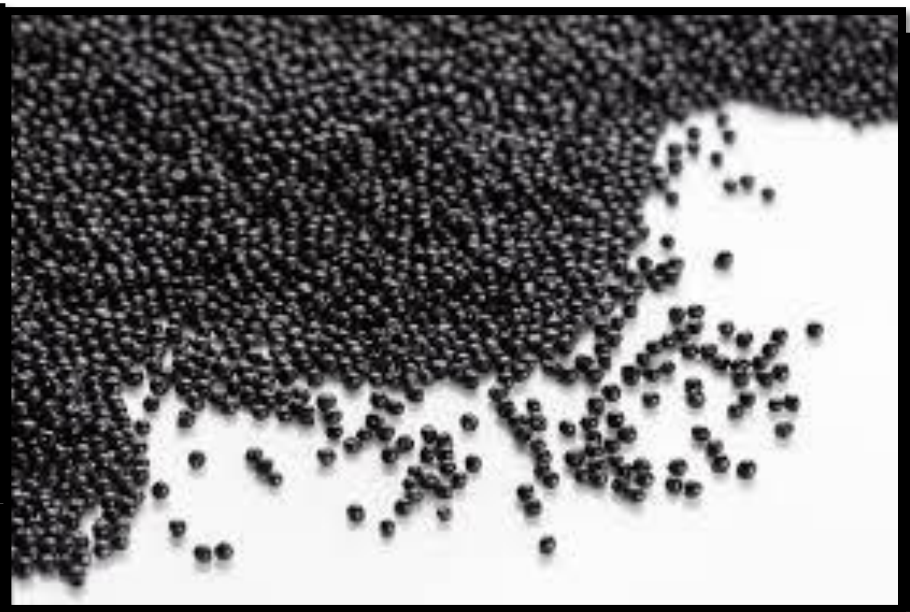
- Compression Molding
- Transfer Molding
- Injection Molding







PLASTIC MATERIAL



TYPES OF PLASTIC MATERIAL[w2]

I. **Thermoplastics**
II. **Thermosetting plastics.**

- **Thermoplastics:-**Thermoplastics are the plastics that do not undergo chemical change in their composition when heated and can be molded again and again. They are easily molded and extruded into films, fibers and packaging. Examples include polyethylene (PE), polypropylene (PP) and polyvinyl chloride (PVC).
- **Thermosetting plastics:-**Thermosetting plastics which are formed by heat process but are then set (like concrete) and cannot change shape by reheating. They are hard and durable. Thermo sets can be used for auto parts, aircraft parts and tires. Examples include polyurethanes, polyesters, epoxy resins and phenolic resins.

THERMOPLASTIC PROPERTIES[w2]

Plastic Names	Products	Properties
Polyamide(nylon)	Bearing, gear wheels, casings for power tools, curtain rail fittings and clothing	Creamy colour, tough, fairly hard, resists wear, self-lubricating, good resistance to chemicals and machines
Polymethyl methacryate(acrylic)	Signs, covers of storage boxes, aircraft windows, covers for car lights	Stiff, hard but scratches easily, durable, machines and polishes well
Polypropylene	Medical equipments, laboratory equipment, plastic seats, rope, keychen	Light, hard but scratches easily tough, good chemical resistance
Polystyrene	Toys, especially model kits, plastic boxes and containers	Light, hard, stiff, transparent, brittle, with good water resistance
Low density polythene(LDPE)	Packaging, especially bottles, toys, bags	Tough, good resistance to chemicals, flexible, fairly soft, good electrical insulator
High density polythene(HDPE)	Plastic bottles, tubing, household equipment	Hard, stiff, able to be sterilised

THERMOSETTING PROPERTIES[w2]

Plastic Names	Products	Properties
Epoxy resin	Adhesives, bonding of other material	Good electrical insulator, hard, brittle unless reinforced, resists chemicals well
Melamine formaldehyde	Laminates for work surfaces, electrical insulation, tableware	Stiff, hard, strong, resists some chemicals and strains
Polyester resin	Casting and encapsulation, bonding of other materials	Stiff, hard, brittle, good electrical insulators
Urea formaldehyde	Electrical fittings, handles and control knobs, adhesives	Stiff, hard, strong, good insulator

POLYPROPYLENE MATERIAL

- Polypropylene, a synthetic resin built up by the polymerization of propylene.
- Polypropylene is molded or extruded into many plastic products in which toughness, flexibility, light weight, and heat resistance are required.
- Polypropylene (pp), also known as polypropene, is a thermoplastic polymer used in a wide variety of applications including packaging and labeling, textiles (e.G., Ropes, thermal underwear and carpets), stationery, plastic parts and reusable containers of various types, laboratory equipment, loudspeakers, automotive components, and polymer banknotes.
- Polypropylene has a variety of different unique properties that makes it invaluable in applications, where rigidity and stiffness are needed. As a result, polypropylene is used in everything from plastic containers to wall siding laminates.[W6]

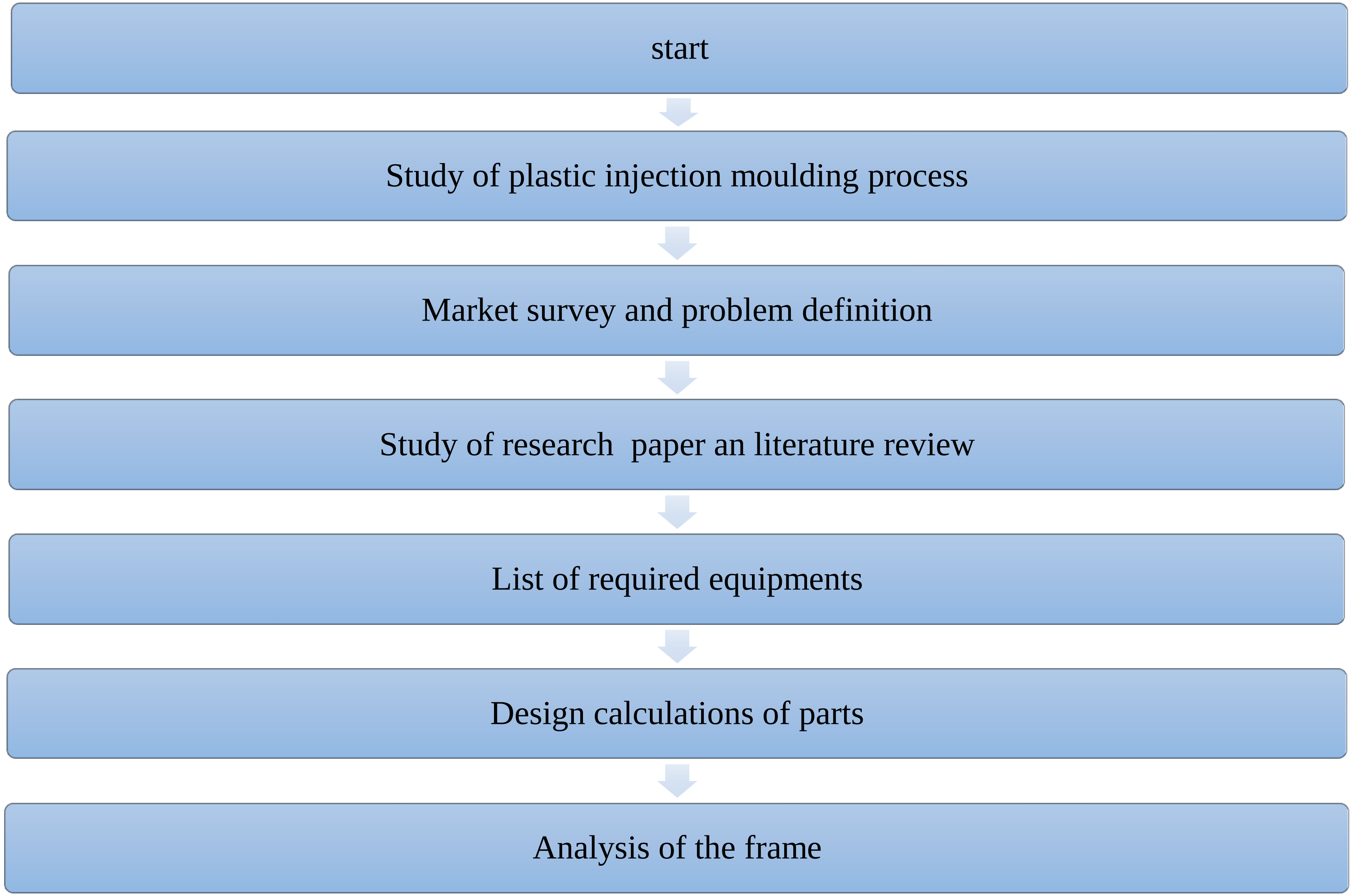
CHARACTERISTIC

- Light in weight
- Excellent resistance to stress and high resistant to cracking (i.e. it has high tensile and compressive strength)
- High operational temperatures with a melting point of 160°C
- Excellent dielectric properties
- Non-toxic
- Easy to produce, assembly and an economic material
- It is often used in applications where rigidity and stiffness are needed. When polyethylene is incapable of providing mechanical properties that are specified, in many cases, it is polypropylene that takes its place. [w5]

SPECIFICATIONS OF PP MATERIAL

- Specific Gravity: 0.90
- Melting Point: 160°C
- Tensile Strength: 31.027 N/mm2
- Hardness: R95
- Rigid [w4]

FLOW PROCESS CHART OF OUR PROJECT



Part modelling in software

Fabrication of parts

Assemble the parts in workshop

Perform experiment on machine with different temperature

Calculate the output parameters

Check quality of the output part

finish

WORK PLAN FOR PROJECT WORK

	July	Aug.	Sep.	Oct.	Nov.	Jan.	Feb.	March	April
1) Definition									
2)Research paper									
3) List of required equipment									
4) Part Design									
5) Part drawing									
6) Part fabrication									
7) Assembly									

LITERATURE REVIEW

Sr.	Title	Investigator	Remarks
1	Mechatronic Design And Injection Speed Control of An Ultra-high Speed Plastic Injection Molding Machine	Ching-Chih Tsai, Shih-Min Hsieh, Huai-En Kao	▪ In this work, pragmatic techniques for mechatronic design and injection speed control of an ultrahigh-speed plastic injection molding machine. ▪ PI controller and a fuzzy PI controller are used, compared and then implemented into a digital signal processor (DSP) using standard C programming techniques.

Sr.	Title	Investigator	Remarks
2	The microscopic features of cavitation erosion and the solution in the plastic injection molding machines	William Liu	▪ The failure of nozzle unit in the plastic injection molding machines was discovered to be cavitation erosion, rather than corrosion ▪ Three types of erosion pits in different size order have been discovered ▪ The cavitation erosion with substituting stainless steel to aluminum has been successful

Sr.	Title	Investigator	Remarks
3	Improvement of Injection Molding Processes By Using Dual Energy Signatures	Egon Müller, Rainer Schillig	▪ This paper presents two methods of dualising the time and energy consumption in the plastic injection moulding process. ▪ Based on the dual process analysis, improvement concepts are brought forward. The value stream mapping method can thus, while maintaining its inner logic, be extended to an energy value stream mapping method (EVSM).

Sr.	Title	Investigator	Remarks
4	CFD-based Predictive Control of Melt Temperature In Plastic Injection Molding	A.G. Gerber, R. Dubay, A. Healy	▪ unique method of coupling computational fluid dynamics (CFD) to model predictive control (MPC) for controlling melt temperature. ▪ The CFD to generate, via open-loop testing, a temperature and input dependent system model for multi-variable control of a three-heater barrel on an injection molding machine. ▪ CFD can be used to dramatically reduce the time associated with open-loop testing through physical experiments.

Sr.	Title	Investigator	Remarks
5	A Simulation Test For The Selection of Coatings And Surface Treatments For Plastics Injection Molding Machines	S.J Bull, R.I Davidson, E.H Fisher, A.R McCabe, A.M Jones	▪ The Glass-filled polymers are known to produce considerable wear on the screws and barrels of injection molding machines and several coatings and surface treatments have been used. ▪ They have developed a novel wear tester to simulate the conditions of wear which occur in the barrel of an injection molding machine. ▪ The tester concept is similar to that of the ASTM rubber wheel abrasion test.

Sr.	Title	Investigator	Remarks
6	Analysis of Premature Failure of a Tie Bar in an Injection Molding Machine	C. Sasikumar, S. Srikanth, S.K. Das	▪ Premature failure of a tie bar made of AISI 4140 steel in a 150 tone plastic injection-molding machine has been analyzed. Although the nominal tensile stress acting on the tie bars (95.5 MPa) is far lower than the yield strength of this material (750–900 MPa). ▪ The solution is a hydraulic clamping mechanism rather than a toggle clamp mechanism for the mold will minimize the cyclic strain on the tie rods.

Sr.	Title	Investigator	Remarks
7	A New Approach to the Optimization of Blends Composition in Injection Moulding of Recycled Polymer	G. Lucchetta, P.F. Bariani, W.A. Knight	▪ Recycled polymers are usually blended with virgin polymers to obtain the best trade-off between cost and low melt viscosity. ▪ This last constraint is necessary to avoid short shots and to minimize the clamp force of the required injection molding machine and, therefore, the process cost. ▪ A new approach to the minimization of the overall manufacturing cost .

Sr.	Title	Investigator	Remarks
8	Failure Analysis of H13 Working Die Used In Plastic Injection Molding	D. Papageorgiou, C. Medrea, N. Kyriakou	▪ The die was made from AISI H13 steel and was intended for the production of plastic cups used for the outer closure of cylindrical aluminum cans in coffee packaging. ▪ Corrosion damage and wide crack are observed by necked eye. ▪ Design deficiency and improper cooling conditions generated a complex fatigue-corrosion cracking mechanism that lead to the damage of the die after half of it’s predicted service life.

Sr.	Title	Investigator	Remarks
9	Barrel temperature control during operation transition in injection molding	Ke Yao, Furong Gao, Frank Allgöwer	• Transitions between the machine's idle state and the operation state, significant temperature variations exist in the temperature zones. • This leads to inhomogeneous melt temperatures and inconsistent product quality. • A feedback controller and an iterative learning feed forward controller are implemented and tested on an industrial-sized reciprocating-screw injection molding machine.

Sr.	Title	Investigator	Remarks
10	Metallic powder injection molding using low pressure	Aparecido Carlos Gonçalves	• PIM is a technology capable of producing a new range of components from powders. • This advanced technology overcomes the existent limitations in the forming of products with complex geometry. • The purpose of this work is to review the metal injection molding techniques and apply the low pressure injection molding process to family of parts using metallic powder with 10 μm particle size

PARTS

- Main frame
- Radial gearbox
- Barrel
- Pushing Handle
- Heating coil and regulator
- Injection mechanism
- die
- Helical compression spring
- Lead screw and vice
- Hopper
- bearing

DESIGN CALCULATIONS OF PARTS

1. Design of shaft
2. Design of gear
3. Design of plunger
4. Design of barrel

DESIGN OF SHAFT

Generally our hand can lift 25kg =250 N
Now,

$$\tau = \frac{16T}{\pi d^3}$$

$$\therefore T = \frac{\pi \tau d^3}{16}$$

$$\therefore \ force \times dis\tan ce = \frac{\pi \tau d^3}{16}$$

$$\therefore 250 \times 250 = \frac{\pi \times 41 \times d^3}{16}$$

$$\therefore d = 20mm$$

So, the diameter of shaft is 20 mm

DESIGN OF GEAR

Now, torque is given by

$$T = F_t \times d$$

Here, we assume V =8 m/sec (for ordinary cut gears)

$$\mathrm{P} = \frac{F_t \times V}{1000}$$

$$\mathrm{P} = \frac{250 \times 8}{1000}$$

$$\mathrm{P} = 2kw$$

Power is 2 Kw.

By using Lewis equation

$$W_{T=}\sigma_d \times c_v \times b \times Y \times m$$

$$\sigma_d = 47.1MN / mm^2$$

b= face width of gear
Y=form factor = π×y
y=0.154-0.912/z (for 20˚ involute system)
y=0.0628
So, Y=0.198

For cast iron grade 20

$$C_v = \frac{3.05}{3.05+V}$$
$$C_v = 0.27$$

Take, V=8 m/sec, b= 10m

$$W_T = \frac{P}{V}$$
$$\therefore 47.1\times10^6\times0.27\times10m\times m\times0.198 = \frac{2\times10^3}{8}$$
$$\therefore m = 3.12$$

For standard value of module take m=3

DATA OF GEAR

Pitch circle diameter=3×10=30mm
Pitch=π×D/Z=10mm
Addendum=m=3mm
Dedendum=1.25m=3.75mm
Clearance= 0.25m=0.75mm
Working depth= 2m=6mm
Whole depth= 2.25m=6.75mm
Tooth thickness= 1.57m=4.71mm
Fillet radius= 0.4m=1.2mm

DESIGN OF PLUNGER

One rotation of handle=one rotation of gear

=no. of teeth × pitch

=10×10

Effective Length =100 mm

Diameter of the plunger:

Volume of plunger=volume of barrel

$$\frac{\pi}{4} d_p{}^2 \times l_e = \frac{m}{\rho}$$

$$\therefore d_p = \sqrt{\frac{4m}{\pi \rho l_e}}$$

$$\therefore d_p = \sqrt{\frac{4 \times 35}{\pi \times 0.92 \times 100}}$$

$$\therefore d_p = 21mm$$

So, the diameter of the plunger is 21 mm.

Total length = 3 × Effective Length = 3 × 100

= 300 mm

DESIGN OF BARREL

Dia. of barrel = Dia. Of plunger + 1mm clearance

= 21 + 1

= 22 mm

External diameter of barrel = Dia. of barrel + 2×thickness of barrel

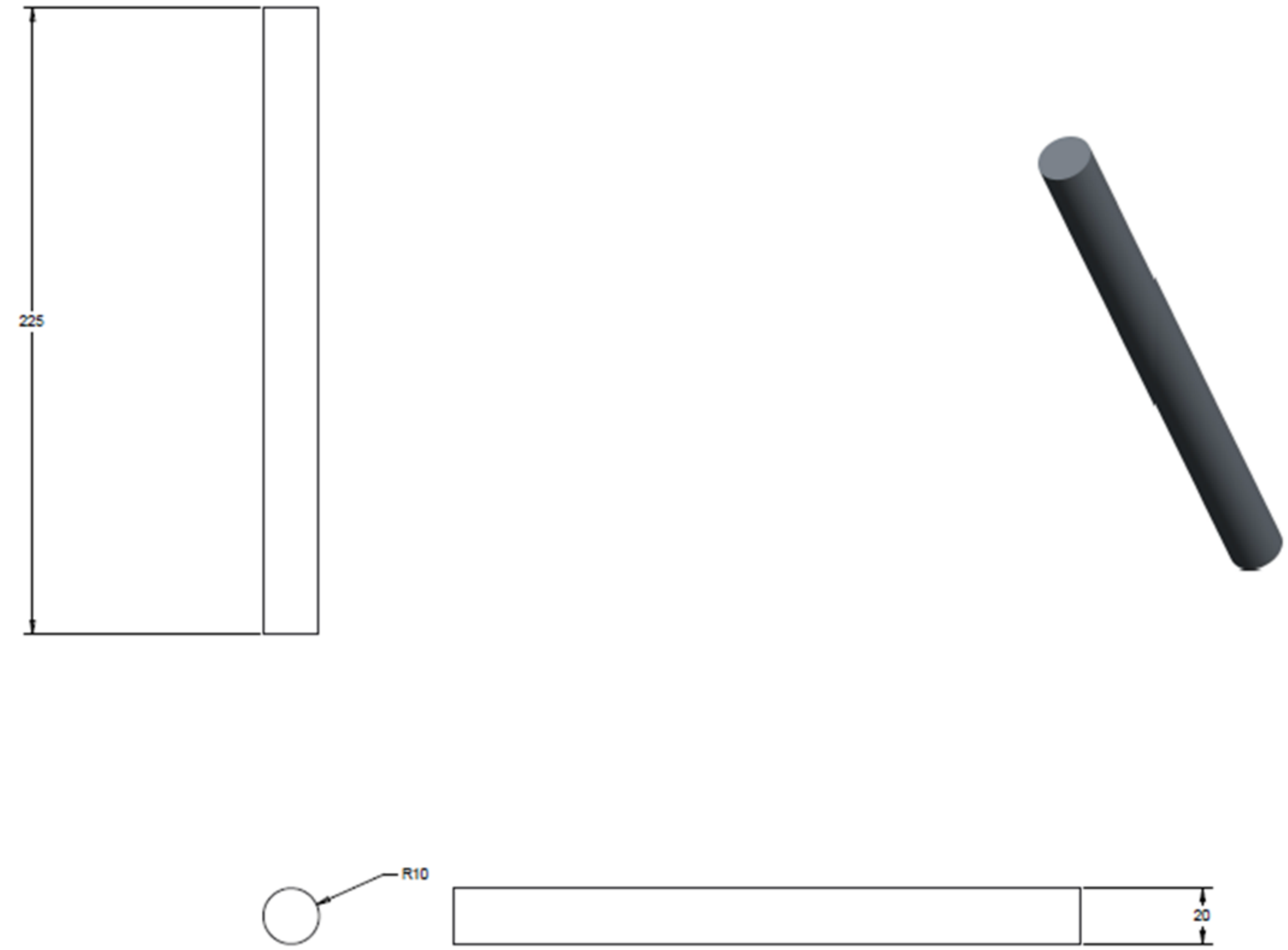
= 22 + 2(7)

= 36 mm

Internal dia. of barrel = dia. Of plunger + clearance

= 21 + 1

= 22 mm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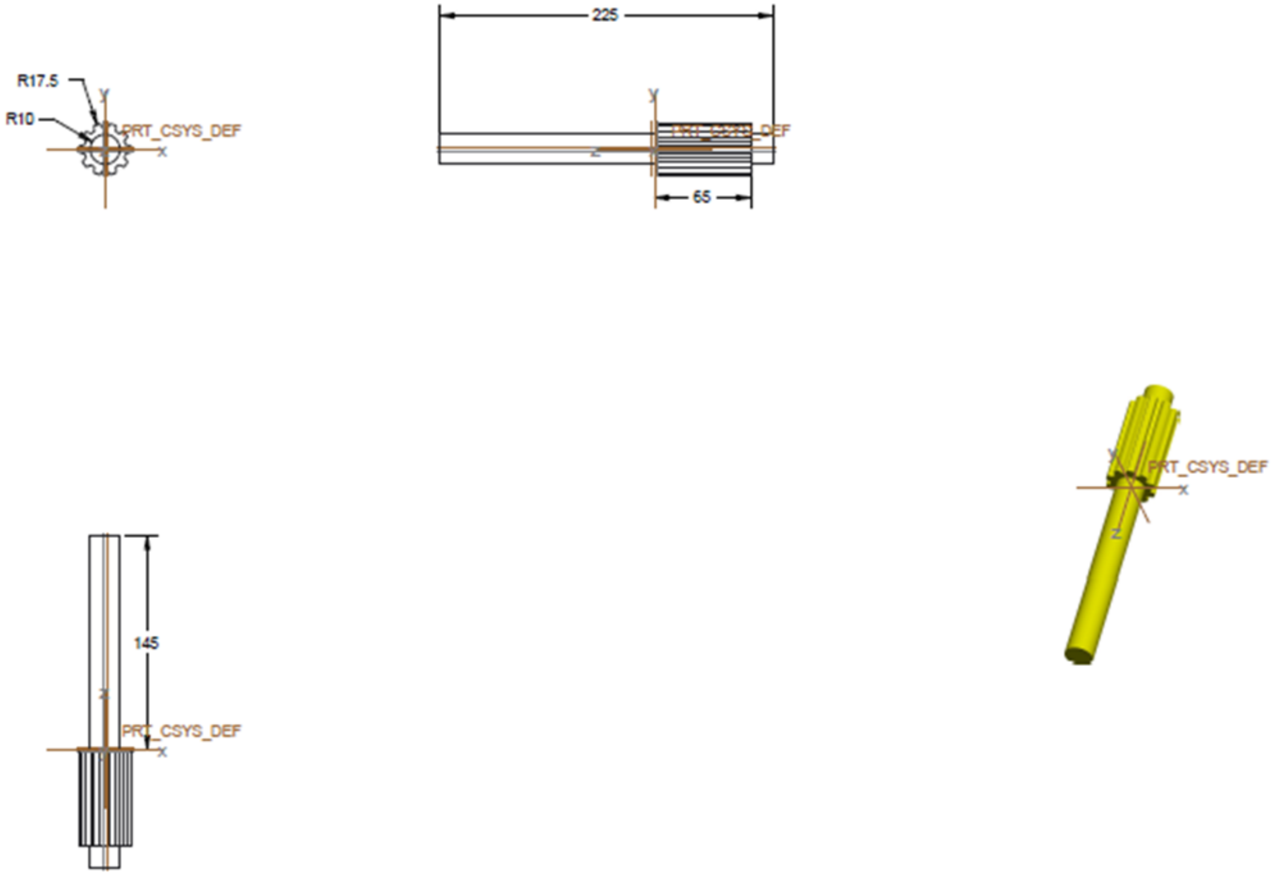
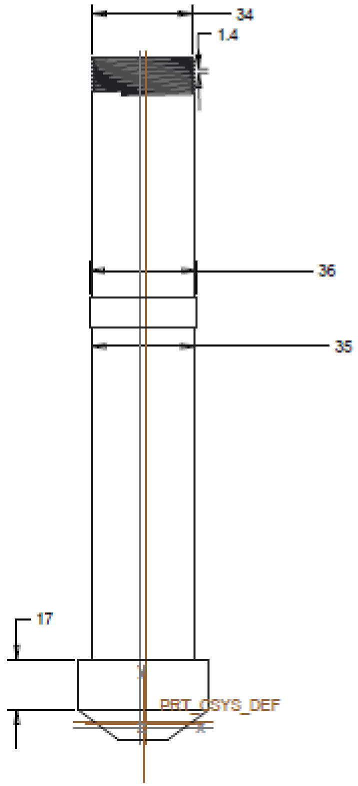
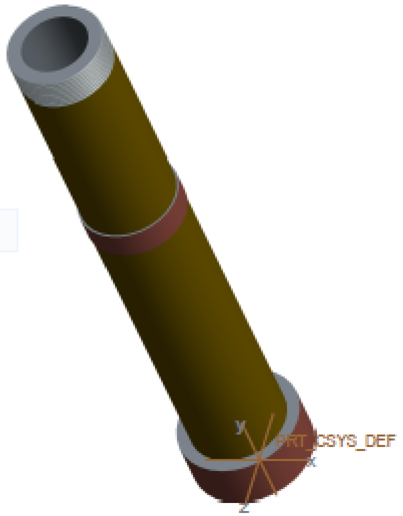
R10
20

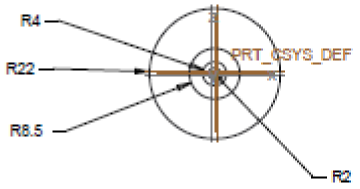


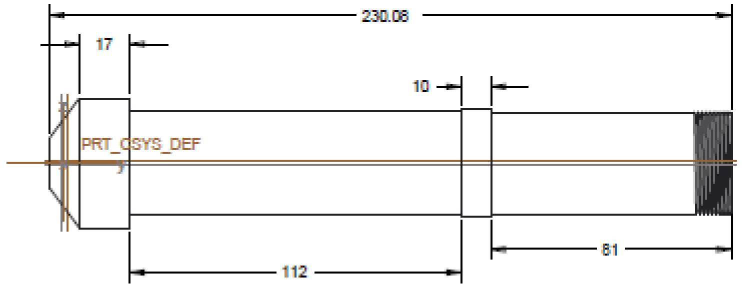
R17.5
R10
PRT_CSYS_DEF
225
65
145
PRT_CSYS_DEF
PRT_CSYS_DEF

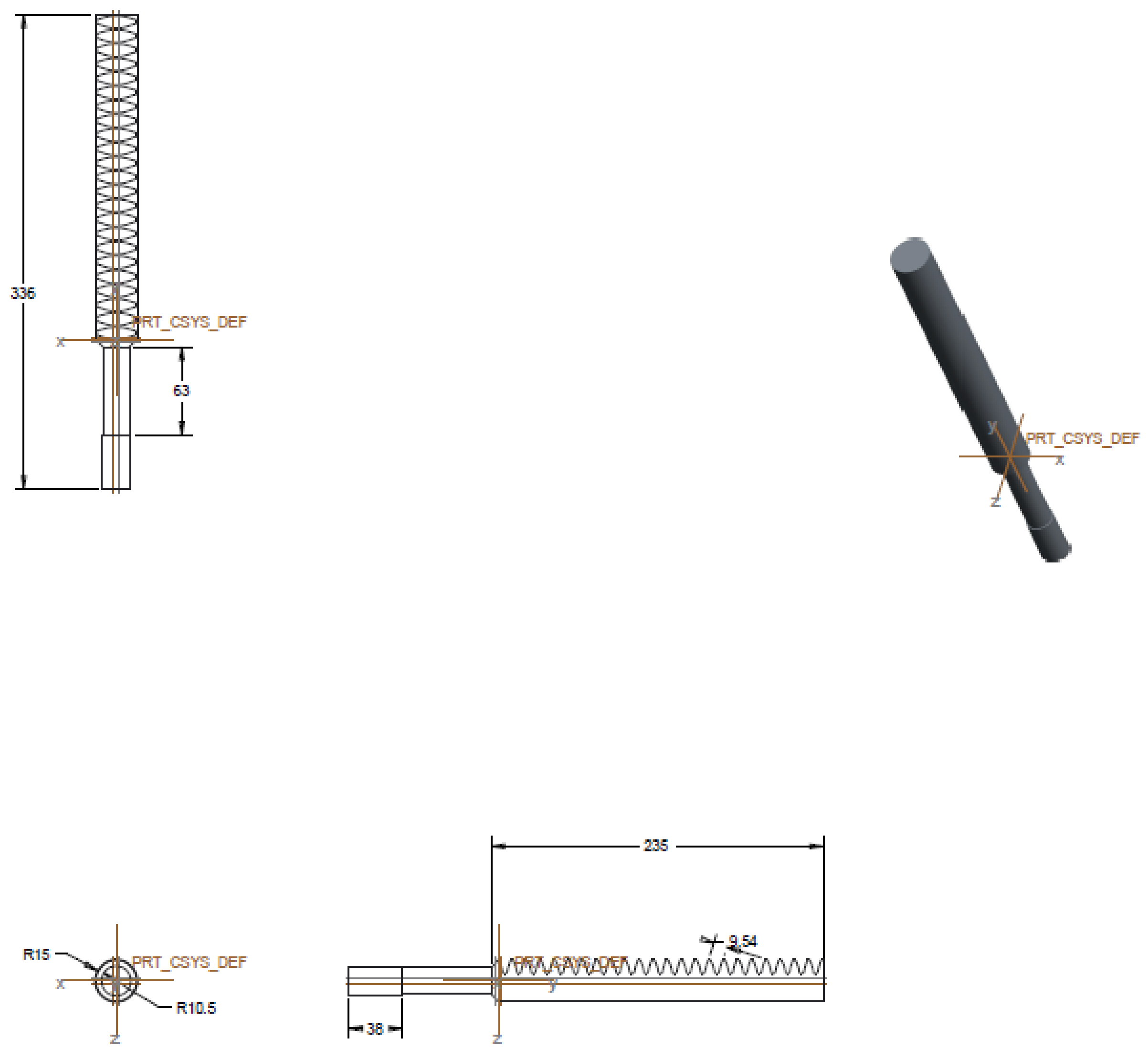


Rectangular Snip





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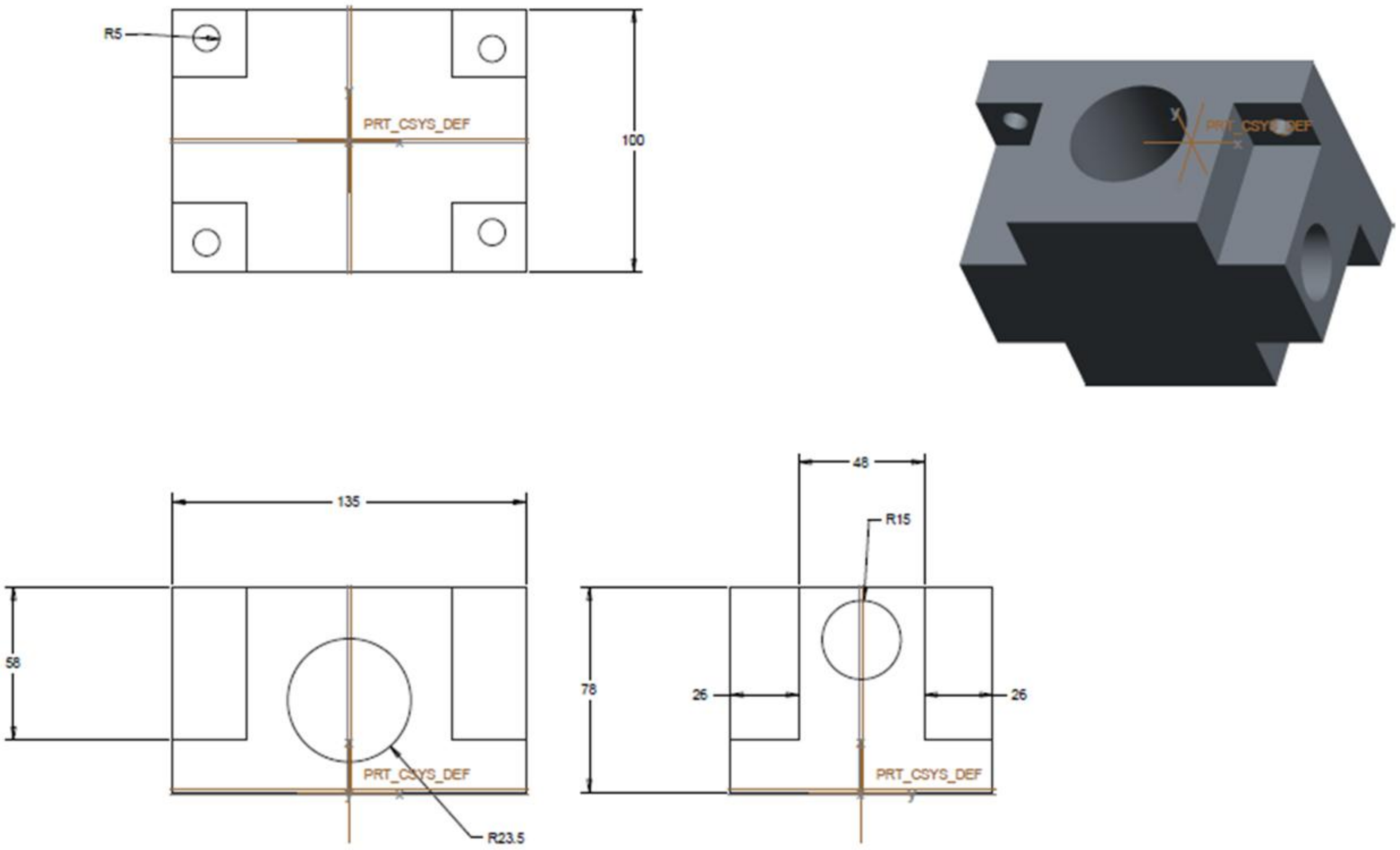
x
63
PRT_CSYS_DEF
y
x
z
R15
PRT_CSYS_DEF
R10.5
x
z
235
9.54
PRT_CSYS_DEF
y
z
38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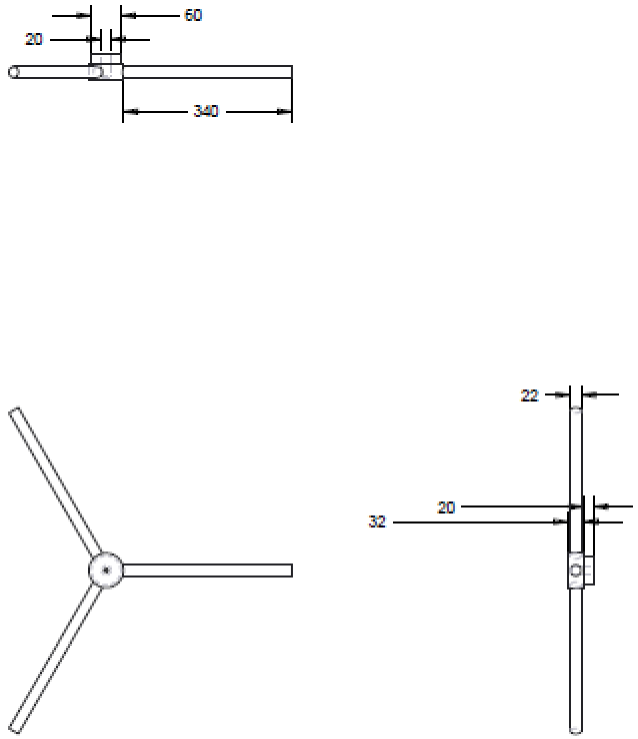
R15
78
26
26
PRT_CSYS_DEF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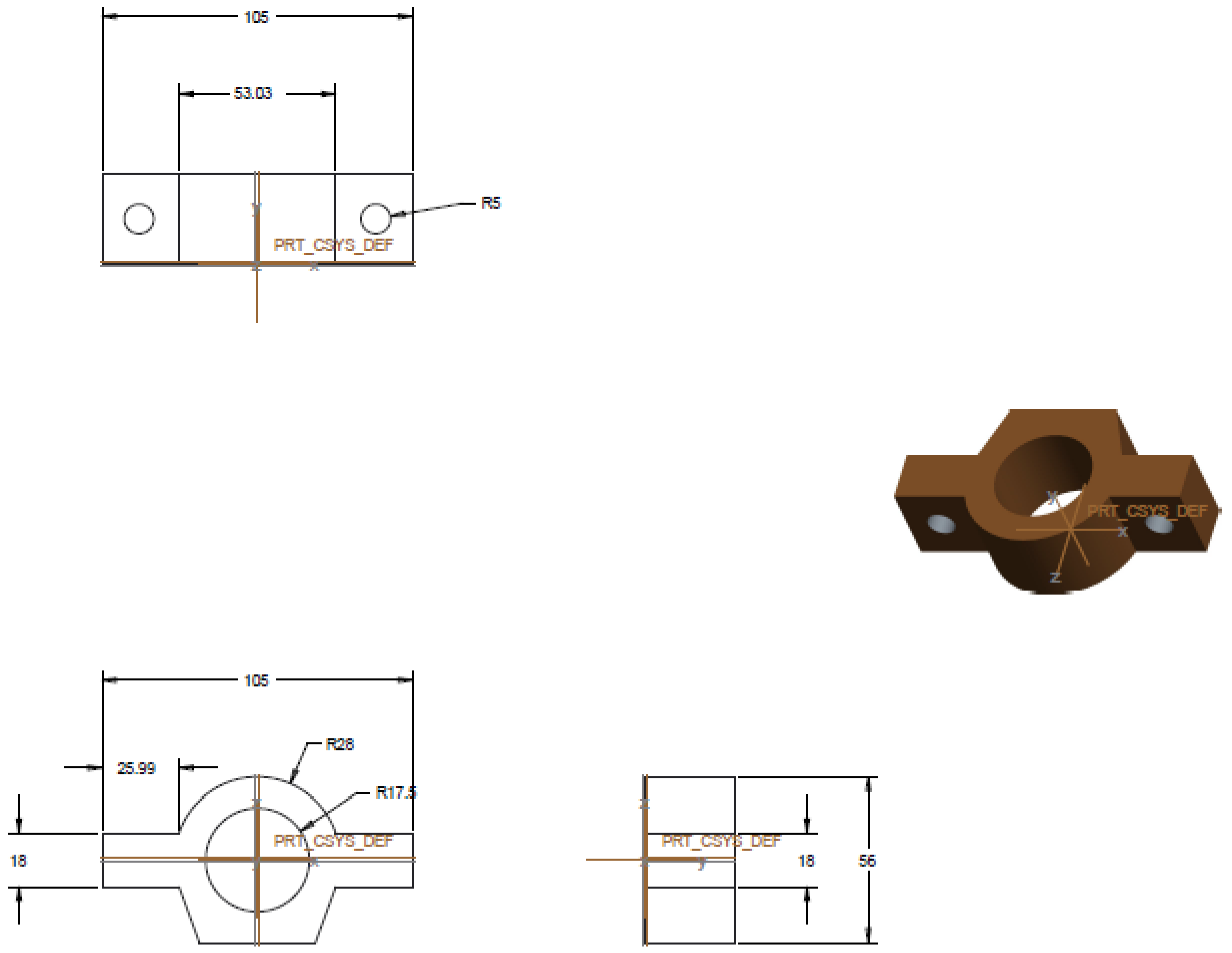
20
32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R5
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R17.5
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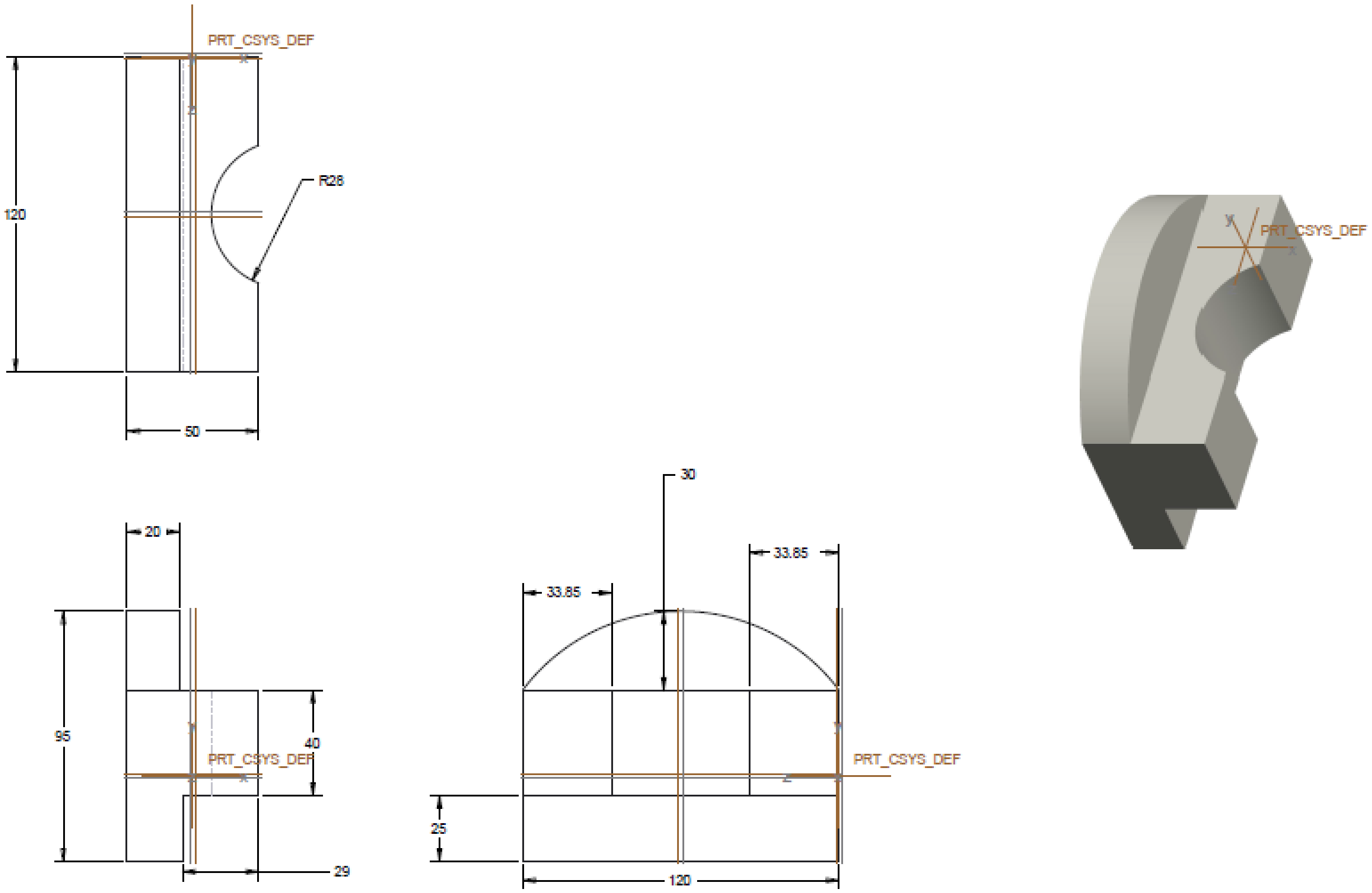
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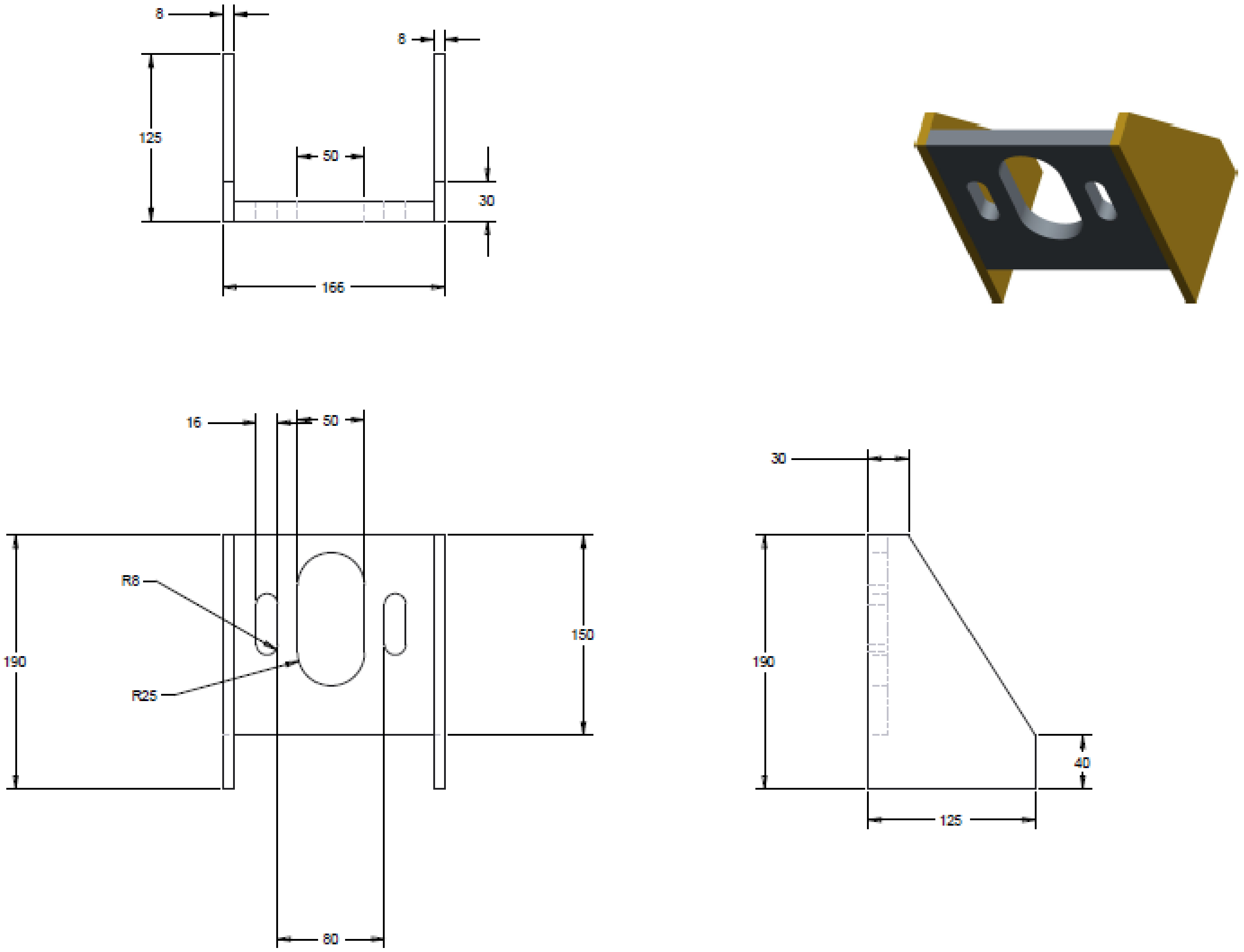
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R25
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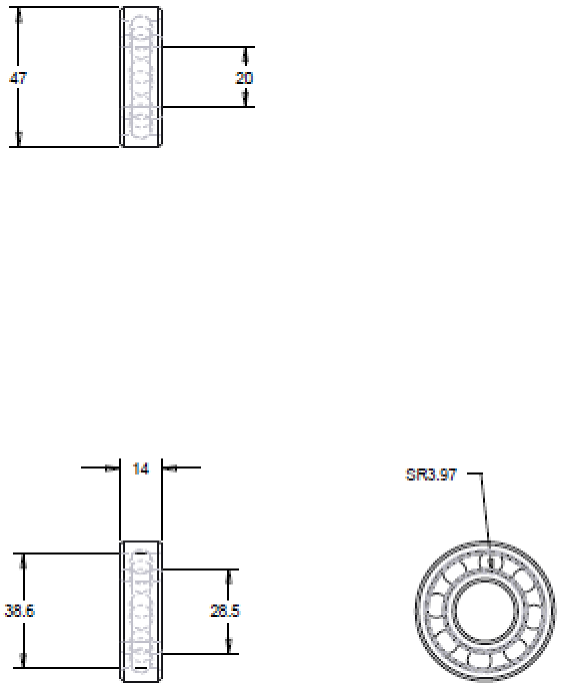
40
125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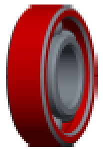
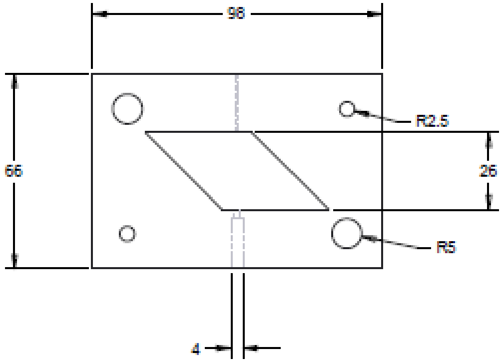
38.6
28.5
SR3.97

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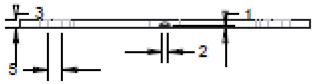
R2.5
26
R5
4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1
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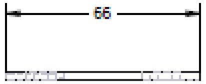
2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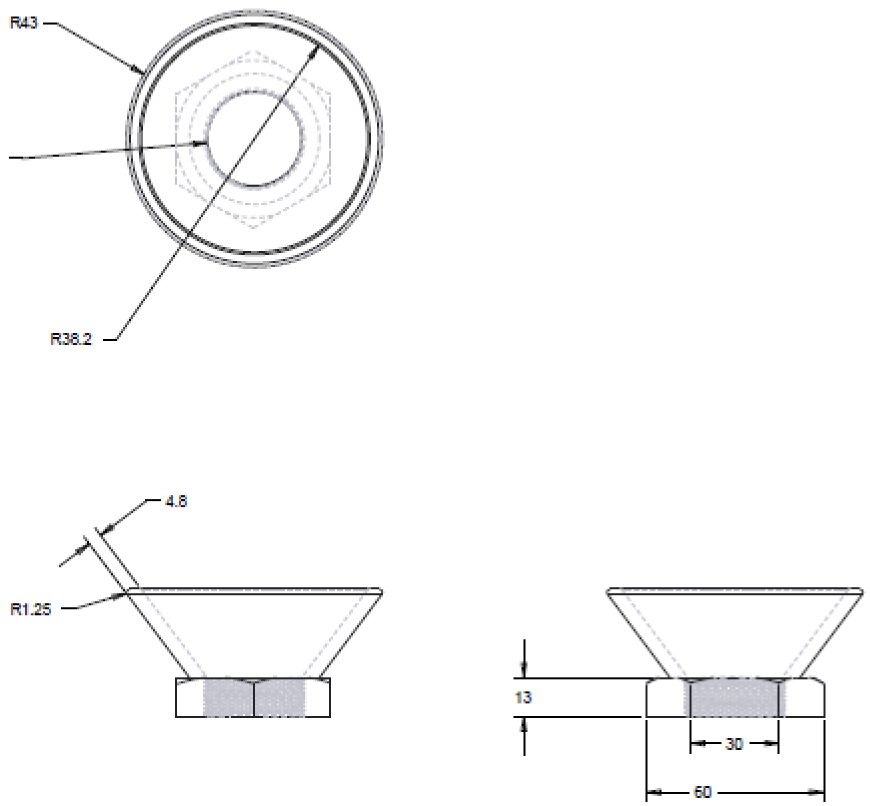
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R38.2
4.8
R1.25
13
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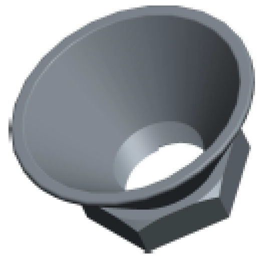

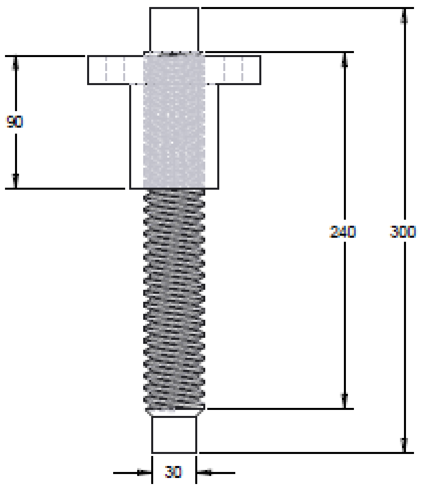
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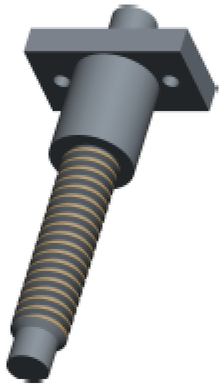
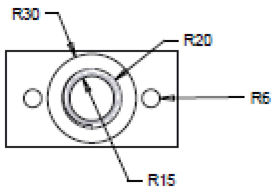
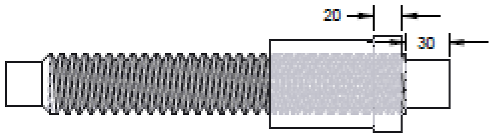



R30
R20
R6
R15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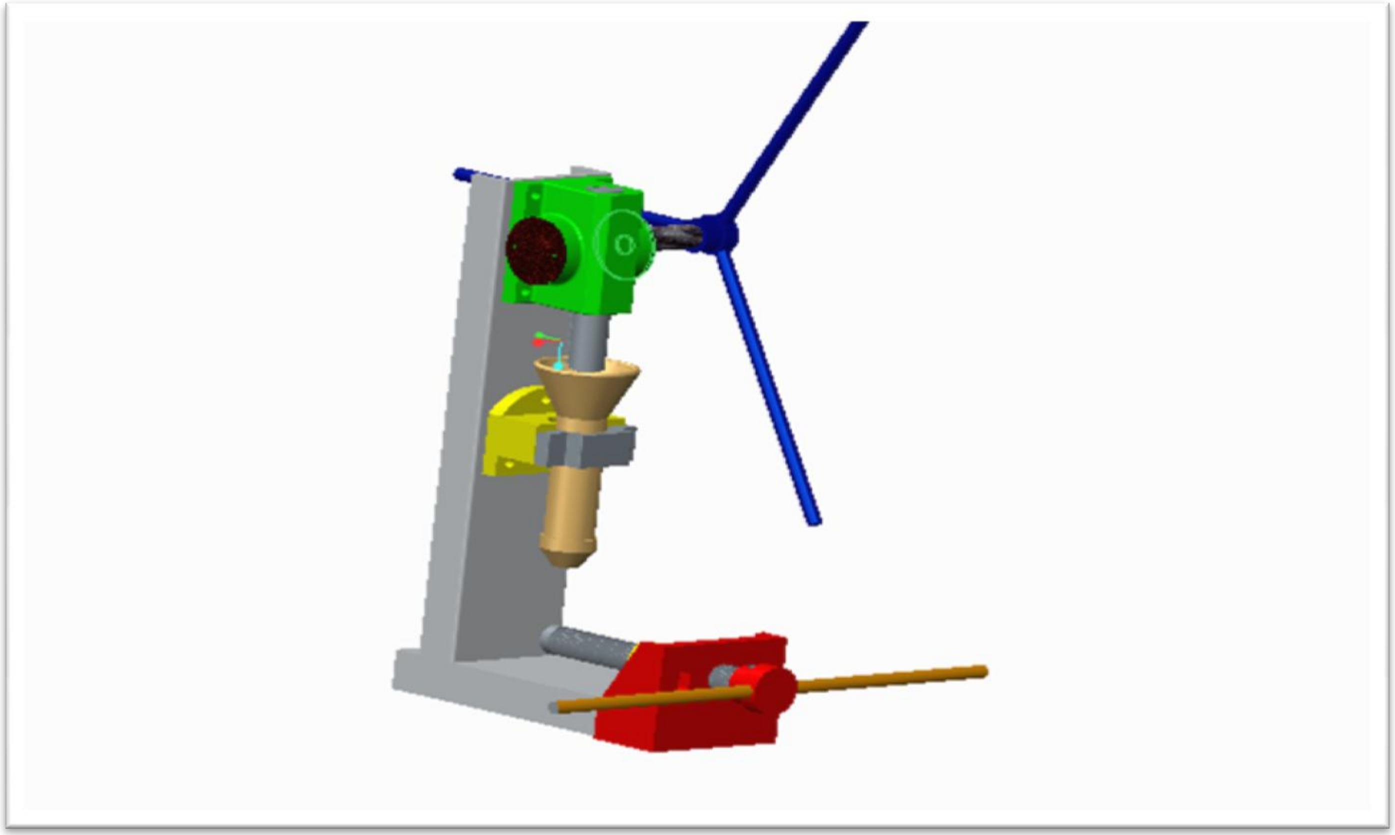
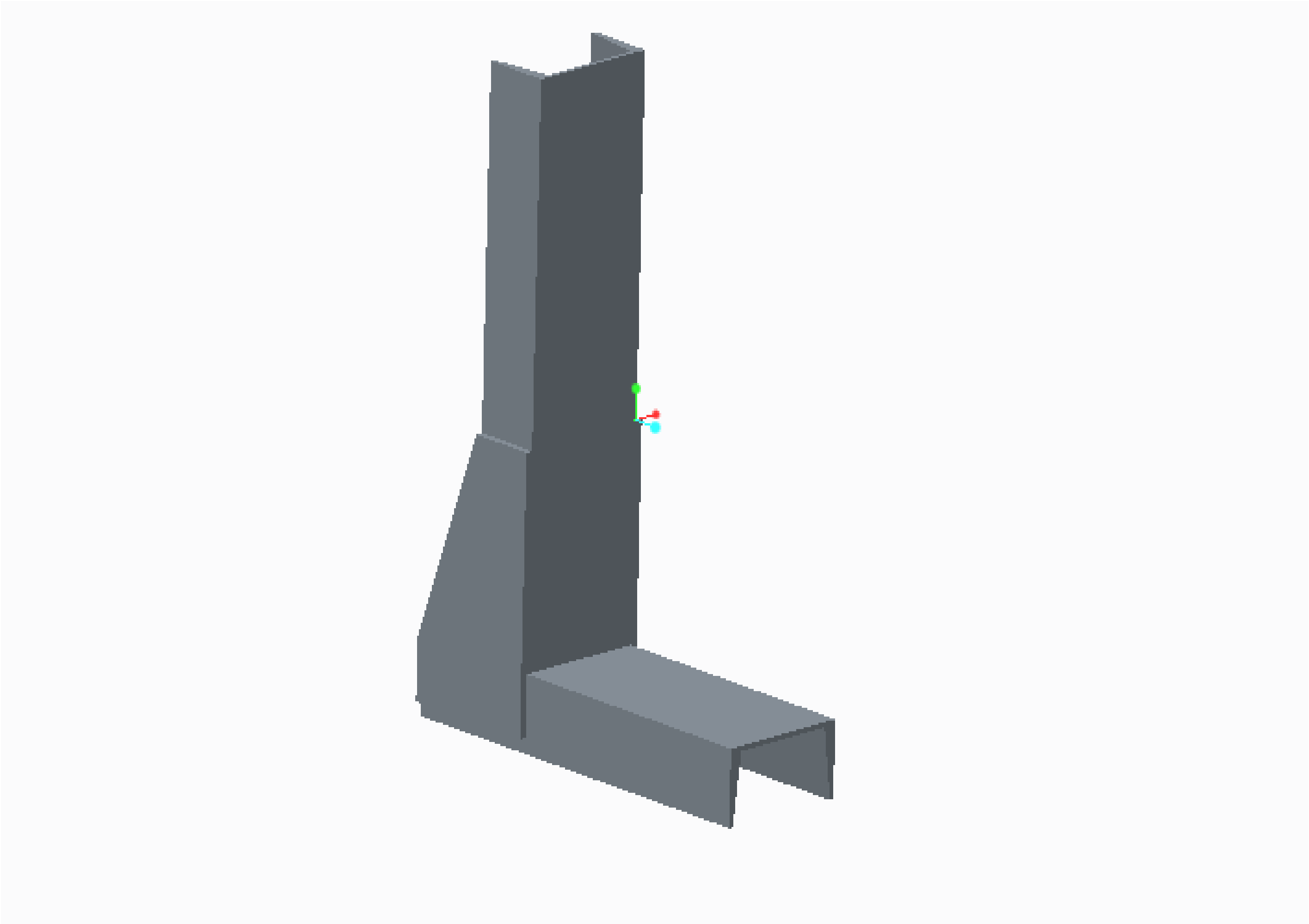
ASSEMBLY



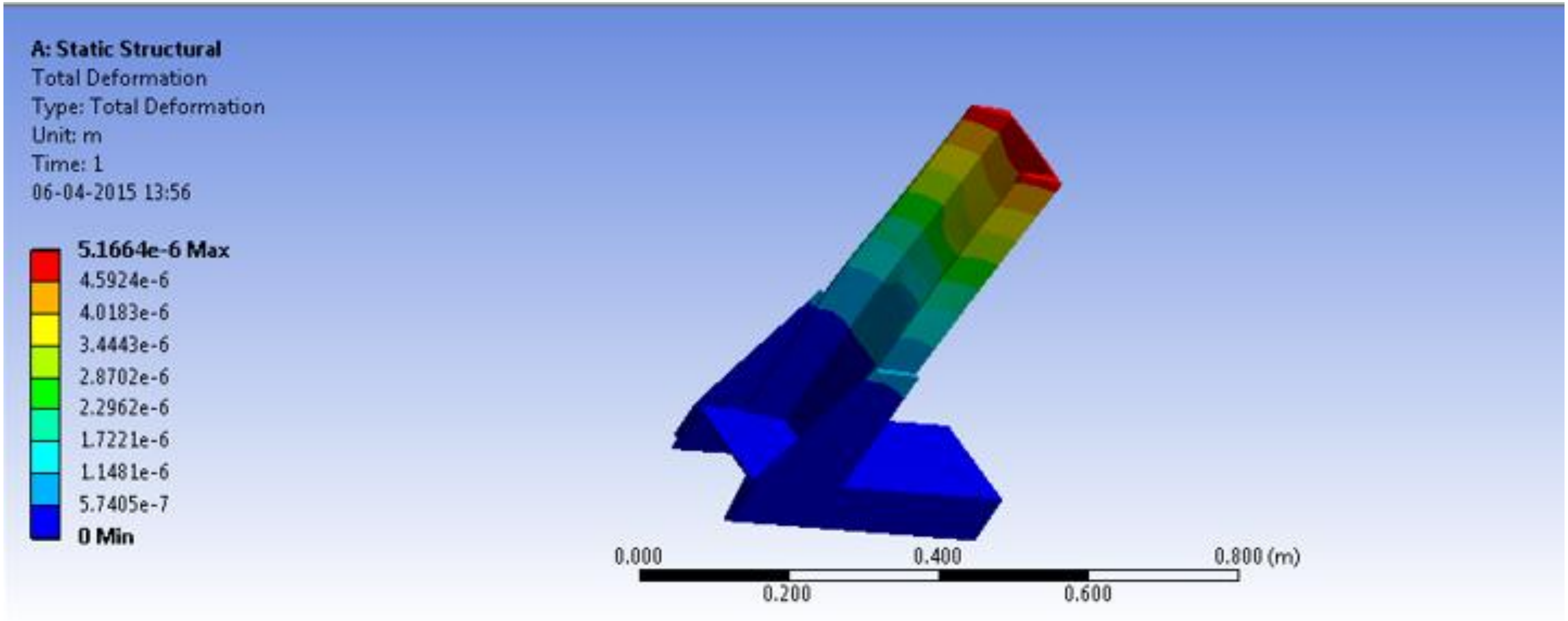
VARIOUS PROBLEMS AND SOLUTIONS

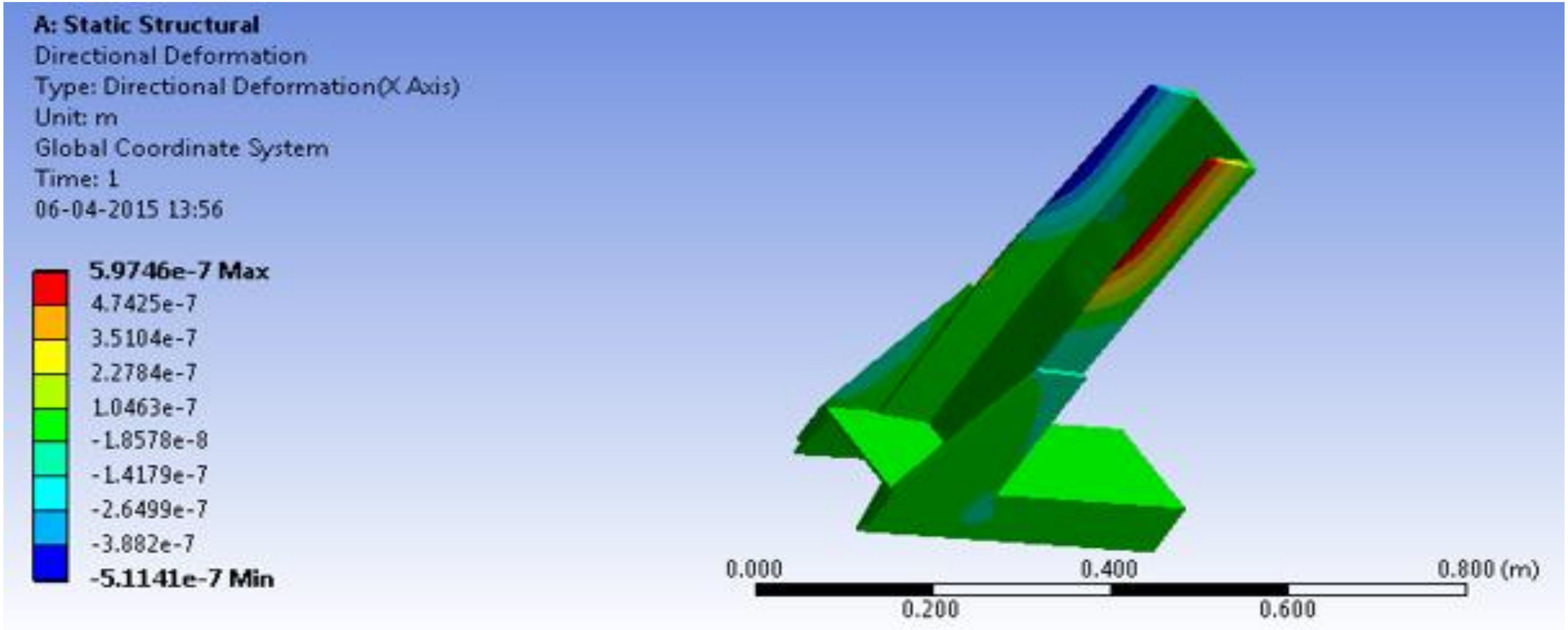
- Die setting
- Stop the molten material leakage in nozzle
- For Diff. die different arrangement of injection mechanism

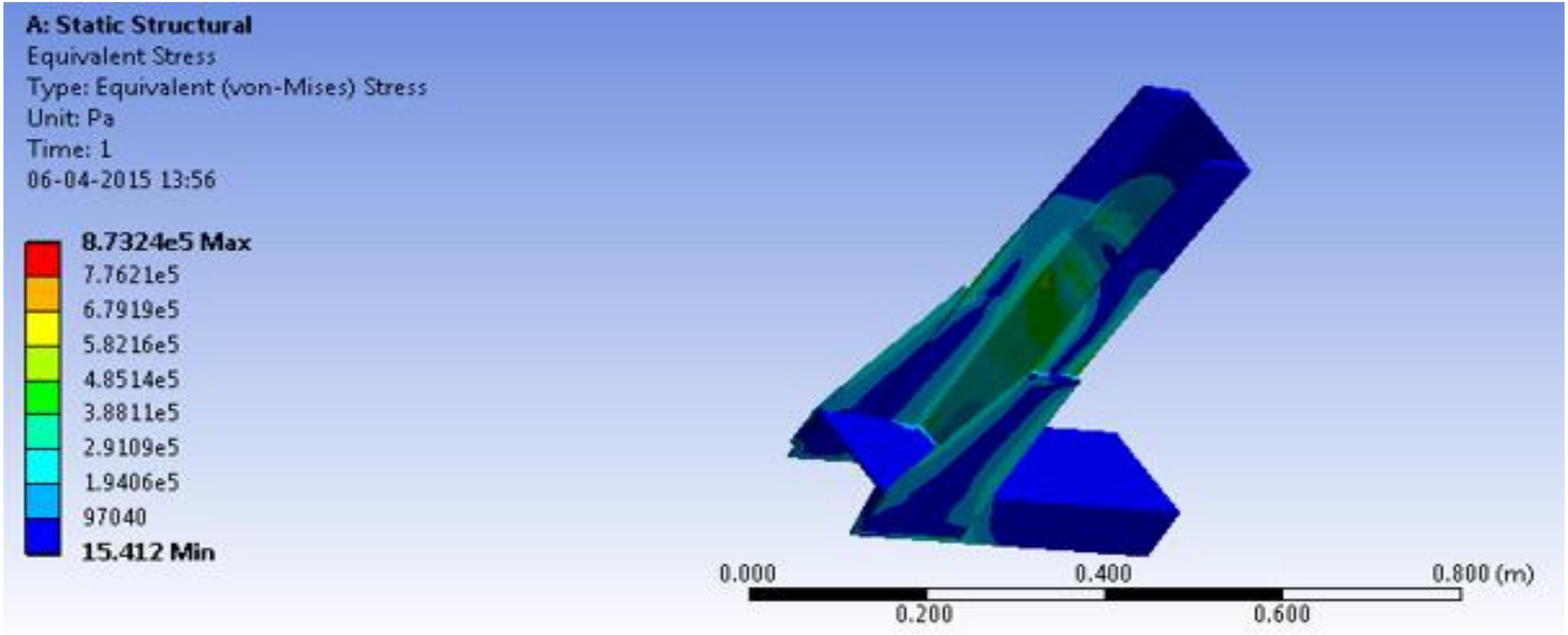
FRAME STRUCTURE

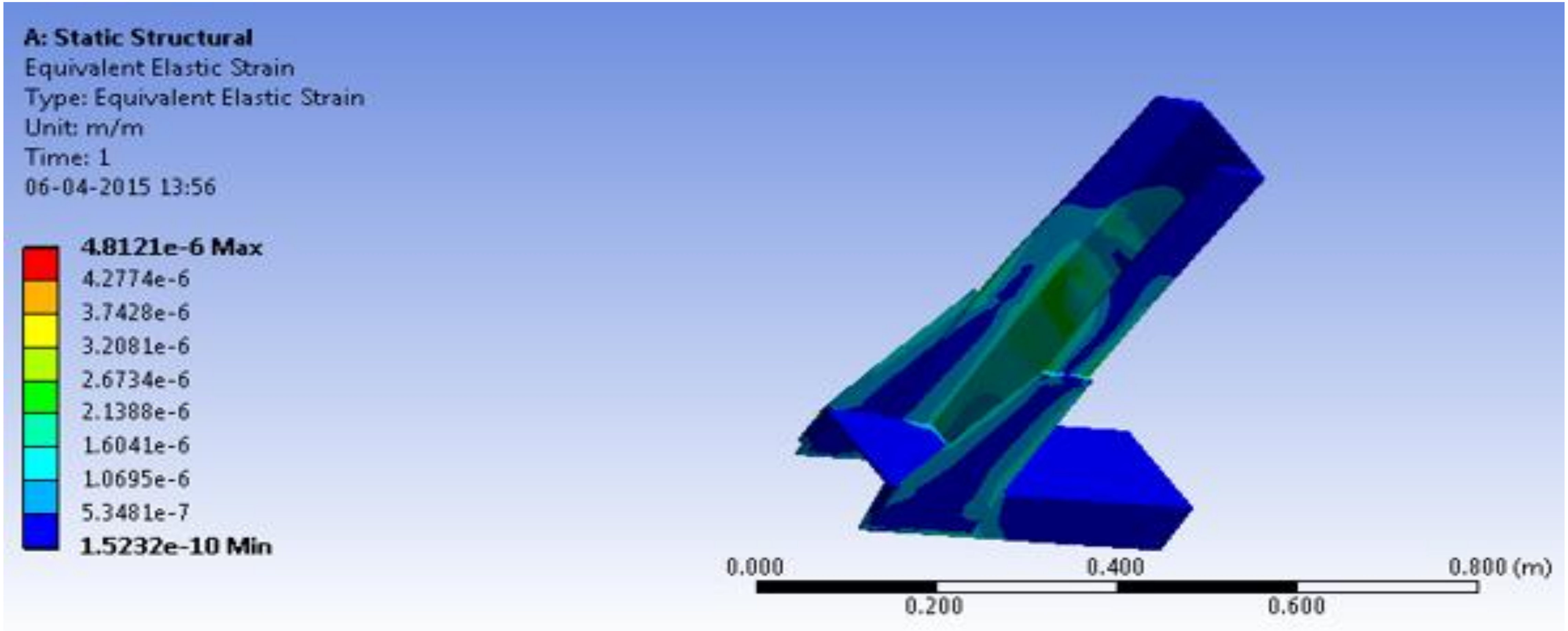


ANALYSIS OF FRAME




A: Static Structural
Directional Deformation
Type: Directional Deformation(X Axis)
Unit: m
Global Coordinate System
Time: 1
06-04-2015 13:56
5.9746e-7 Max
4.7425e-7
3.5104e-7
2.2784e-7
1.0463e-7
-1.8578e-8
-1.4179e-7
-2.6499e-7
-3.882e-7
-5.1141e-7 Min
0.000
0.200
0.400
0.600
0.800 (m)


A: Static Structural
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: Pa
Time: 1
06-04-2015 13:56
8.7324e5 Max
7.7621e5
6.7919e5
5.8216e5
4.8514e5
3.8811e5
2.9109e5
1.9406e5
97040
15.412 Min
0.000
0.200
0.400
0.600
0.800 (m)


A: Static Structural
Equivalent Elastic Strain
Type: Equivalent Elastic Strain
Unit: m/m
Time: 1
06-04-2015 13:56
4.8121e-6 Max
4.2774e-6
3.7428e-6
3.2081e-6
2.6734e-6
2.1388e-6
1.6041e-6
1.0695e-6
5.3481e-7
1.5232e-10 Min
0.000
0.400
0.800 (m)
0.200
0.600

ADVANTAGES

- Alternative for plastic cups and plates.
- Cheaper and easily available material used.
- Quick response
- No fire hazard problem due to over loading.
- Continuous operation is possible without stopping.
- High production rate.
- High tolerances.
- Occupies less floor space.
- Fastest cycle time incase of rubber, the rubber is warmed before going into the mold.
- Little finishing part after injection.
- Minimum scrap losses.

FUTURE SCOPE

- Plastic injection moulding industry is now facing the very heavy competition; most of the plastic injection moulding companies is working on mercy profits and low technologies.
- Speed up all the moulding machines. For this point you need to be sure that your machines are suitable for high speed running
- Even if your machine are high speed, but if you are in shortage of automation system in your injection moulding plants, then you need a lot of labour to pick up the moulded plastic components from the machine and you need to stack or collect them before packing. All these need labours and this will reduce the production capacity, in the same time the labour cost will be highly increased.
- In the project we have used manual plunger arrangement for pressing the molten plastic instead of that we can have hydraulic arrangement for the automatic control that will reduce production time.
- Also for the batter and quick heating to melt the plastic insulation can be done which will reduce the heat loss.

CONCLUSION

- Due to it’s low cost, this working model can be successfully inducted in small scale molding units and can be used to manufacture small plastic component at an acceptable cycle rate within an effective cost component.

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[w2]http://www.stephensinjectionmoulding.co.uk/revision/plastics/thermoplastics.html

[w3]http://en.wikipedia.org/wiki/Injection_moulding

[w4]http://www.dynalabcorp.com/technical_info_polypropylene.asp

[w5]http://www.lenntech.com/polypropylene.htm

[w6]http://www.britannica.com/EBchecked/topic/469069/polypropylene

[B1]Design data hand book

[B2]Machine design 2

[B3]Injection moulding handbook


Thank You!