Vacuum casting

Similar to investment casting, except: fill mold by reverse gravity. This process is also called counter-gravity casting. It is basically the same process as investment casting, except for the step of filling the mold (step (e) above). In this case, the material is sucked upwards into the mould by a vacuum pump. The figure 9 below shows the basic idea – notice how the mold appears in an inverted position from the usual casting process, and is lowered into the flask with the molten metal.

One advantage of vacuum casting is that by releasing the pressure a short time after the mold is filled, we can release the un-solidified metal back into the flask. This allows us to create hollow castings. Since most of the heat is conducted away from the surface between the mold and the metal, therefore the portion of the metal closest to the mold surface always solidifies first; the solid front travels inwards into the cavity. Thus, if the liquid is drained a very short time after the filling, then we get a very thin walled hollow object, etc. (see Figure 10).

The main steps of Vacuum casting are:

(a) Wax patterns are produced by injection molding

(b) Multiple patterns are assembled to a central wax sprue

(c) A shell is built by immersing the assembly in a liquid ceramic slurry and then into a bed of extremely fine sand. Several layers may be required.

(d) The ceramic is dried; the wax is melted out; ceramic is fired to burn all wax

(e) (e) The shell is filled with molten metal by gravity pouring. On solidification, the parts, gates, sprue and pouring cup become one solid casting. Hollow casting can be made by pouring out excess metal before it solidifies

(f) The parts are cut away from the sprue using a high speed friction saw. Minor finishing gives final part.

(g) After metal solidifies, the ceramic shell is broken off by vibration or water blasting

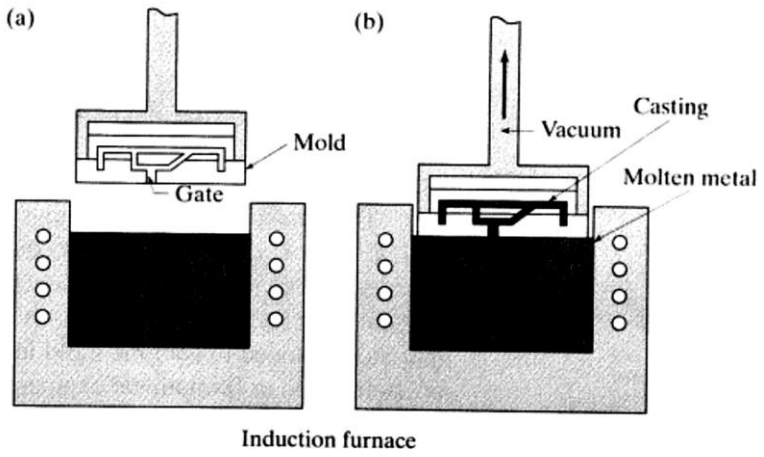


Figure 9. Vacuum casting [source: Kalpakjian & Schmid]

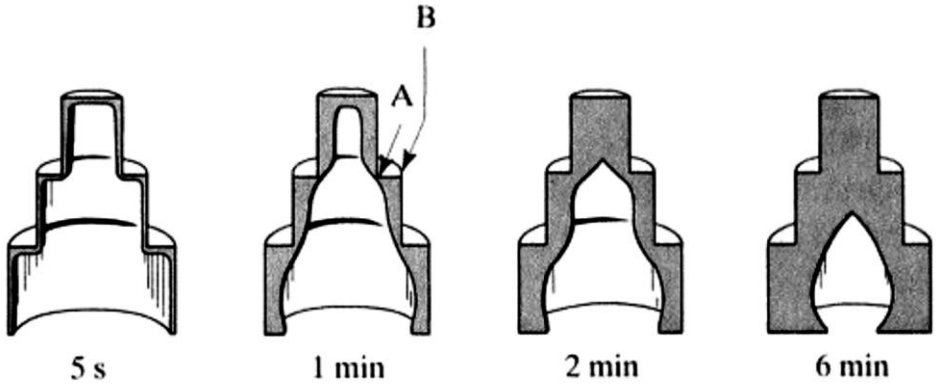


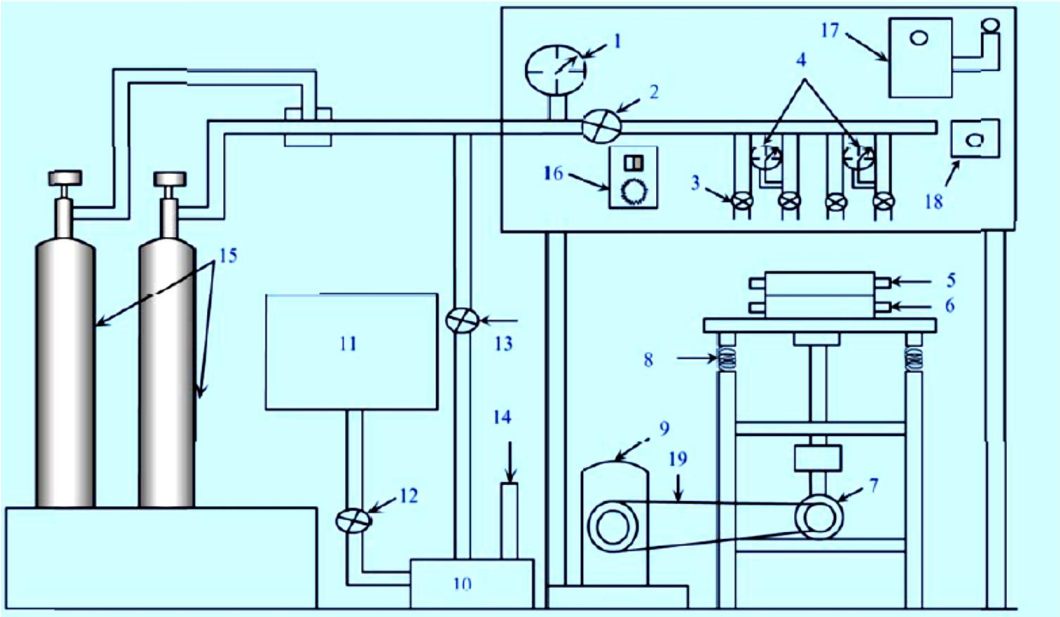
Figure 10. Draining out metal before solidification yields hollow castings [source: Kalpakjian & Schmid]

Vacuum Sealed Molding Process Set Up

The set up details are not available in literature. However, at IIT Roorkee the set up, to produce the V-Process mold, was developed. A photograph of the set up is shown in Fig. 2.5.1. The schematic diagram of the V-process experimental set up is shown in Fig. 2.5.2. The whole set up is divided into the following parts:

- Molding System: (a) Pattern box, (b) Molding box, (c) Pattern
- Vacuum System
- Vibrating System: (a) Vibration table, (b) Vibrator, (c) Motor
- Plastic Film Holding and Heating System

Fig.2.5.1 Photograph of Experimental Set-up in Vacuum Sealed Molding



1. Vacuum gauge in main line, 2. Main control valve, 3. Control valves in sub line for cope and drag, 4. Vacuum gauge in sub-line,5. Molding box, 6. Pattern plate, 7. Vibrator, 8. Spring, 9. Motor, 10. Vacuum pump, 11. Water tanks, 12. Water out let valve, 13. Inlet control valve of vacuum pump, 14. Outlet control valve of vacuum pump, 15. Surge tank, 16. speed controller box, 17. Main starting switch, 18. Vacuum pump control switch, 19. V-belt

Fig.2.5.2 Schematic diagram of V process experimental set-up

Molding System

The molding system comprises of the equipment needed to prepare the mould. This includes the pattern box, molding box and pattern.

Pattern box

The pattern box is shown in Fig. 2.5.3. The pattern plate is placed on the straight top open surface of the pattern box, and perfect matching between the mating surfaces is achieved. In order to ascertain the perfect matching, the pattern plate, having equidistant holes, is provided with four support blocks at the four corners in the pattern box. Additional support at the centre has been provided to prevent warping of pattern plate when subjected to vacuum pressure. The pattern box is fixed to the vibrating table.

Molding box

In the design of molding box, shown in Fig. 2.5.4, the major consideration is to have a uniform distribution of vacuum throughout the body of sand to form the mould. The design of molding box for V-process is more complicated than conventional sand molding process. The box has to be made with annular wall on all the four sides. Inside walls are provided with windows. These windows are covered with very fine mesh and backed by a thin metallic strip having small holes for supporting the fine mesh. This mesh prevents very fine sand particles from being sucked up from the sand voids in the box into the vacuum pump. Two metallic pipes are connected with outside wall of the box. One pipe is used to suck the vacuum from the box and another pipe to release the vacuum to the atmosphere.

Pattern

The patterns used in V-process are similar to the pattern used in other conventional sand casting processes. Numerous small holes are created on the vertical edges of the pattern, used in V-Process, so that plastic film is correctly adhered to the vertical surface of the pattern, thus creating the right cavity in the mold. A simple four stepped pattern, having small holes at the vertical edges, is shown in Fig. 2.5.5.

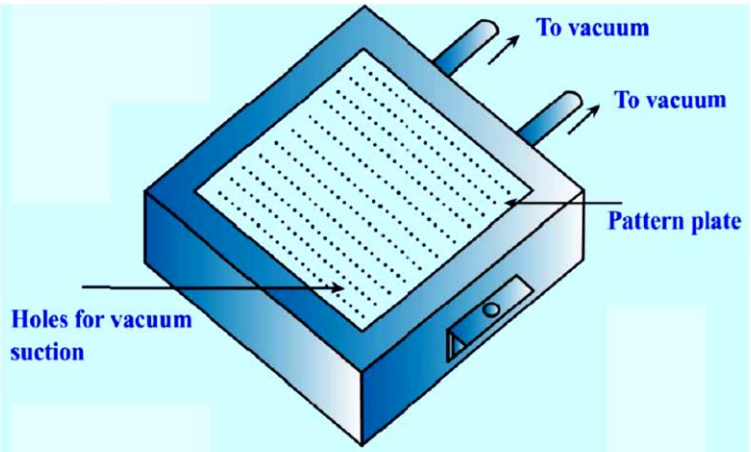


Fig.2.5.3 Pattern Box

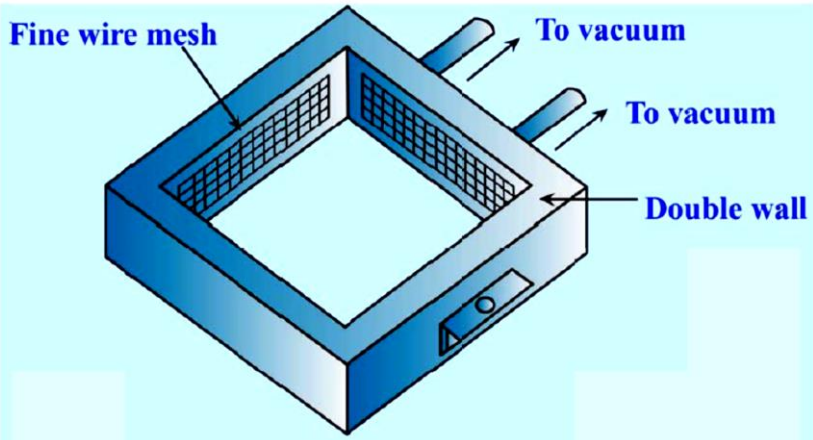


Fig. 2.5.4 Molding Box

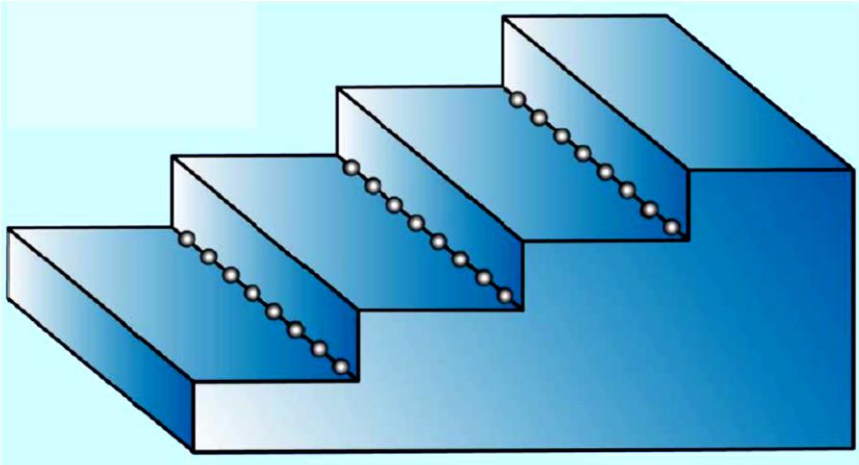


Fig.2.5.5 Four Stepped Pattern

Vacuum System

Vacuum is applied to the molding box containing sand to ruggedize the mould as well as to withdraw the decomposed gases. It remains constant and active during pouring of molten metal till solidification.

Vibrating System

Vibration system is used to compact the sand. Vibration system must have a provision for varying vibration amplitude and frequency. The vibration system consists of vibrating table, vibrator and digital varied-drive motor.

Plastic Film Holding and Heating System

To prepare a mould, two plastic polyethylene / Ethylene vinyl Alcohol films are used. The purpose of using two plastic films (one on top and other for bottom of the molding box) is to seal the box. The film is heated up to plastic deformation so that it adheres tightly to the pattern and the top / bottom surface of the mold. Also, heating system is needed to soften the plastic film.

Process Parameters of V-Process

To identify the major process parameters which affect the qualities in a V-process, an Ishikawa cause and effect diagram is constructed and is shown in Fig. 2.5.6. It depicts that the following process parameters considerably affect the quality of castings produced by V-process.

- Variables based on molding sand: - shape, type, size and size distribution.
- Variables based on plastic film - type and thickness.
- Variables based on vibration - amplitude, frequency and time of vibration.
- Variables based on vacuum - degree of vacuum imposed.
- Pouring material based variables – pouring time and temperature.

V-Process Outcome Specifications

- Tolerances: One side of parting line ± .010" up to 1". Over 1" add ± .002"/in.
- Surface Finish: 125 – 150 RMS
- Surface Finish: Cored Area 150 – 250 RMS
- Draft Requirement: Nil
- Minimum Section Thickness: 2.5 mm

Vacuum Sealed Molding Process

The Vacuum sealed molding (V process) makes use of dry sand, plastic film and a negative vacuum pressure as a means for binding. The process was developed in 1971 in Japan. Due to its unique capability in producing smooth and accurate castings, the process gained further importance. The basic difference that exists between the V-process and other sand molding

processes is the different method by which sand is bound to form the mold cavity. In vacuum used in the V-process is of the order of 250 – 450 mm Hg. This pressure is used to bind the dry and free flowing sand particles which is encapsulated in between two plastic films. This process makes use of vacuum assisted by the plastic film to form a mold cavity over the pattern. Unbounded dry sand is used as a backing material and vibrations are used to compact it.

After pouring the molten metal into the mold, the plastic film melts and gets sucked inside the sand voids due to imposed vacuum. It further gets condensed and forms a shell-like layer. The vacuum is required to be maintained till the metal is solidified. Then it is released, allowing the sand to drop away, thereby leaving behind the casting with a smooth surface.

The process does not require shaking out methods and equipment to remove the casting out and the sand can be reused after cooling without any reatments.

Advantages

- Very good surface finish with good dimensional accuracy.
- Patterns have a long life.
- Reproducibility is good and consistent.
- Draft is not required, thereby reducing material and realted costs.
- Low Cleaning / Finishing Cost.

Applications

The size of the product is no limitation in the V-Process. However, as found in literatures, the application of V-process castings are in the range of up to 8 tons for ingots. Some other applications, wherein V-process was used as a preferred casting method are:

- Medical devices
- Computers
- Instrumentations
- Electronic Enclosures

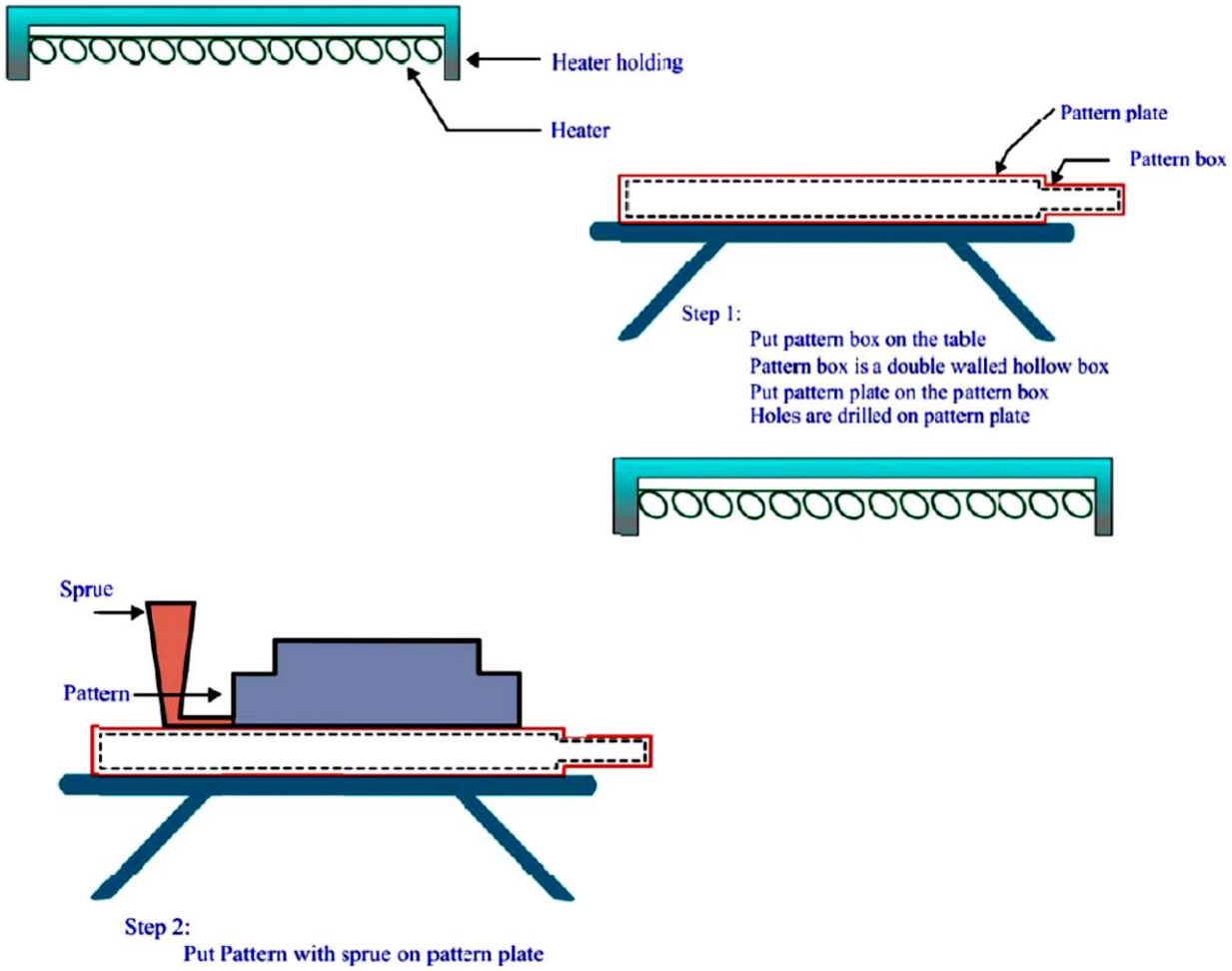
Sequence of Producing V-Process Molds (As shown in fig.2.4.1 below)

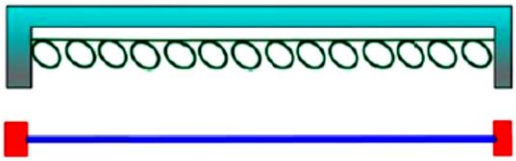
1. The Pattern is set on the pattern plate of pattern box. The pattern and the pattern plates have numerous small holes, which help the plastic film to adhere closely on the pattern when vacuum is applied.
2. In-order to soften the plastic film, a suitable heater is used.
3. The pattern is draped by a softened plastic film. The suction of vacuum takes place through the vents and the plastic film adheres very close to the pattern.
4. The mold box is set on the film coated pattern
5. The mold box is compacted by filling it with dry sand and providing slow vibrations.
6. The mold is further leveled and a plastic film is covered on the top of the

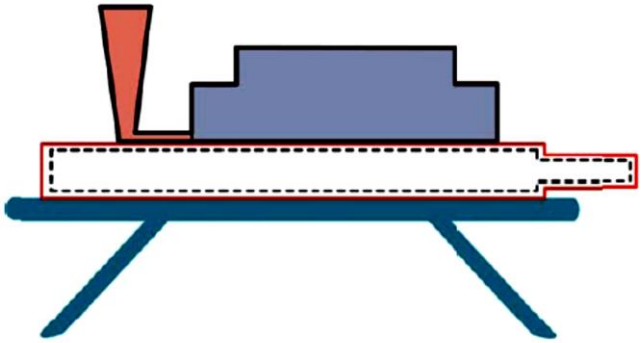
box. The suction created due to vacuum helps in stiffening the mold.

7. Releasing the vacuum on the pattern box, helps in stripping off the mold easily.
8. Cope and Drag are both assembled and the metal is poured. Vacuum is maintained during pouring.
9. The vacuum is further released, once the mold boxes get cooled, this allows sand to freely flow back, thereby leaving a clean casting behind.

The sequence of producing the casting made by vacuum sealed molding process is shown in following figures.

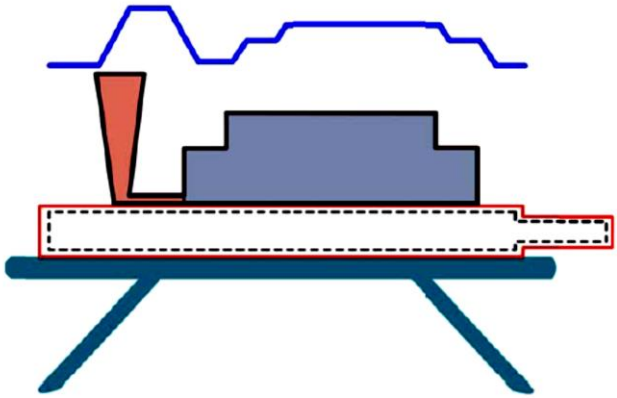






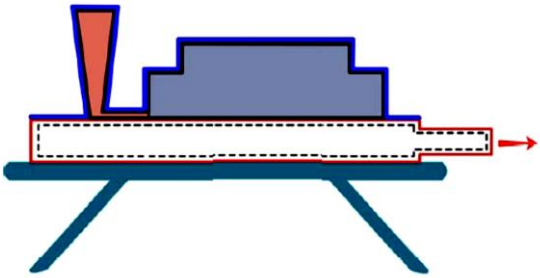
Step 3 (a):

Switch on the heater, heat film and put it over pattern plate
Apply vacuum to pattern box.

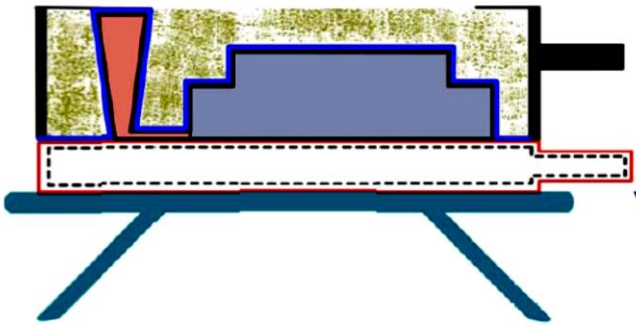


Step 3 (b):

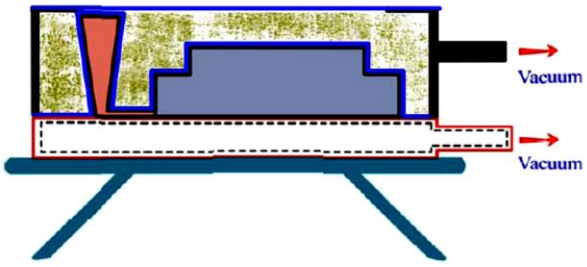
Switch on the heater, heat film and put it over pattern plate
Apply vacuum to pattern box.



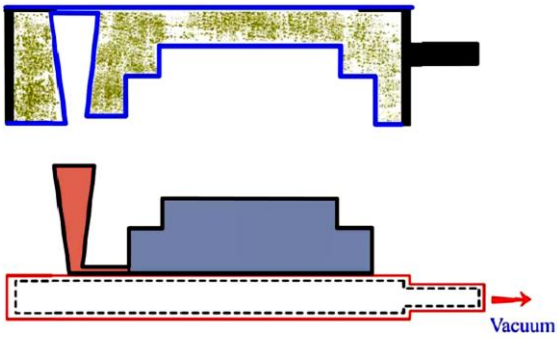
Step 3:
Switch on the heater, heat film and put it over pattern plate
Apply vacuum to pattern box.



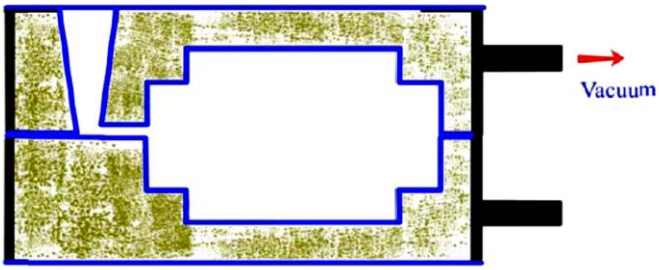
Step 4:
Now put cope on pattern plate fill it with sand ans shak



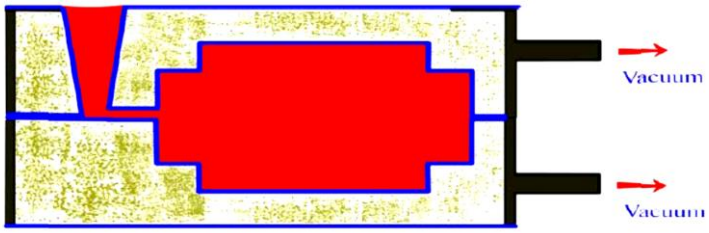
Step 5:
Heat film and put it over cope and apply vacuum



Step 6:
Release the vacuum of pattern plate and remove cope with sand carefully from pattern plate.



Step 7:
Prepare drag simillarly



Step 8.
Pour molten metal in cavity andrelease vacuum form cope and drag

It is the final casting

Fig.2.4.1: Different steps in vacuum sealed molding process