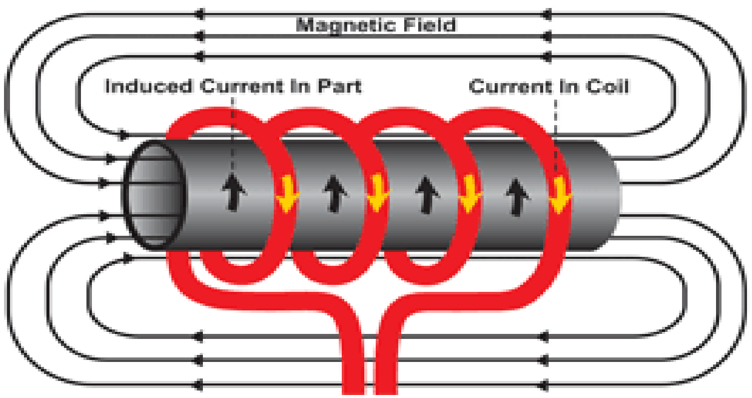
Induction Heating



•Works like a transformer (Step down transformer – low voltage and high current)

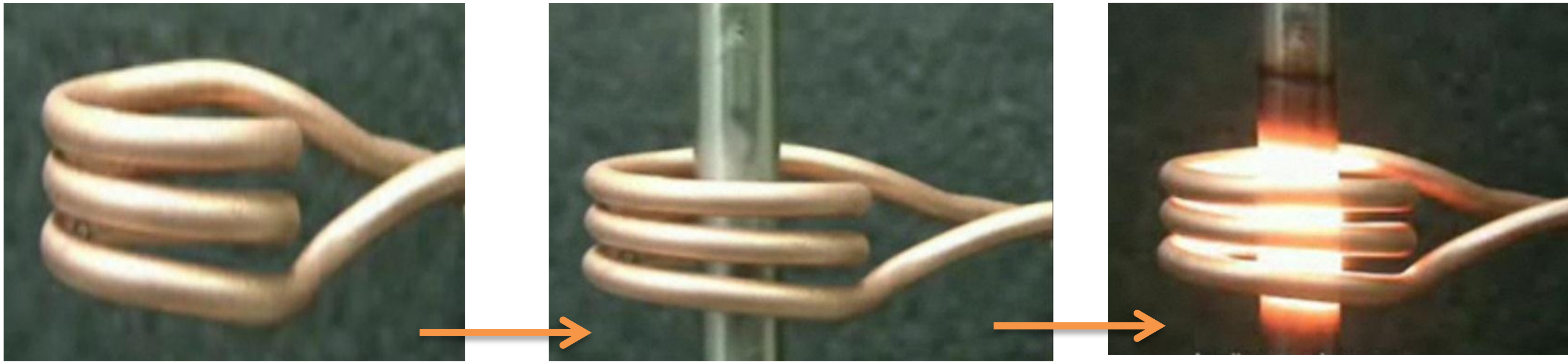
– electromagnetic induction principle

Induction furnace

•Primary coil - induction coil

•Secondary coil – work piece - **poor conductor of electricity** - eddy-currents

Resistance



- All metals conduct electricity - offering resistance to the flow of electricity.
- The resistance to the flow of current causes losses in power that converted into heat.
- The losses produced by resistance is: **Heat = i^2R**,
  - where i is the amount of current, and R is the resistance.

ADVANTAGES

- No contact is required between the work piece and the induction coil as the heat source

- Heat is restricted to localized areas or surface zones immediately adjacent to the coil.

- Alternating current (ac) in an induction coil has an invisible force field (electromagnetic, or flux) around it

Heating Rate

- The rate of heating of the work piece is dependent on the :-
  - Frequency of the induced current,
  - The intensity of the induced current,
  - The specific heat of the material (ability to absorb heat),
  - The magnetic permeability of the material,
  - The resistance of the material to the flow of current.

Magnetic Permeability & Curie Temperature

- The magnetic permeability of steel is high at room temperature.

- But at the Curie temperature, just above 760 °C (1400 °F), steels become nonmagnetic with the effect that the permeability becomes the same as air.

Magnetic Permeability & Curie Temperature

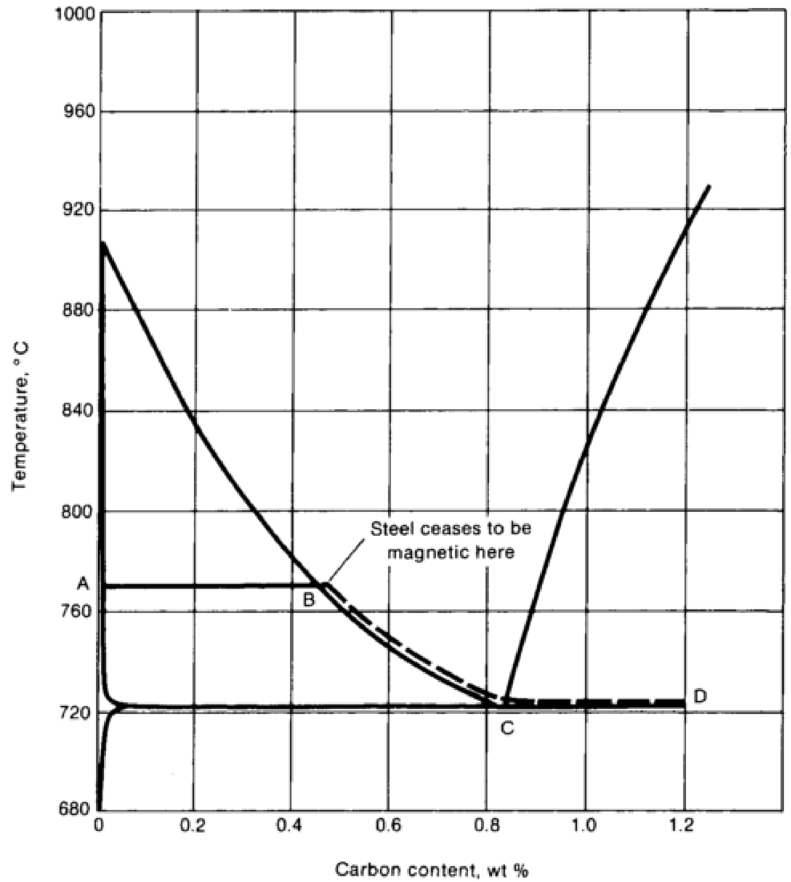


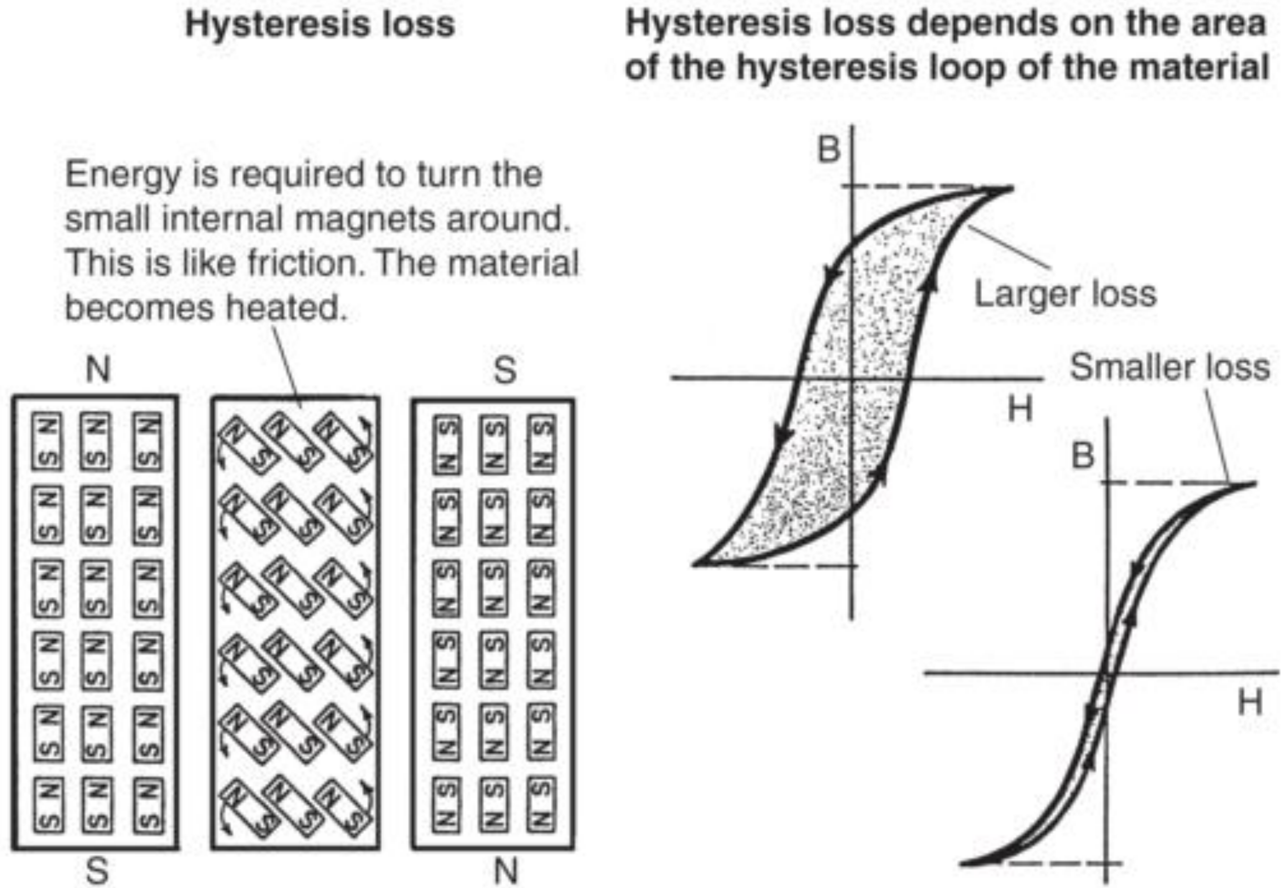
Fig. 2.4 Curie temperature for carbon steels. Source: Ref 2

Hysteresis

- The alternating magnetic flux field causes the magnetic dipoles of the material to oscillate as the magnetic poles change their polar orientation every cycle. This oscillation is called hysteresis.

- A minor amount of heat is produced due to the friction produced when the dipoles oscillate.

Hysteresis



Effect of hysteresis on heating rate. N, north; S, south; B, flux density in a ferromagnetic material; H, corresponding magnetic intensity. Source: Ref 4

Hysteresis

- Hysteresis losses occur only in magnetic materials such as steel, nickel.

- When steels are heated above Curie temperature they become nonmagnetic, and hysteresis ceases.

Skin Effect And Reference Depth

- The basic nature of induction heating is that the eddy currents are produced on the outside of the work piece in what is often referred to as “skin effect” heating

- Almost all of the heat is produced at the surface, the eddy currents flowing in a cylindrical work piece will be most intense at the outer surface, while the currents at the centre are negligible.

Skin Effect and Reference Depth

❖ The depth of heating depends on :-

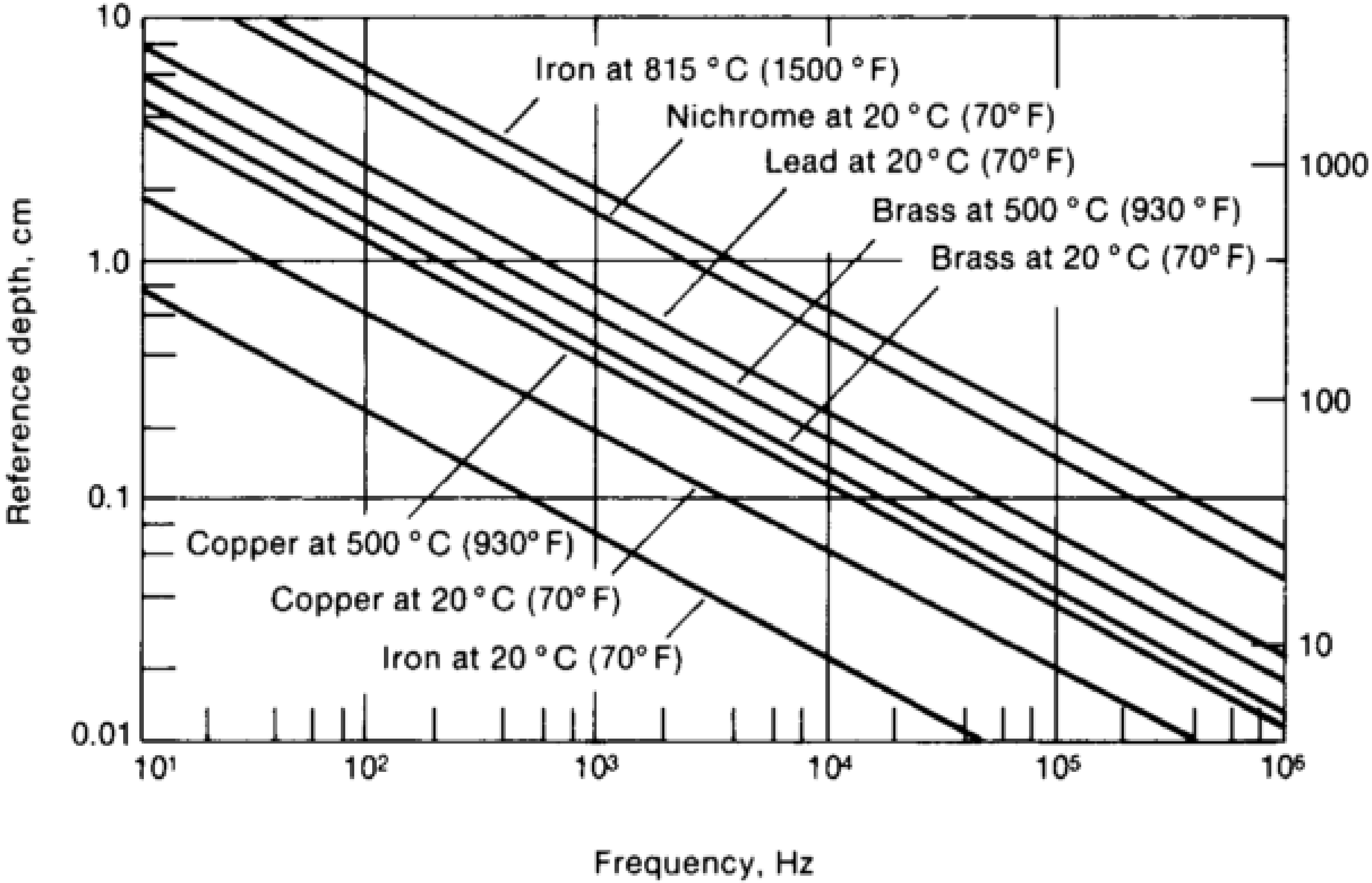
- The frequency of the ac field,
- The electrical resistivity, and
- The relative magnetic permeability of the work piece

Skin Effect and Reference Depth

- The skin heating effect (reference depth) is defined as the depth at which approximately 86% of the heating due to resistance of the current flow occurs.

  - ➢The reference depths decrease with higher frequency and Increase with higher temperature.

Skin Effect and Reference Depth



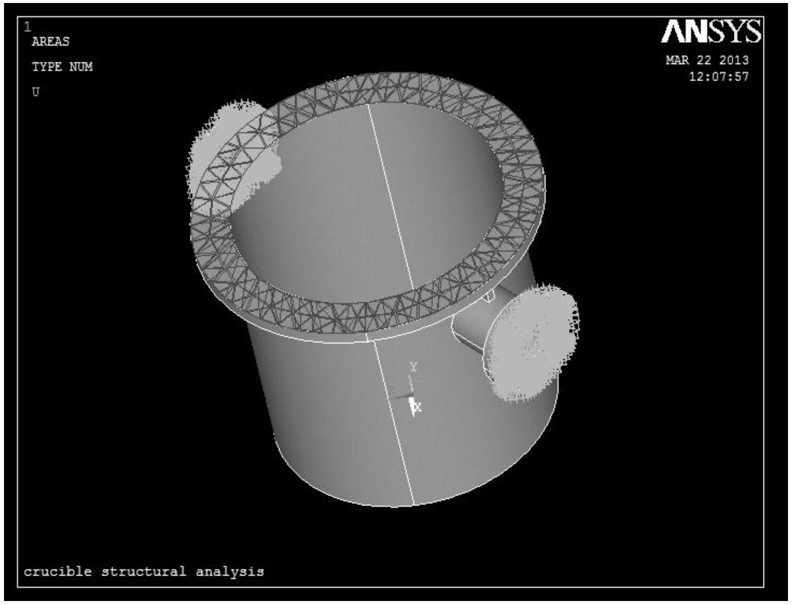
Reference depth for various materials. Source: Ref 2

Skin Effect and Reference Depth

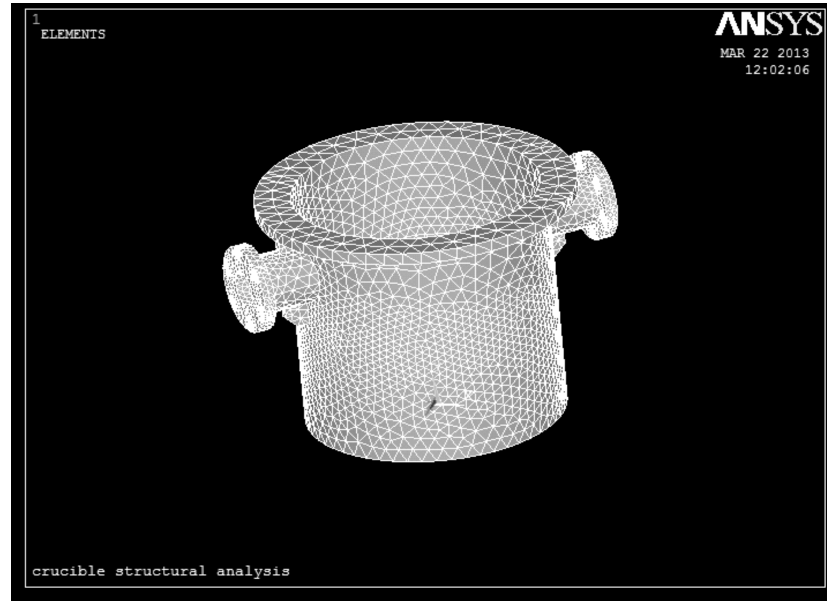
- The reference depth, as mentioned, becomes the theoretical minimum depth of heating that a given frequency will produce at a given power and work piece temperature.
- The cross-sectional size of the work piece being heated must be at four times the reference depth

DESIGN ANALYSIS

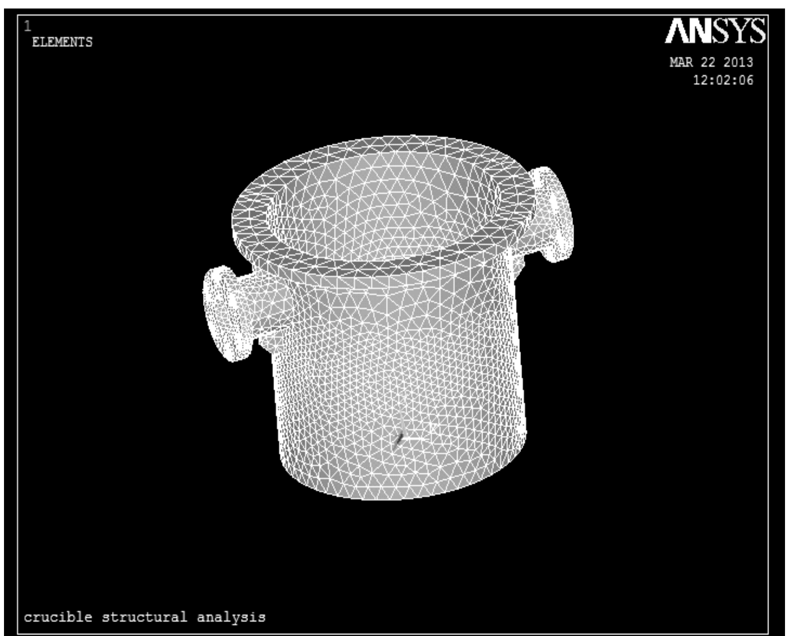
LOAD APPLIED



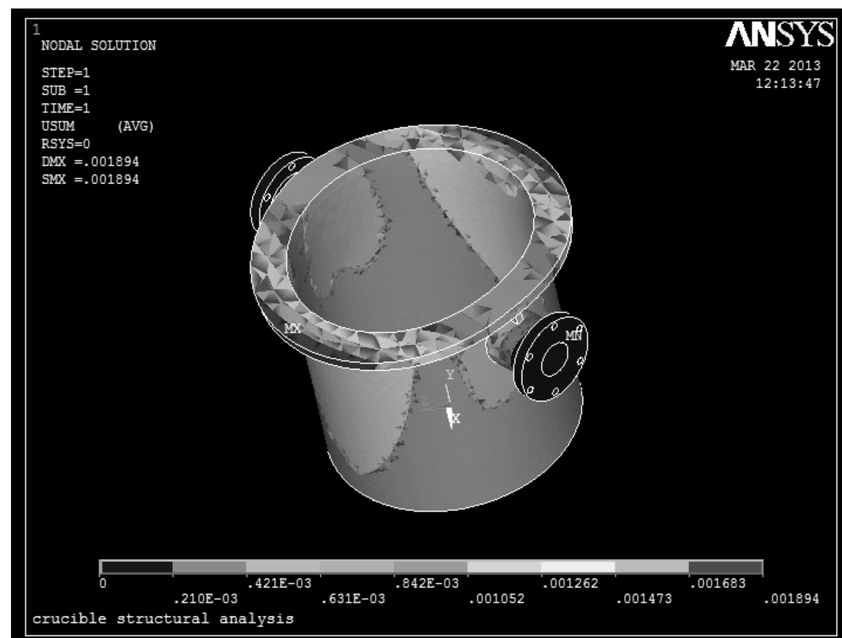
MESHING



DISPLACEMENT

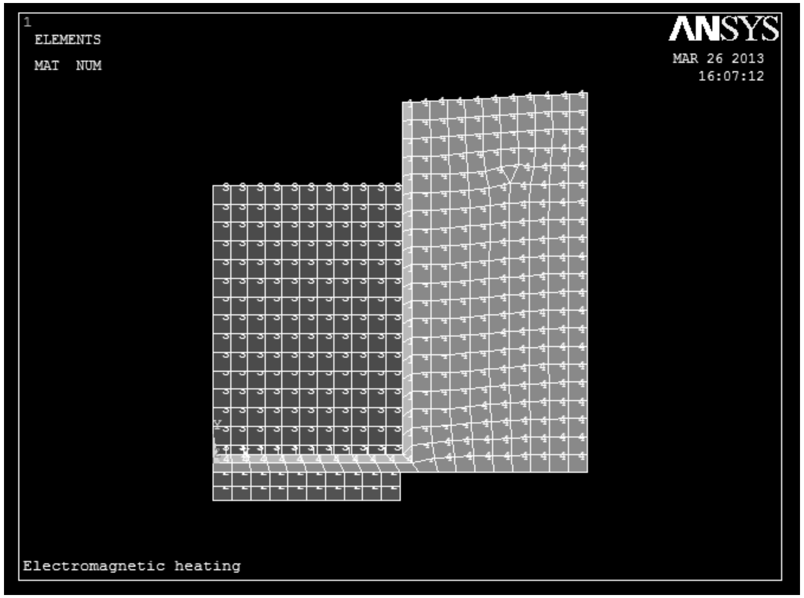


RESULT OF APPLIED LOAD



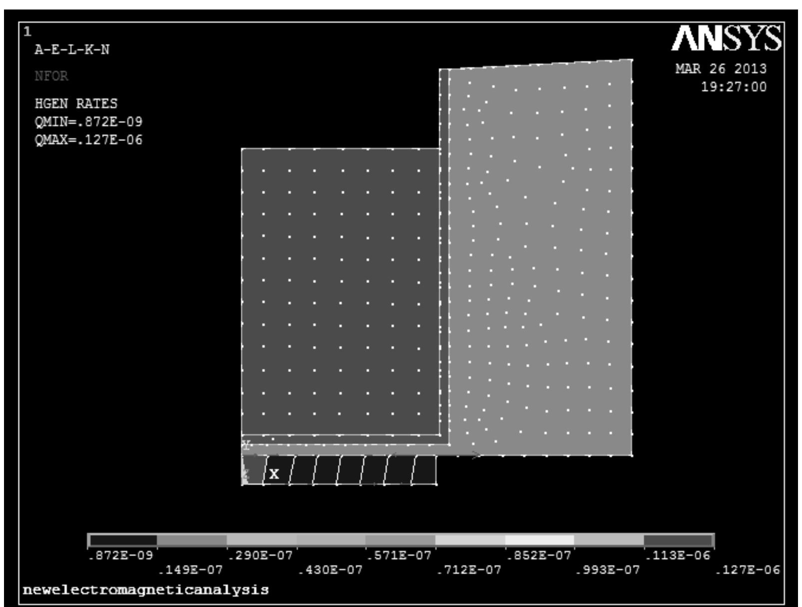
<u>ELECTROMAGNETIC & THERMAL ANALYSIS</u>

MESHING

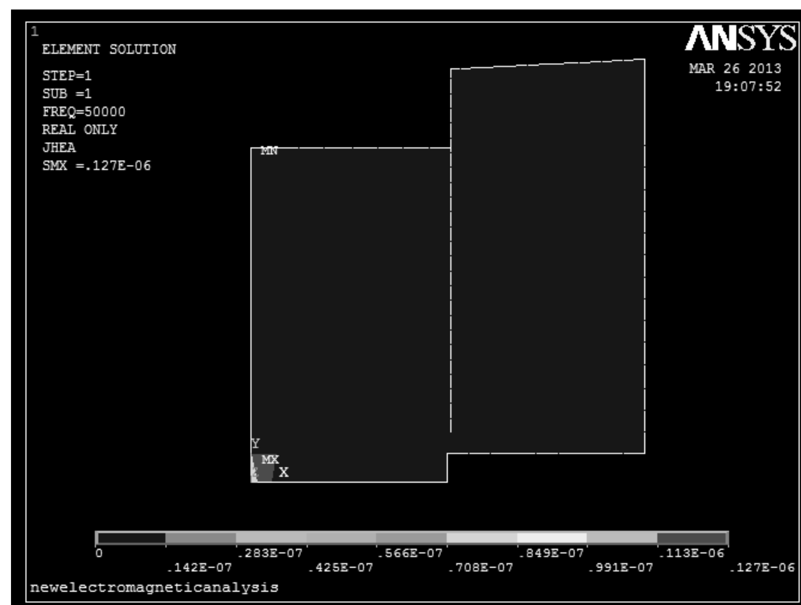


HEAT GENERATION

ELECTROMAGNETISATION



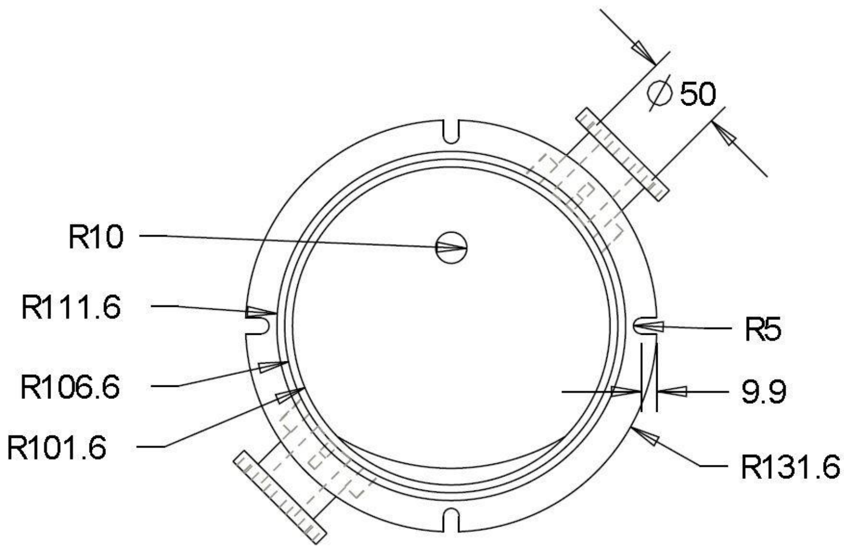
JOULE HEAT GENERATION



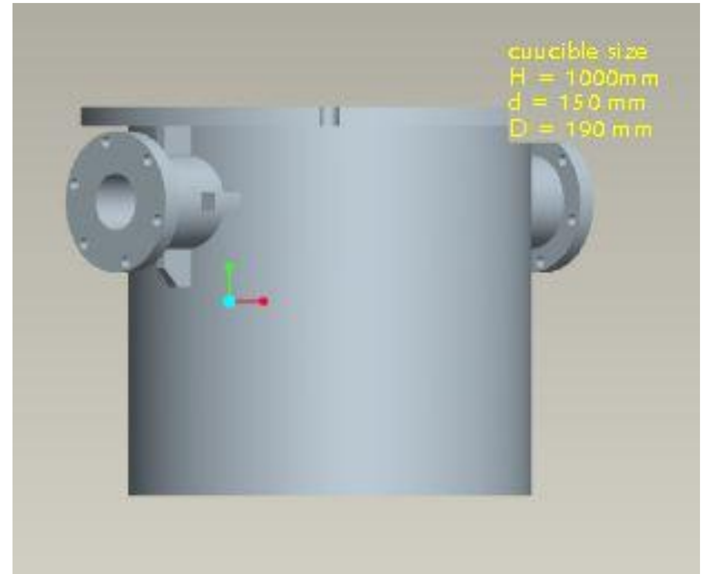
MAGNETIC FLUX GENERATION

PRODUCTION DRAWING

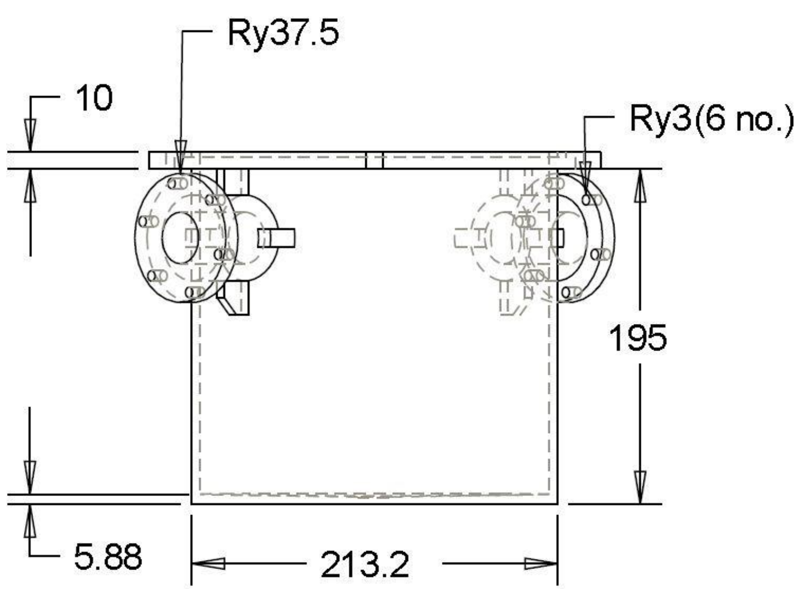
CRUCIBLE



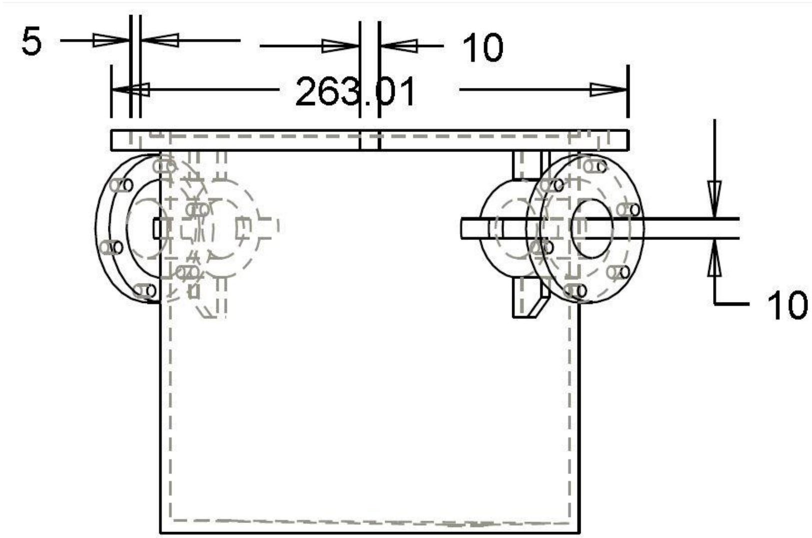
∅50
R10
R111.6
R106.6
R101.6
R5
9.9
R131.6



cuucible size
H = 1000mm
d = 150 mm
D = 190 mm

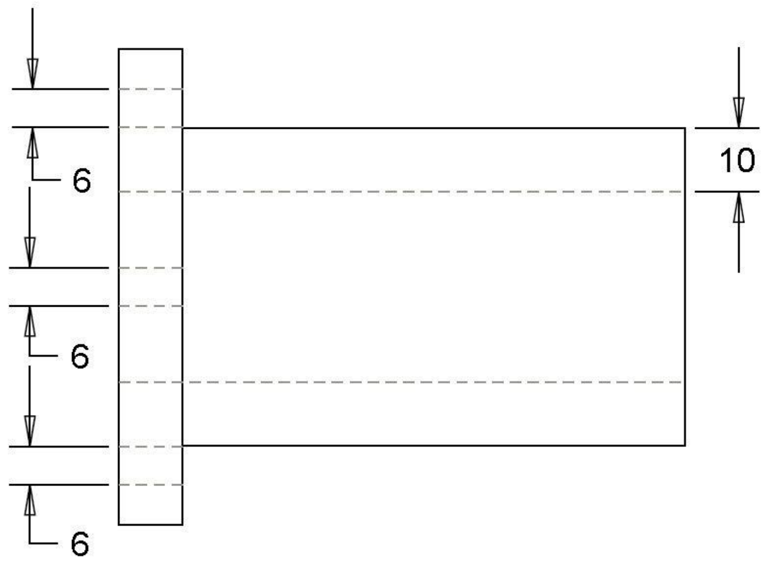


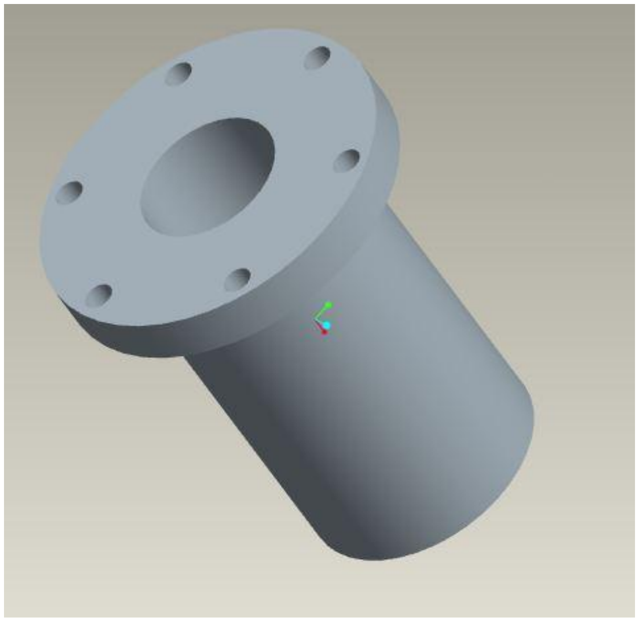
Ry37.5
10
Ry3(6 no.)
195
5.88
213.2

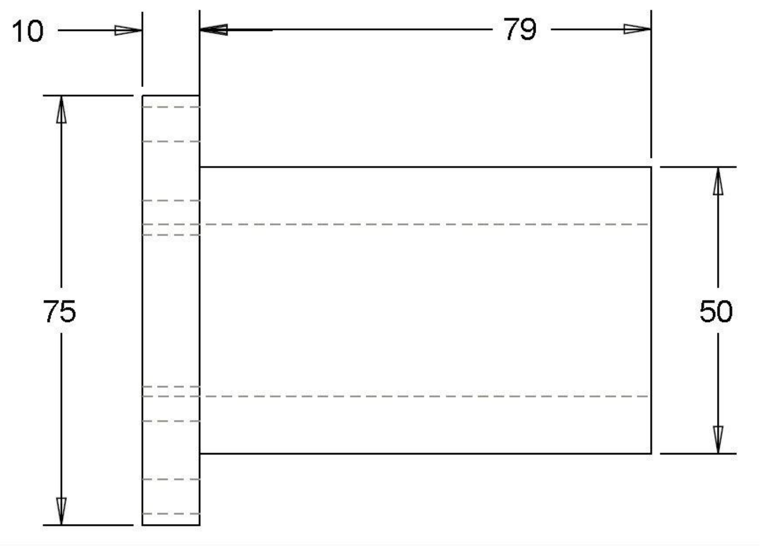


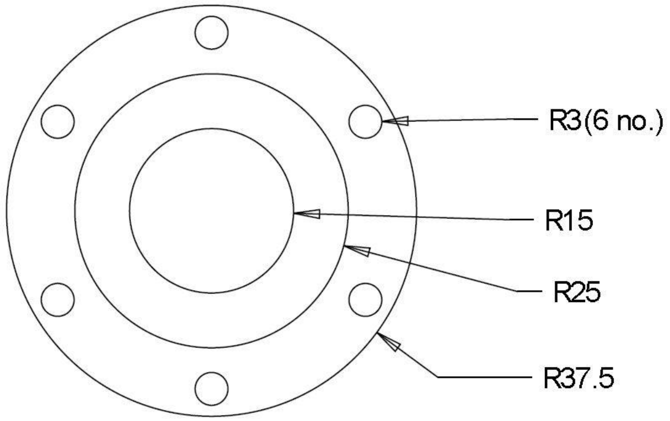
5
10
263.01
10

CRUCIBLE HOLDER

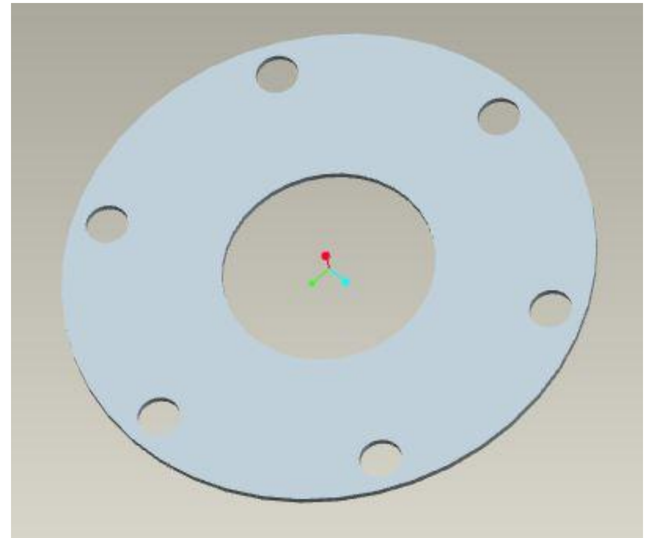


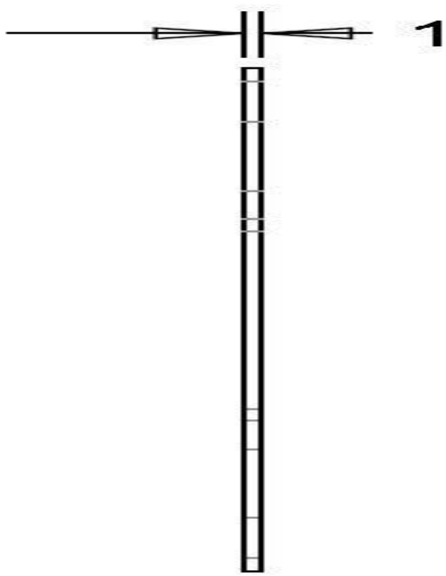


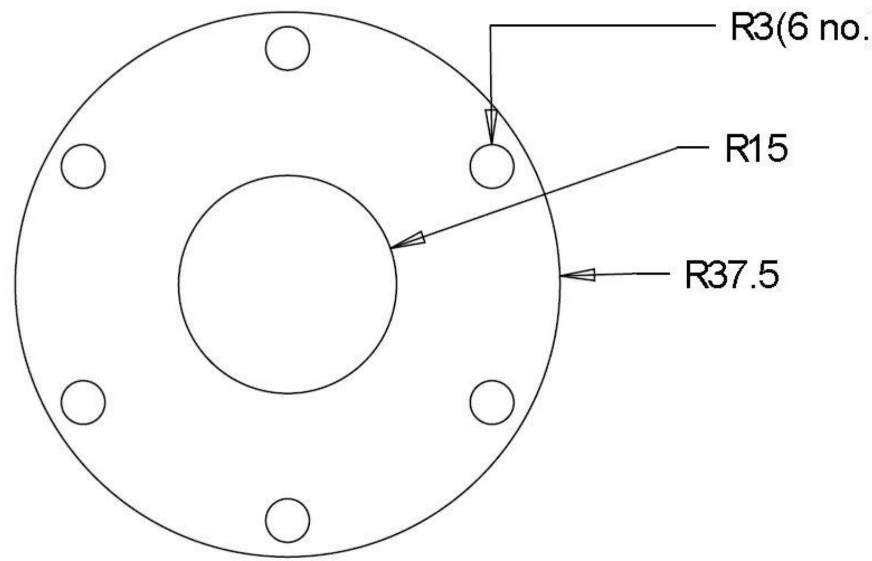




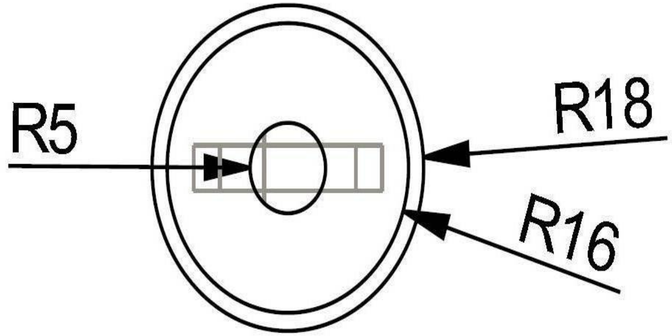
WASHER

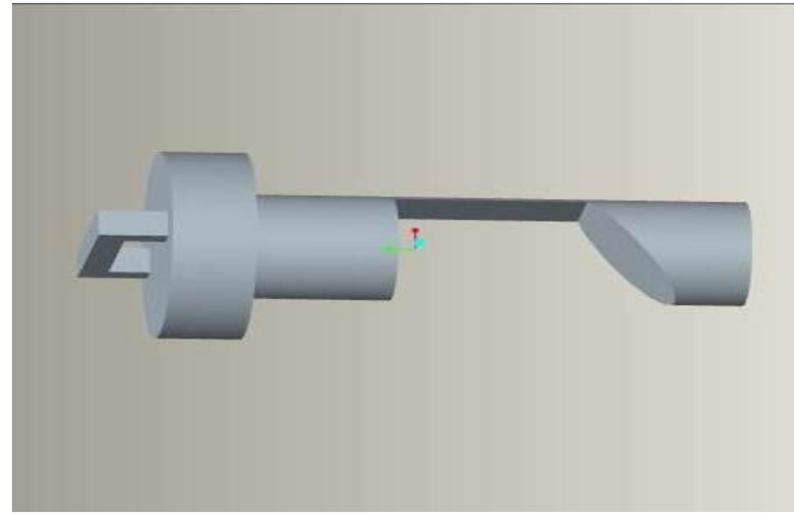


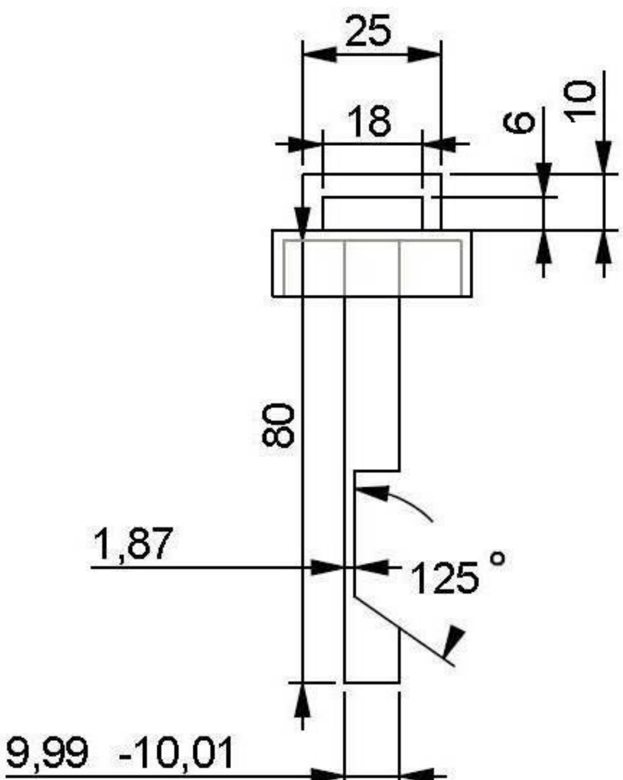


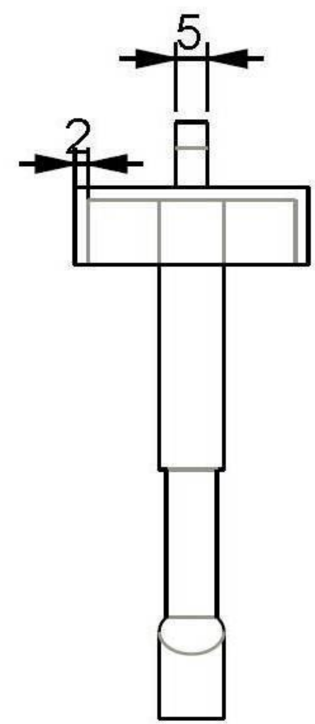


CHARGNG ROD

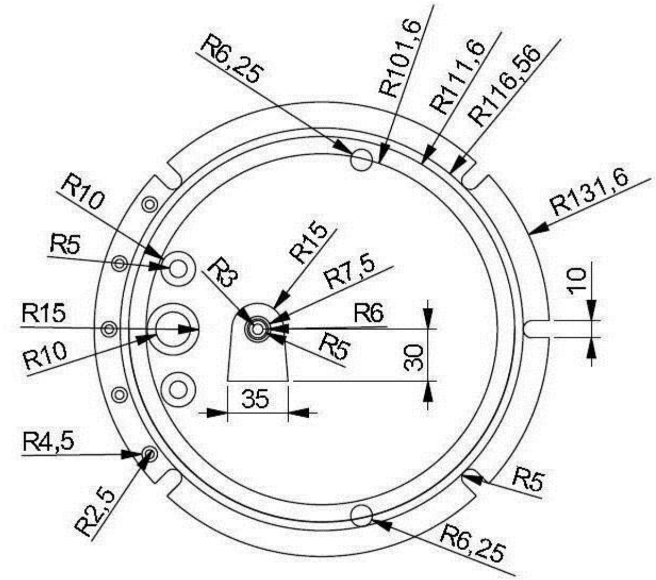


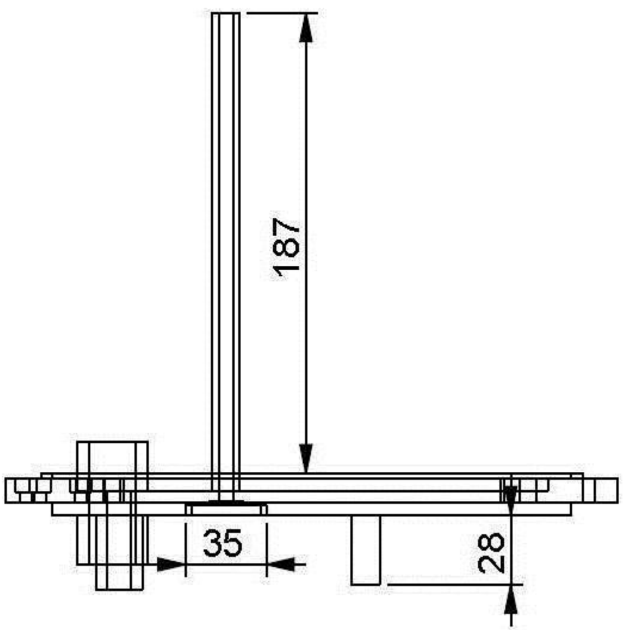


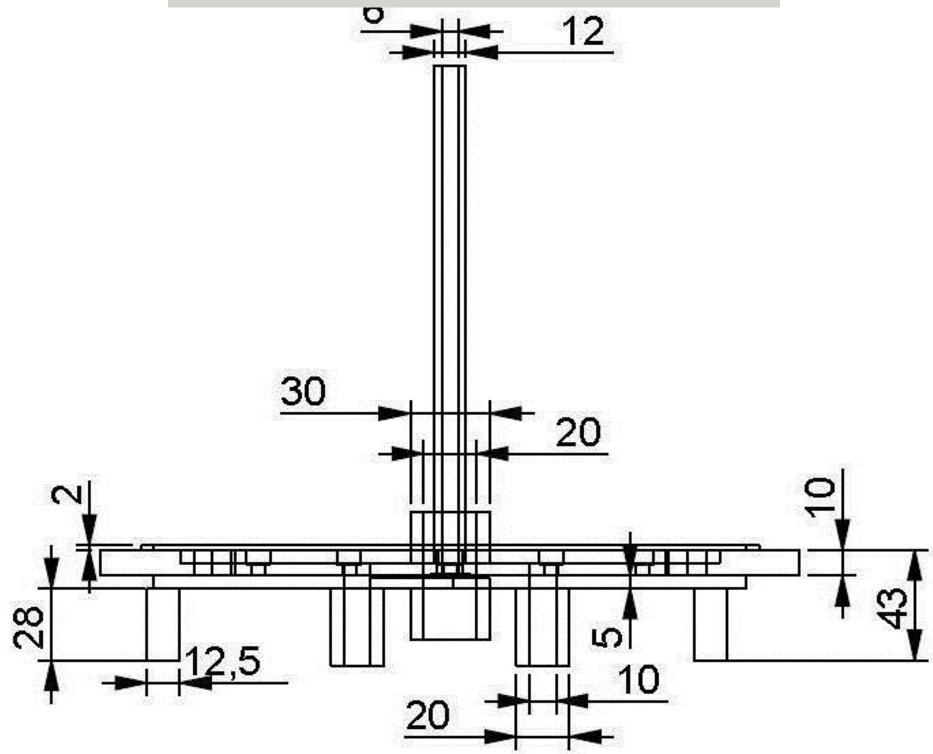




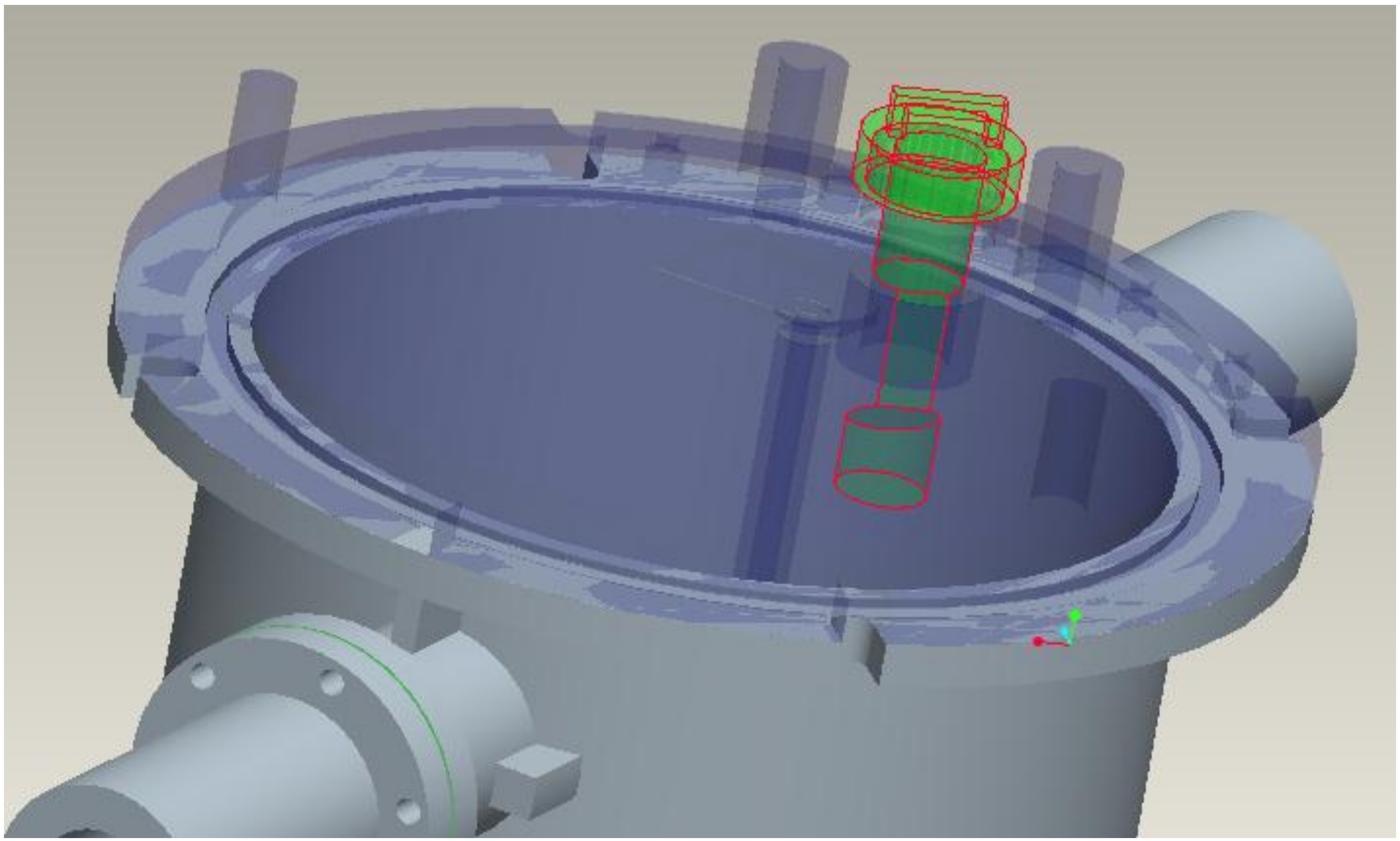
COVER


R6,25
R101,6
R111,6
R116,56
R131,6
R10
R5
R15
R7,5
R3
R6
R5
R15
R10
10
30
35
R4,5
R2,5
R5
R6,25

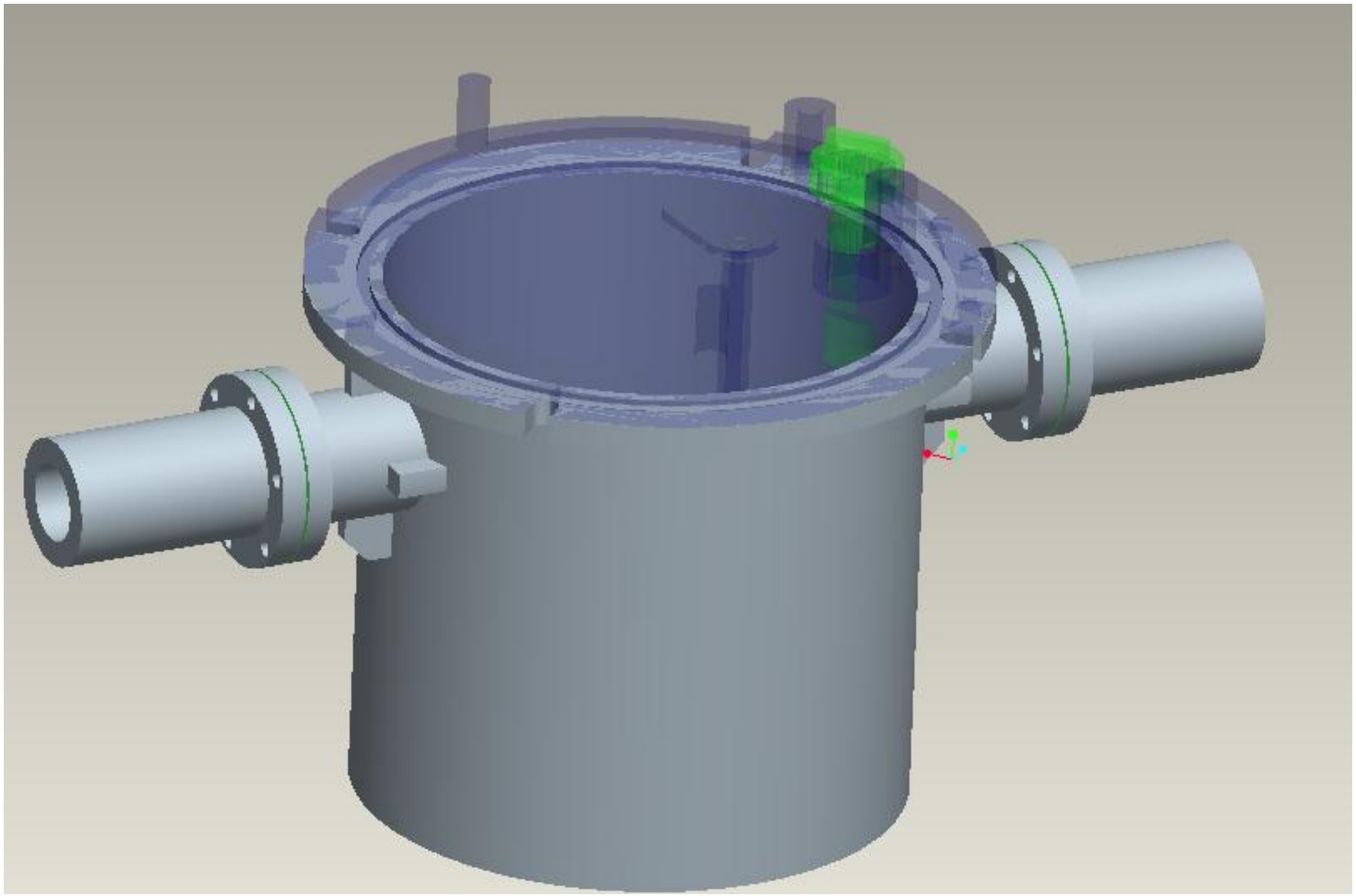

187
35
28

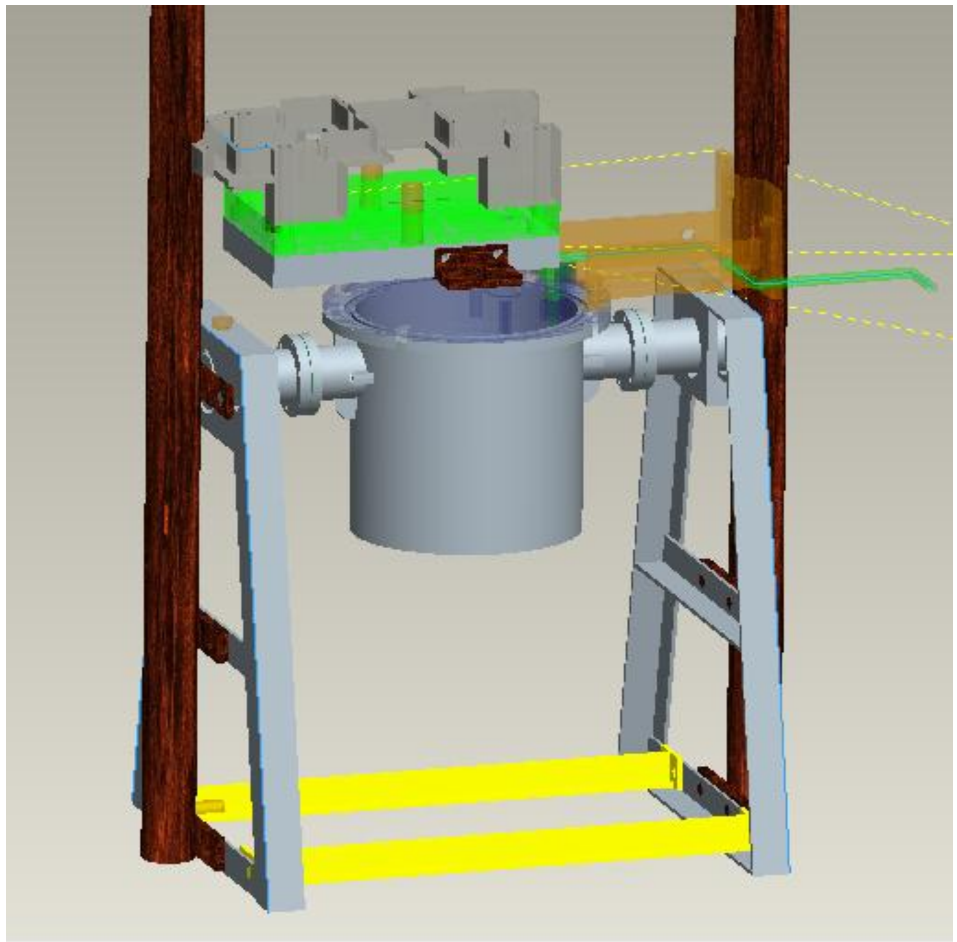

6
12
30
20
2
10
28
43
5
12,5
10
20

Assembly



crucible





CONCLUSIONS

- The induction melting furnace is design for 5 litre by volume capacity 8 Kg
- The structural analysis of the furnace is safe with the load of 150 kg self and accessories weight.
- Structural and thermal analysis is carried on sucessfully
- Transient Thermal analysis of induction furnace is being carried out in this study which is highly important for operation and control of the process.
- The coil temperatures are above the acceptable temperature of copper material, hence different cooling technique is to be adopted.

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