Advanced Manufacturing Processes
Prof. Dr. Apurbba Kumar Sharma
Department of Mechanical and Casting Process
Indian Institute of Technology, Roorkee

Module - 2
Advanced Metal Casting Processes
Lecture - 4
Hybrid EPC Processes and Vacuum EPC Process

Welcome to this session on casting processes under advanced manufacturing processes. In this session, we will study the hybrid evaporative pattern, casting processes. That is vacuum assisted evaporative pattern casting processes. In the previous session, we have already studied few advanced casting processes like continuous casting process, permanent mold casting process, etcetera. Now, let us come to the hybrid evaporative pattern casting processes. We have already seen while discussing the evaporative pattern casting processes.

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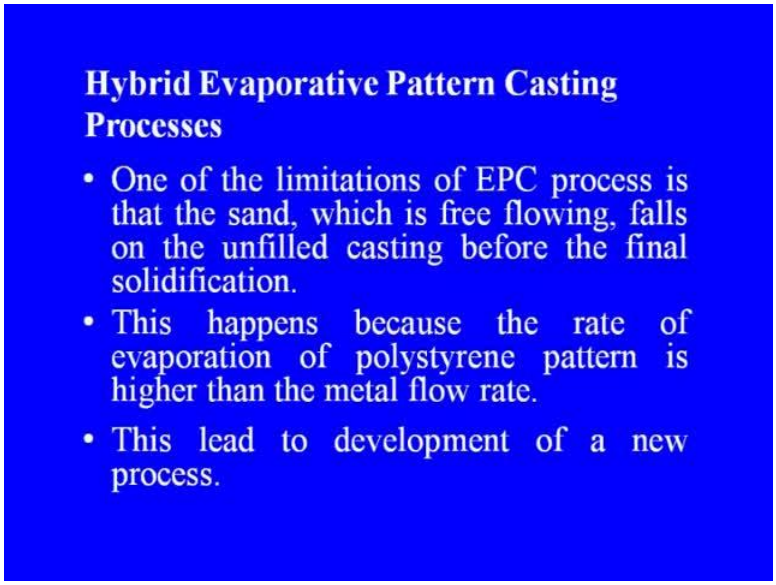

That in evaporative pattern casting process sand, which is free flowing falls on the unfilled casting before the final solidification. This happens because the rate of evaporation of polystyrene pattern is higher than the metal flow rate. This lead to development of a new process. The pattern vaporises ahead of the flowing stream of the metal because of the radiant heat send at it from the hot metal. As a result, the sand falls in the cavity and intern produces a defective casting. This problem has been overcome by

combining the process sequence of the evaporative pattern casting and vacuum sealed molding process.

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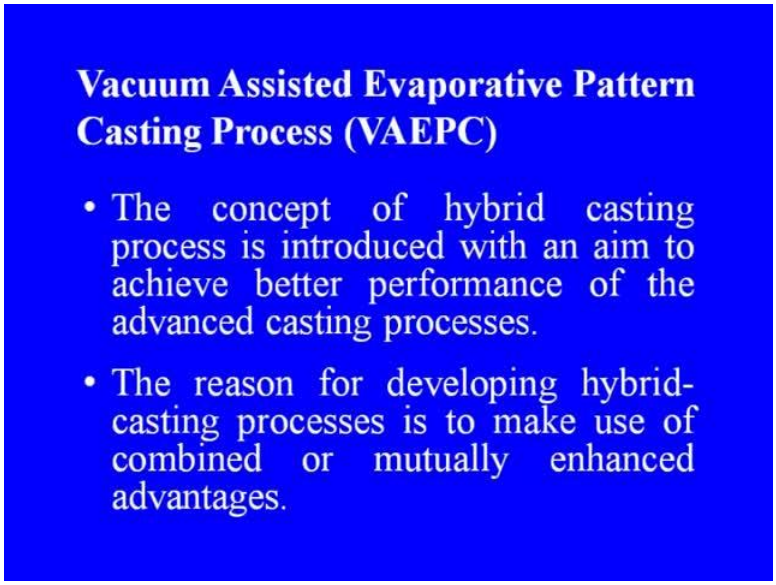

Now, let us see in details, the vacuum assisted evaporative pattern casting process. In short it is known as VAEPC process. The concept of hybrid casting process is introduced with an aim to achieve better performance of the advance casting processes. The reason for developing hybrid casting processes is to make use of combined or mutually enhanced advantages. It avoids or reduces some adverse effects of the constituent processes, if there is any, when they are individually applied. It has been discussed earlier that the evaporative pattern casting process is a binder less process, wherein no physical bounding is required to bind a sand aggregates. The process, however does not guaranty a sound casting every time as it becomes difficult to control the rate of pouring.

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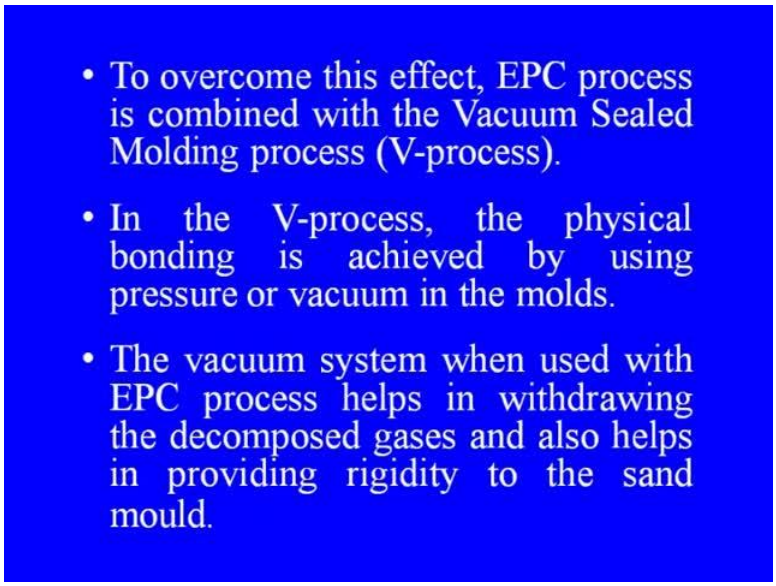

So, as to match with the rate of polystyrene burning to overcome this effect, the evaporative pattern casting process is combined with the vacuum sealed molding process, also known as V process. In the V process the physical bonding is achieved by using pressure or vacuum in the mold. The vacuum system when used with EPC process helps in withdrawing the decomposed gases and also helps in providing rigidity to the sand mold. Then what are the additional requirements for vacuum assisted evaporative patters casting process?

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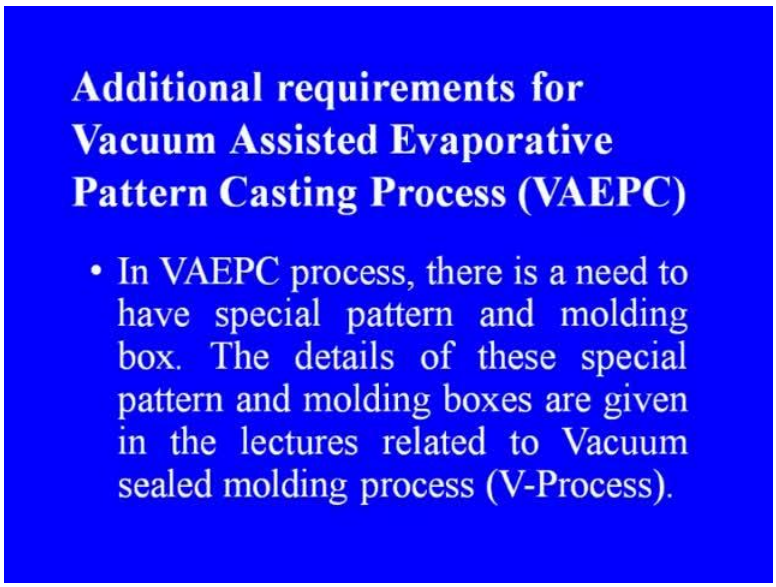

In the vacuum assisted evaporative pattern casting process, there is a need to have special pattern and molding box the details of these special pattern and molding boxes are given in the lectures related to vacuum sealed molding process. Similarly, as in the V process, there is a need to have an arrangement for vacuum denoting system to apply vacuum. In the pattern and molding boxes, the vacuum assisted evaporative pattern casting process also uses such an arrangement the pattern box.

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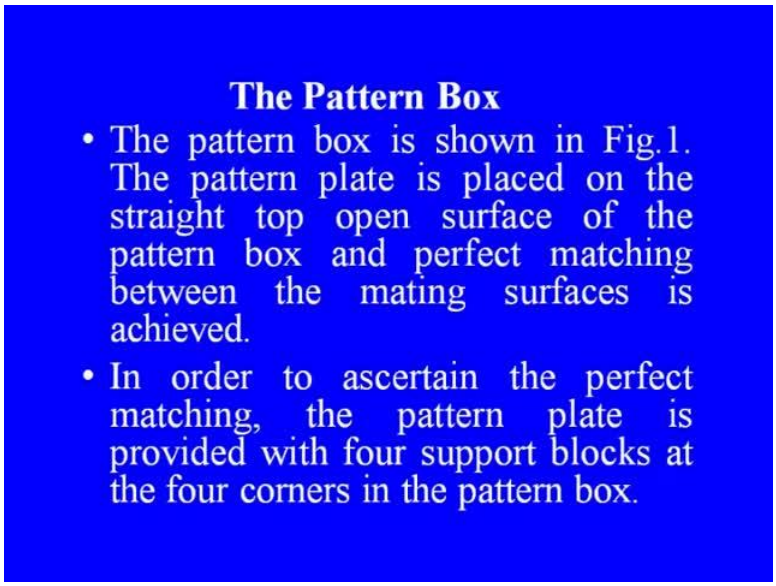

The pattern box is as shown in figure one, the pattern plate is placed on the straight top open surface of the pattern box and perfect matching between the mating surface is achieved. In order to ascertain the perfect matching the pattern plate is provided with four support blocks at the four corners in the pattern box. The additional support at the centre has been provided to prevent wrapping of the pattern plate when subjected to vacuum pressure. The pattern box is fixed to the vibrating table a pattern plate having small holes at equidistant places can be used.

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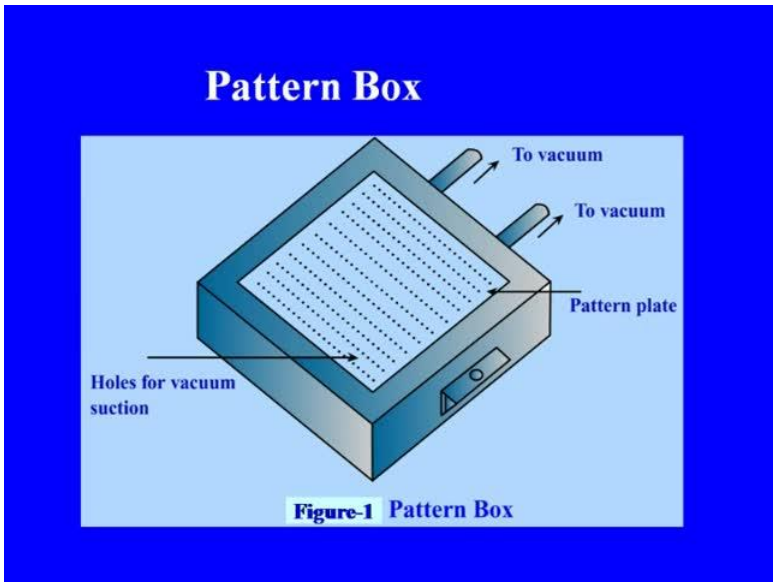

This is the figure of a pattern box, these are the small holes for suction for vacuum, this is the pattern vacuum pattern plate and this is the arrangement for the connection to the vacuum system.

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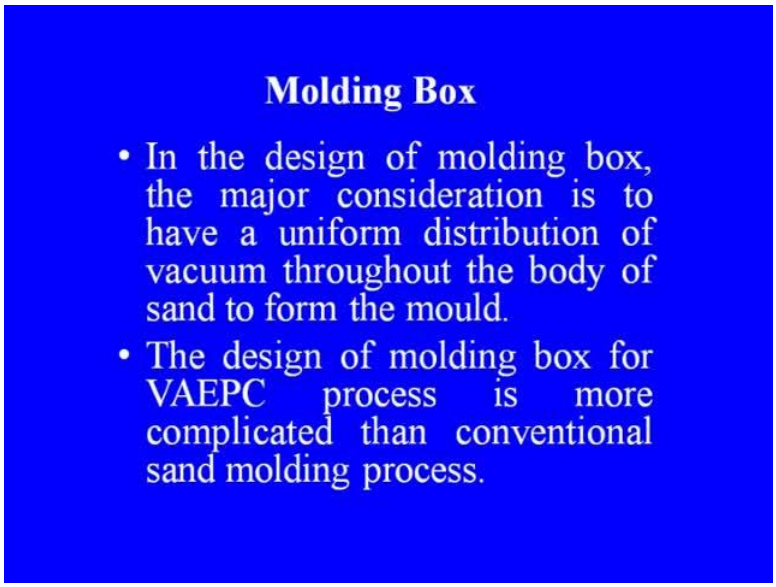

The molding box, in the design of molding box, the major consideration is to have a uniform distribution of vacuum throughout the body of sand to form the mold .The design of molding box for VAEPC process is more complicated than conventional sand molding process. The box has to be made, which annular wall on all the four sides inside

walls are provided with windows. These windows are covered with very fine mesh and backed by a metal 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 pipes are connected with outside wall of the box. One pipe sucks the vacuum from the box and another pipe releases the vacuum to the atmosphere.

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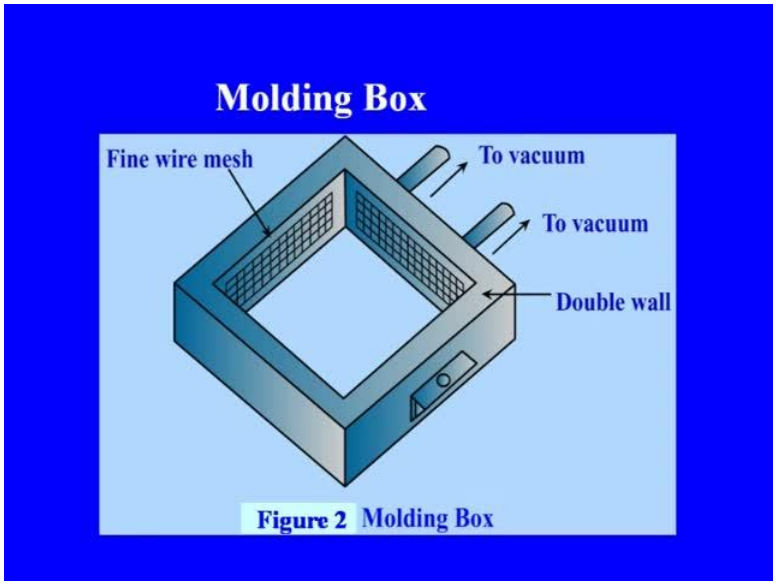

The molding box is shown in figure two, this is the molding box arrangement, this is the double wall arrangement and these are the two openings to the vacuum arrangements, this is the fine wire mesh. Now, let us see the process description, the process sequence of the vacuum assisted evaporative pattern casting is shown in figure three.

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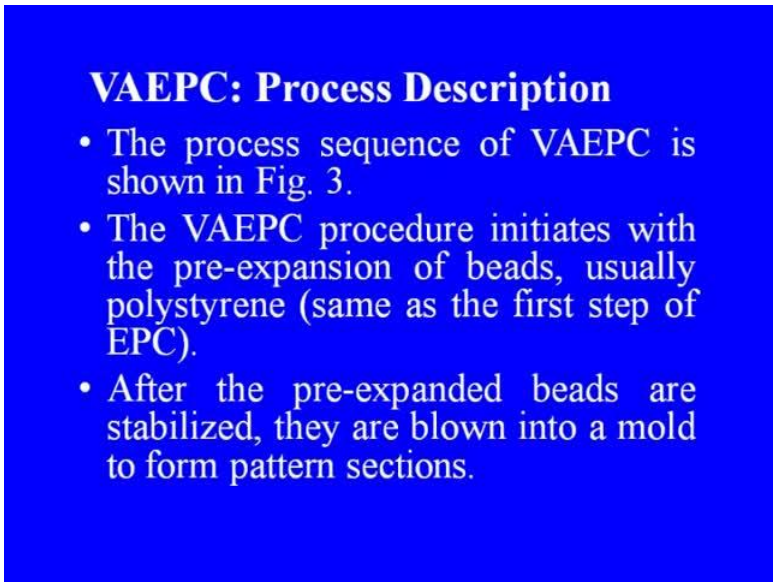

The procedure initiates with the pre expansion of the beads usually polystyrene. This is same as the first step of the earlier discussed evaporative pattern casting process. After the pre expanded beads are stabilised, they are blown in to a mold to form pattern sections.

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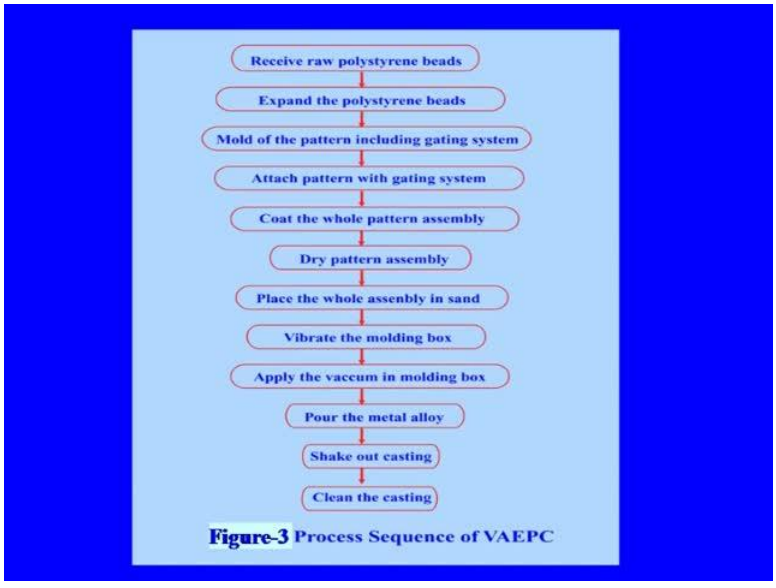

This is the complete flow chart of the vacuum assisted evaporative pattern casting process. The first thing in the first stage raw polystyrene beads are received. They are expanded, then the mold of the pattern including the gating system is been made. Then

the pattern is attached with getting system. The whole pattern assembly is coated in the next stage. The pattern assembly is dried then it is placed in the sand the entire assembly then the molding box is vibrated. Then the vacuum is applied on the molding box, in the next stage metal alloy is poured and then shake out the casting.

Then followed by cleaning of the cast in the mold. The steam cycle helps in fusing the beads together by full expansion. This type is again similar to the first step of the evaporated pattern casting process. The different sections of patterns are joined by gluing together and assembled the gating system is also glued and attached in.

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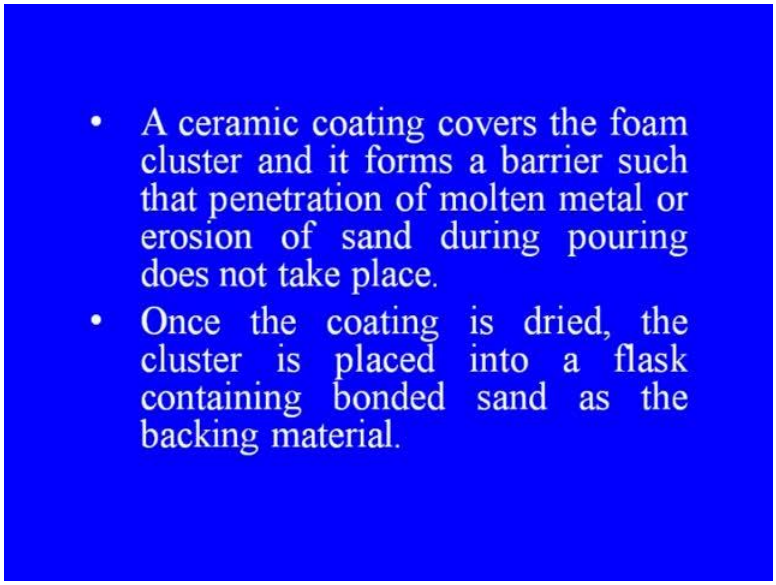

A similar fashion a ceramic coating covers the form cluster and it forms a barrier such that penetrating of molten metal or erosion of sand during pouring does not take place. Once the coating is dried the cluster is placed into a flask containing bonded sand as the backing material. In this process, any sand which has enough refractory strength to resist the molten metal temperature can be used silica sand, olivine sand, zircon sand and chromides can be used as molding sands. As in the evaporative pattern casting process, the sand loss is less and much of it is recovered. Therefore, even the expansive sands such as zircon and chromides can be used.

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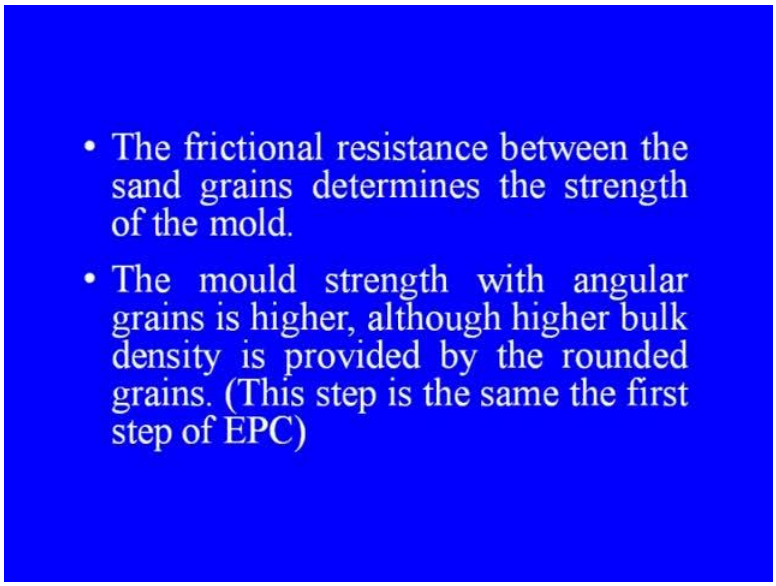

The frictional resistance between the sand grains determines the strength of the mold. The mold strength with angular grains is higher although higher bulk density is provided by the rounded grains. The pattern coated with a suitable refractory vast is further embedded with dry unbounded. Sand it is next vibrated to produce a rigid mold to plastic. Films are used to encapsulate the mold in between and vacuum is applied in the sand owned.

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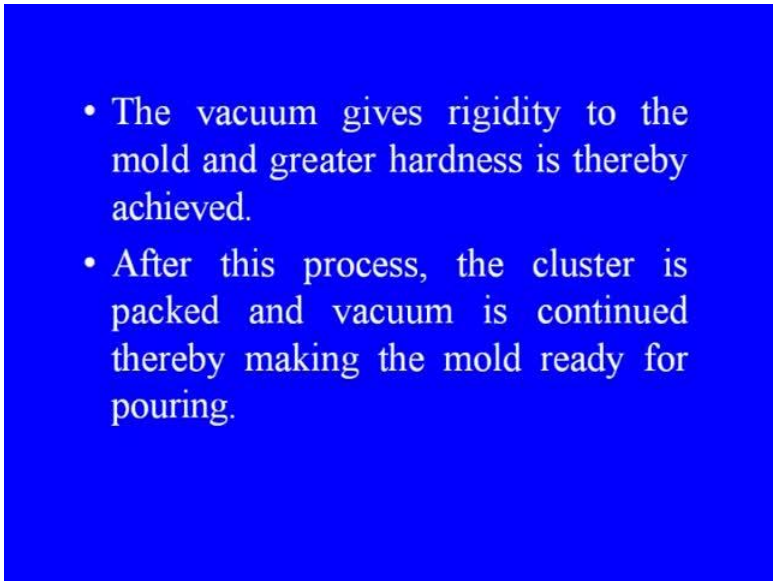

The vacuum gives rigidity to the mold and greater hardness is thereby achieved. After this process the cluster is packed and vacuum is continued thereby making the mold ready for pouring. After pouring the molten metal occupies precisely the shape and size of the pattern and duplicates all of its features. The surface finish and dimensional accuracy of the pattern is very important, as it has the direct relation to the casting quality being produced. Once the casting is removed from the mold by shake out method, very little fettling is recovered. Since, the process does not recover mold joint lines and even the course are entirely eliminated.

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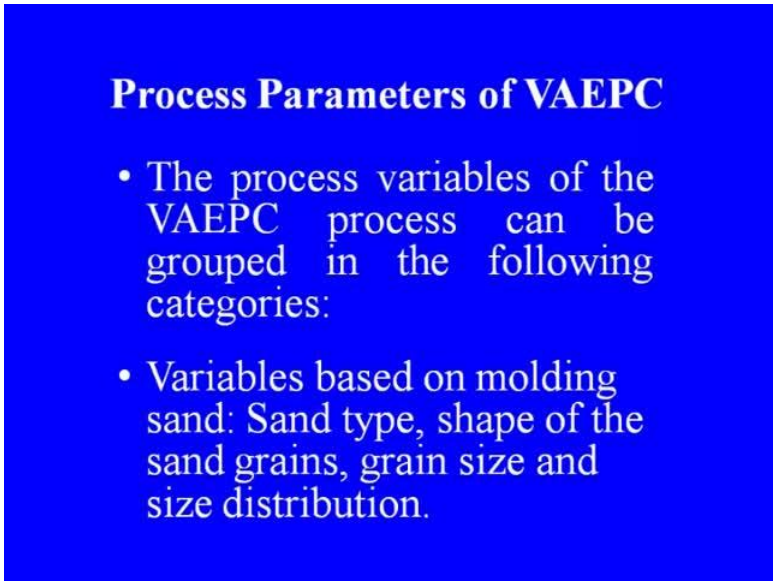

Now, let us see the process parameters, that affected the vacuum assisted evaporative pattern casting. The process variables of the vacuum assisted evaporative pattern casting process can be grouped in the following categories. Number one, the variables based on molding sand, these variables are sand type shape of the grand sand grains, grain size and size distribution.

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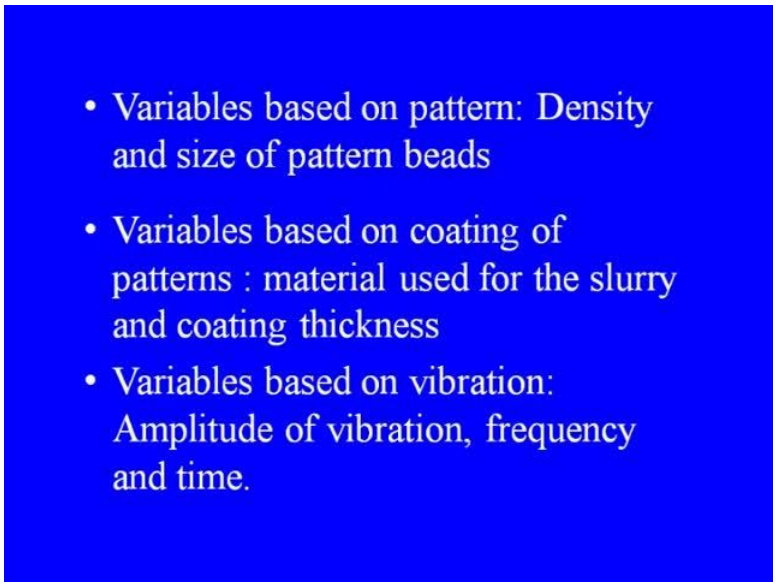

Number two, variables based on pattern, these variables are density and size of pattern beads. Number three, variables based on coating of patterns, variables are material used for the slurry and the coating thickness. The number four groups of variables based on vibration, here the variables are amplitude of vibration. Vibration frequency and time the next group of variables are based on vacuum.

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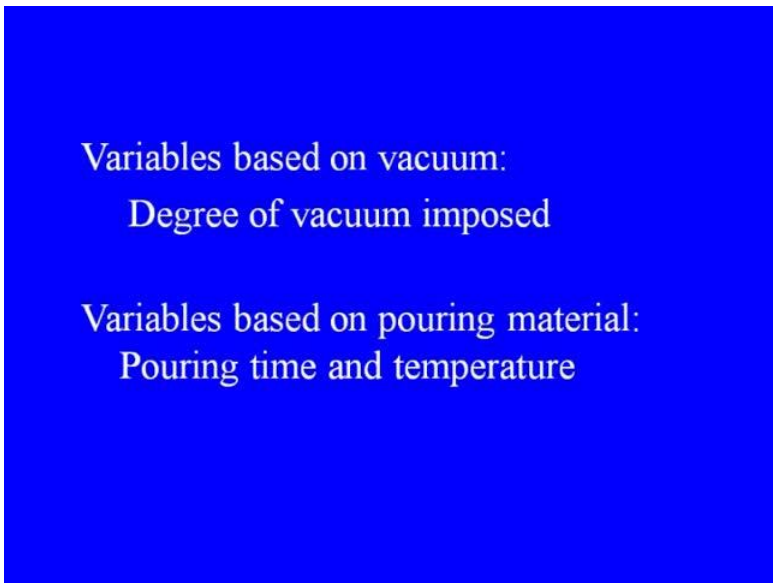

Here degree of vacuum imposed is the major variable. The next group of variables are based on pouring material, the next group is pouring time and temperature. In order to

identify the important process variables effecting the quality of vacuum assisted evaporative pattern casting process, and and Ishikawa cause and effect diagram is constructed as shown in a figure four.

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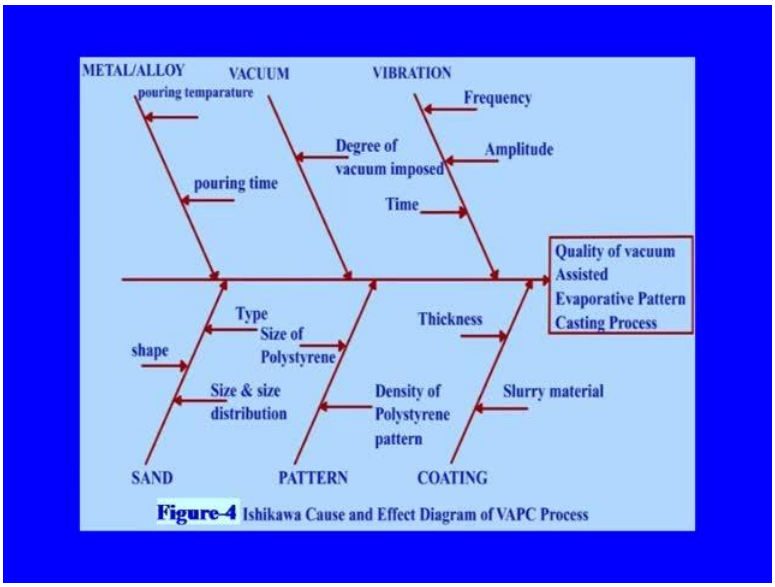

This is the Ishikawa cause and effect diagram, which shows the relationship of different variables that finally, affects the quality of the process product. These are basically the metal and alloy based parameters. Then vacuum based parameters, then vibration based parameters like frequency and amplitude, then time, then the sand based parameters shape, size and the type of the sand etcetera. Then the pattern based parameters, mostly the density of the polystyrene pattern and then coating based parameters. Here the slurry material and the thickness are the major concerns.

All these variables in different degrees affects the quality of the products produced by these process. A rigorous study and analyses are required to find out the degree of effect or influences of these parameters, individual parameters on to this product quality. Thus we have seen that the evaporative pattern casting process can give us very good results, yet the search for improvisation is never ending, hence another process in this category was developed.

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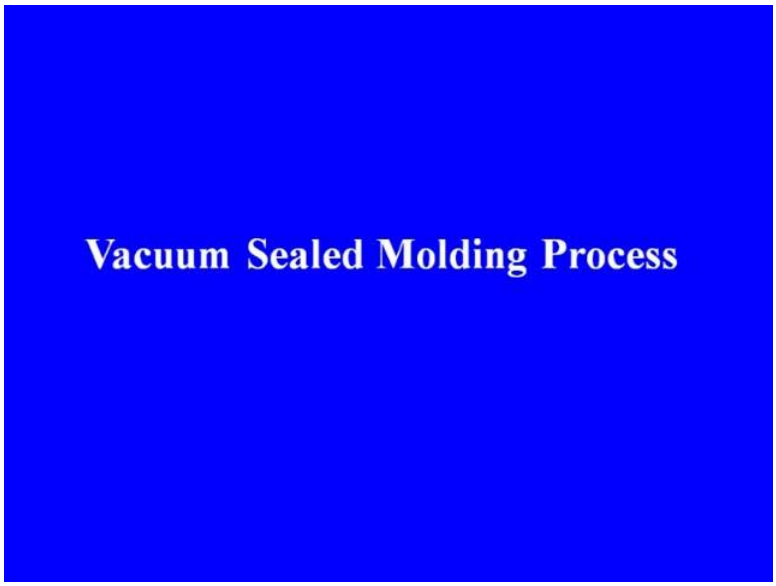

The next process that we are going to discuss is vacuum sealed molding process.

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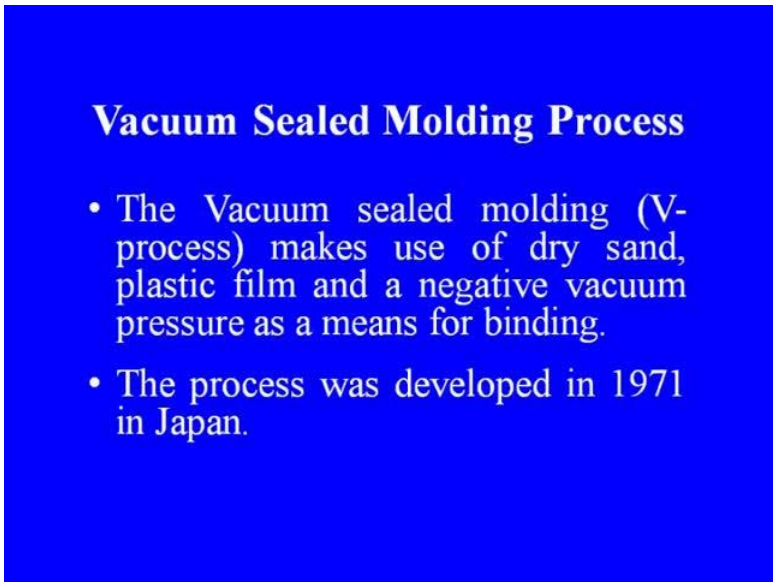

The vacuum sealed molding process also known as V process makes use of dry sand plastic film and a negative vacuum pressure as a means for binding. The process was developed in 1971 in Japan thus this can be regarded as a young process in the family of casting due to its unique capability in producing 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 difference mattered by which sand is bound to form the mold cavity.

The vacuum used in the V process is in the order of 250 to 450 millimeter of mercury. This process 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 baking material and vibrations are used to compact it.

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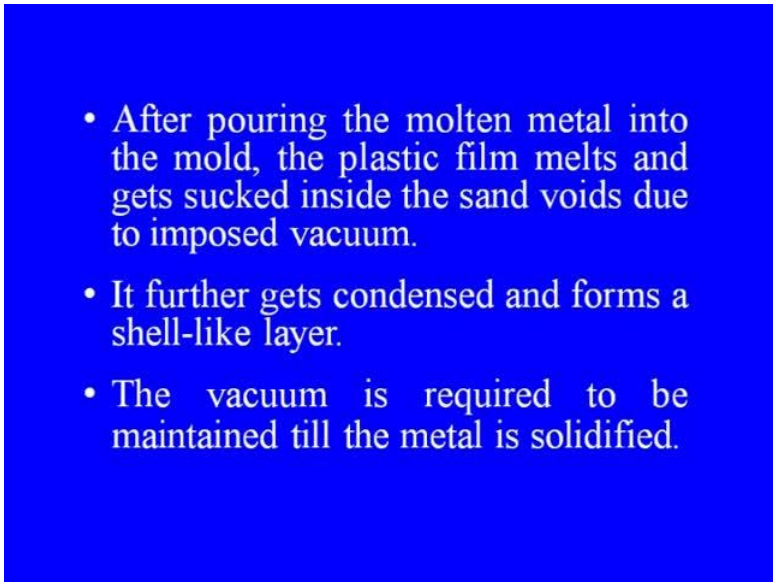

After pouring the molten metal into the mold the plastic film melts and gets sucked inside the sand voids due to imposed vacuum. It further gets condensed and forms a shell like layer. The vacuum is required to be maintained till the metal is solidified. Then it is released allowing the sand to drop away, thereby leaving behind the casting, which is smooth surface. The process does not required checking out matters and equipment to remove the casting out and the sand can be reused after quelling without any treatment. Now, let us see the advantages of this V process.

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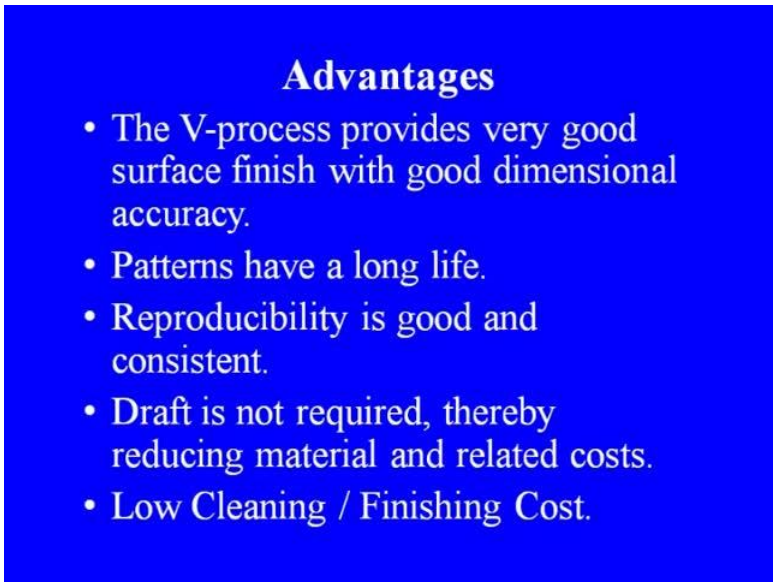

The V V process provides very good surface finish with good dimensional accuracy. The patterns have a long life. Reproducibility is good and consistent. Draft is not required in this process, thereby reducing material and related costs. Also the cost due to cleaning or finishing is relatively low. Now, let us see few applications of this process, the size of the product is no limitation in the V process. However, as found in literature the application of V process castings are in the range of up to eight thorns for in guts. Some other applications were in V process was used as a preferred casting mold.

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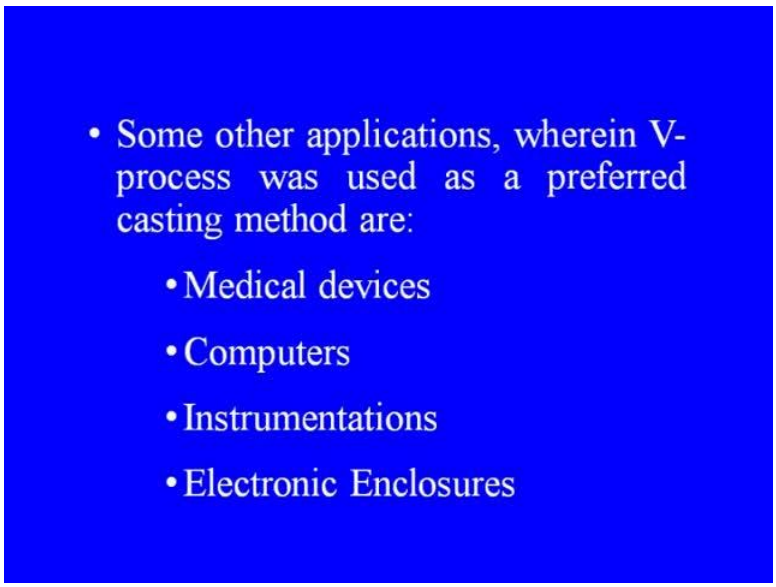

Mold are medical devices, computers, instrumentations, electronic enclosures etcetera. Now, let us see the sequence of producing V process molds first.

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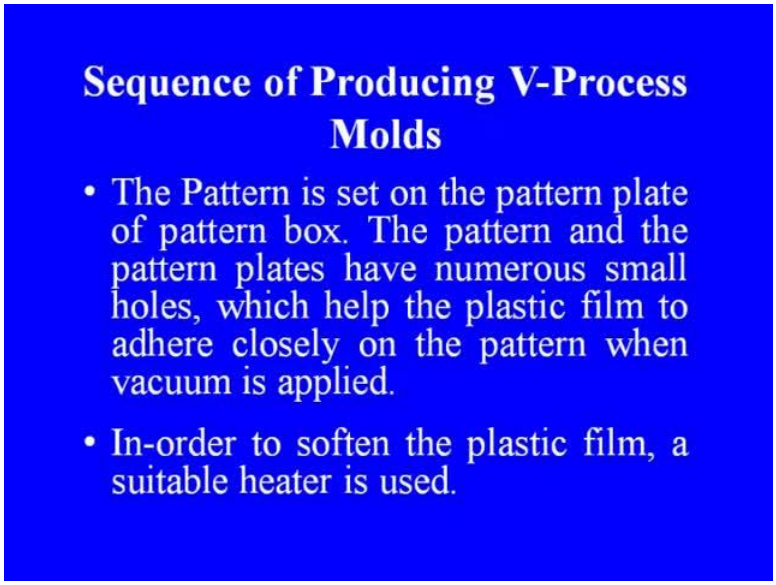

The pattern is set on the pattern plates have numerous small holes, which help the plastic film to adhere closely on the pattern when vacuum is applied. In order to soften the plastic film a suitable heater is used. The pattern is draped by a soften plastic film, the section of vacuum takes place through the vens and the plastic film adheres very close to the pattern. The mold box is set on the film coated pattern, the mold box is compacted by filling it with dry sand and providing slow vibrations. The mold is further levelled and a plastic film is covered on the top of the box the section created due to vacuum helps in stiffening the mold.

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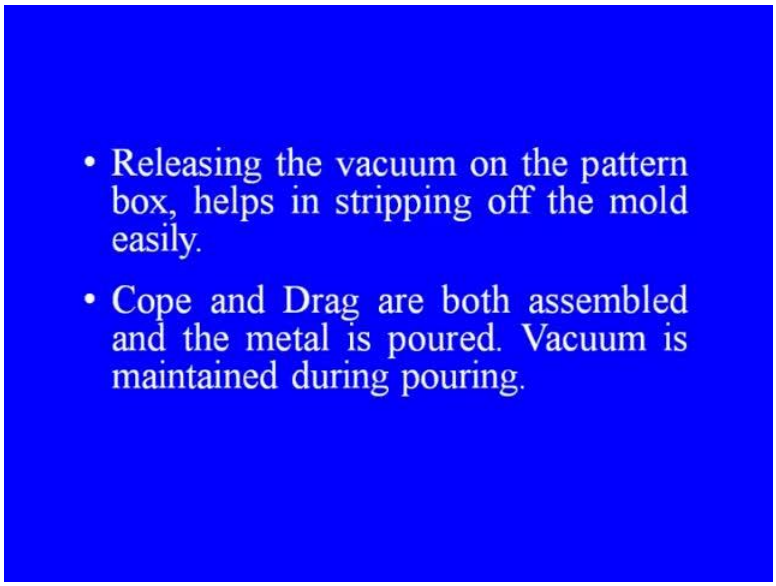

Releasing the vacuum on the pattern helps in stripping off the mold easily. Cope and drug are both assembled and the metal is poured vacuum is maintained during pouring. The vacuum is further released once the mold box is cooled, this allows sand to freely flow back there, by leaving a clean casting behind the sequence of producing the casting made by vacuum sealed molding process, is shown in the following figures.

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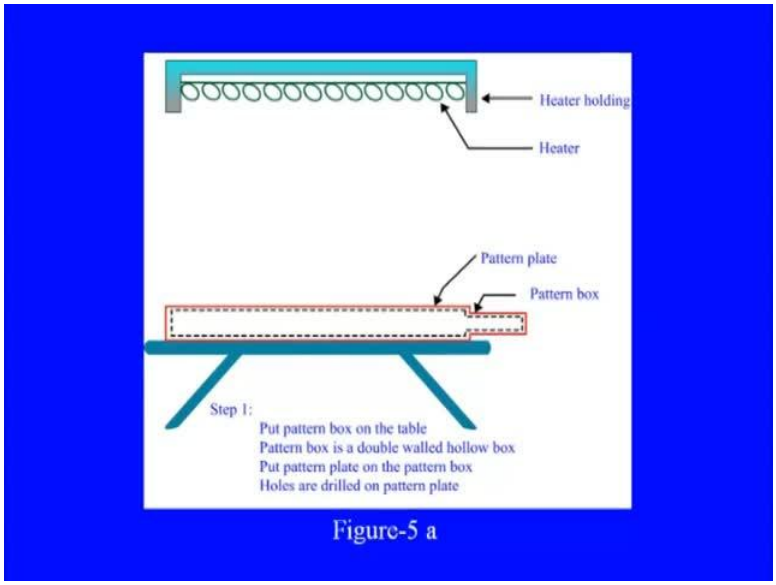

The first step is as shown in the screen here, the pattern box on the table is placed like this, then the pattern plate is places on top of the pattern box.

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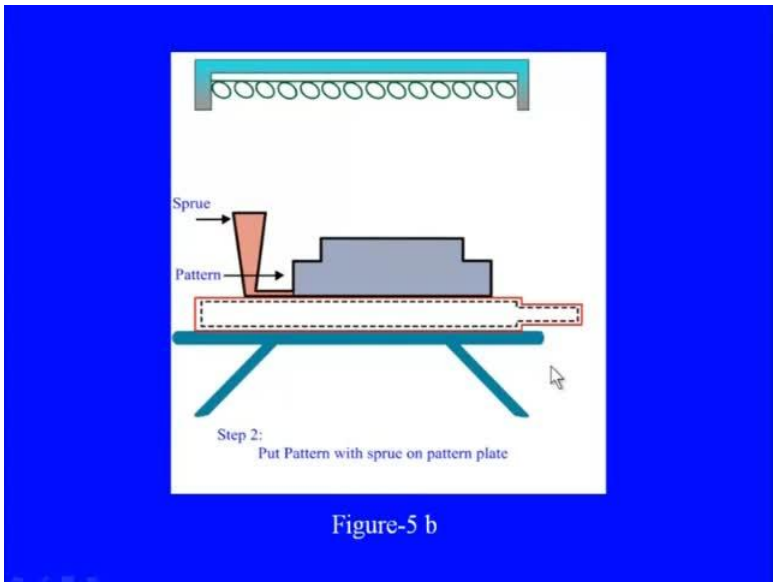

Figure-5 b

In the next step with sprue is placed on the pattern plate, this is the sprue and this is the pattern.

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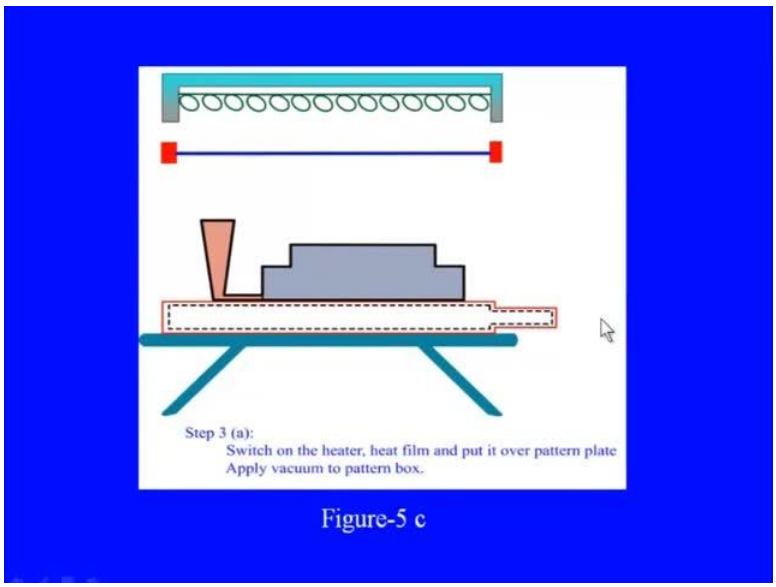

Figure-5 c

In the next step, the heater is switched on this heats the film and put it over the pattern plate. Then simultaneously, vacuum is also applied to the pattern box.

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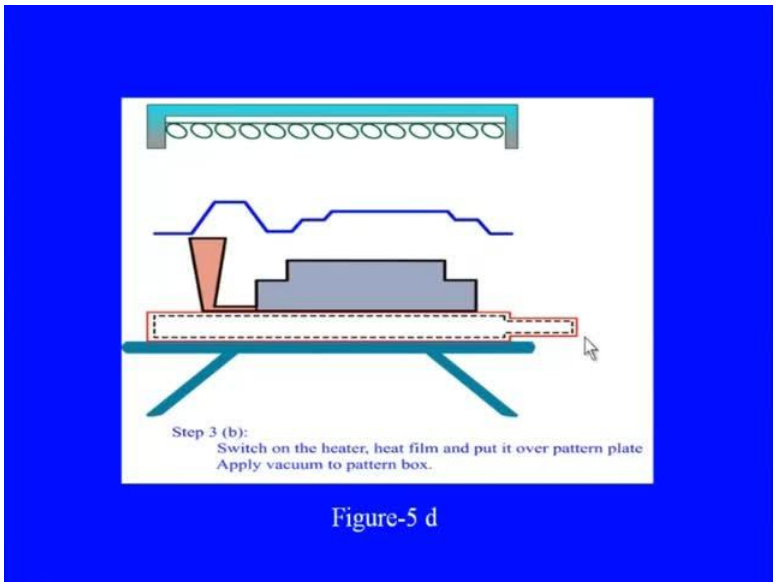

Figure-5 d

In the next step, the heater is switched on the film is heated and it is put over the pattern plate. Then vacuum is maintained in this step the vacuum is maintained on the pattern box.

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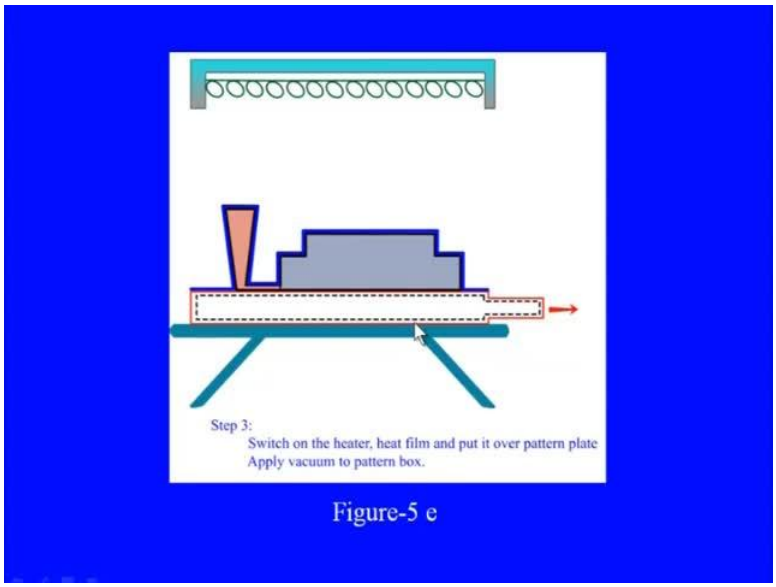

Figure-5 e

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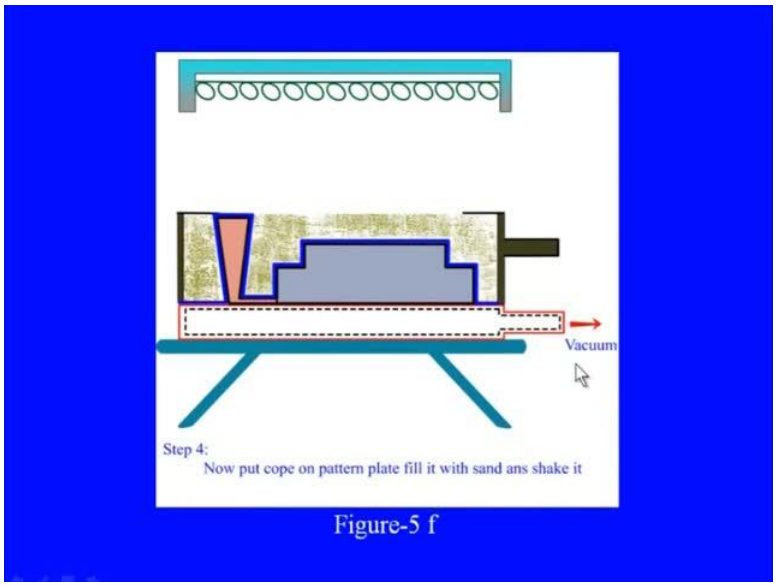

Figure-5 f

In the next step, the cope is put on the pattern plate and it is with sands and it is shacked.

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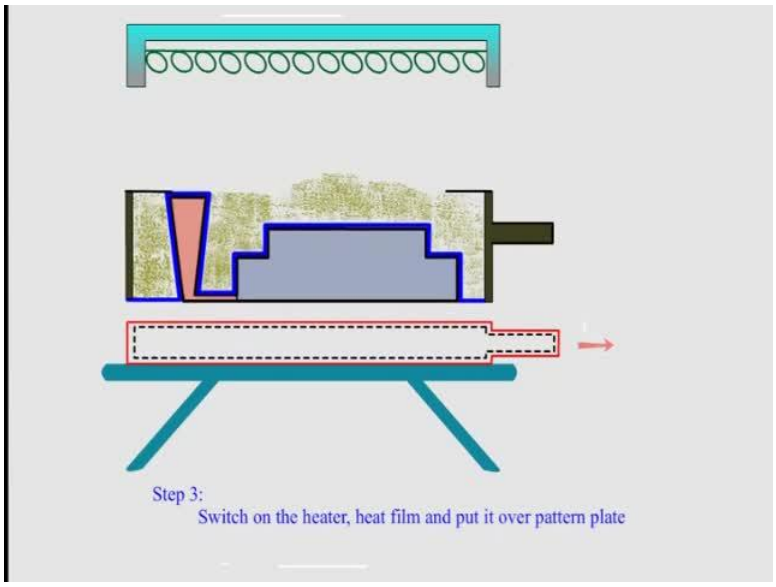

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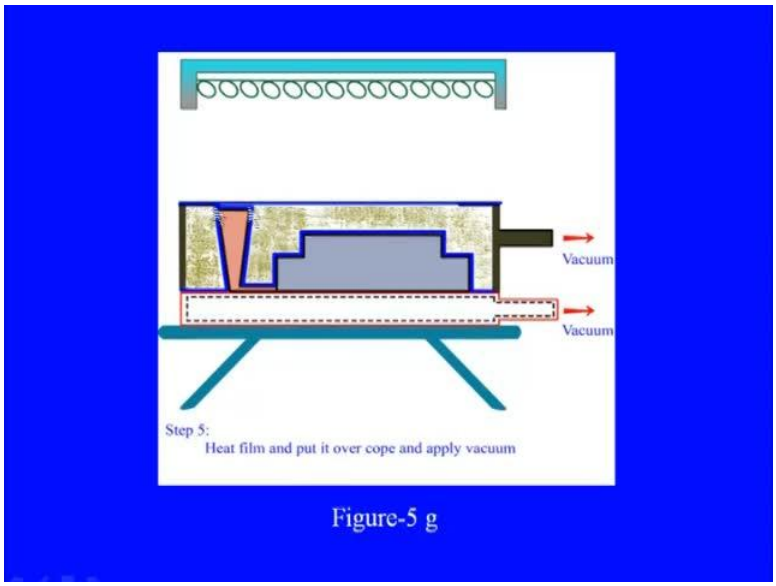

Figure-5 g

Then the film is heated, and it is put over the cope as shown here and at the same time vacuum is maintained.

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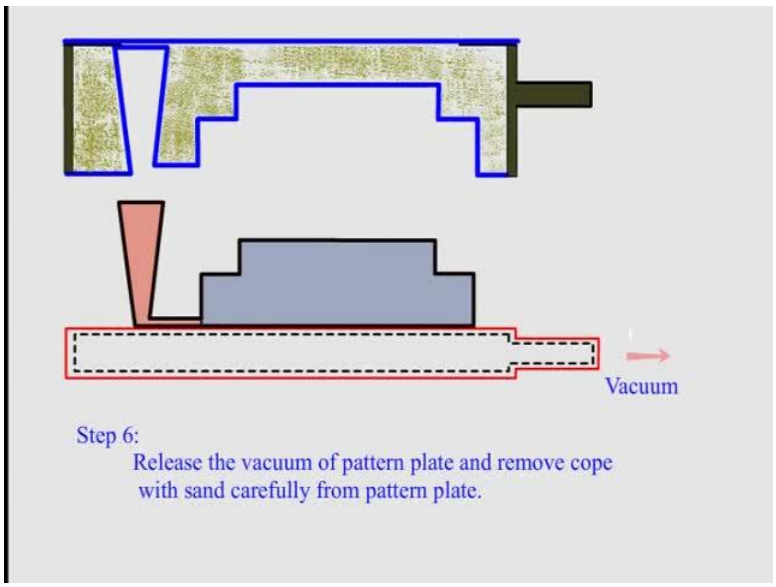

Now, the vacuum is released and this is removed from the pattern plate, then prepare the drag in the same way.

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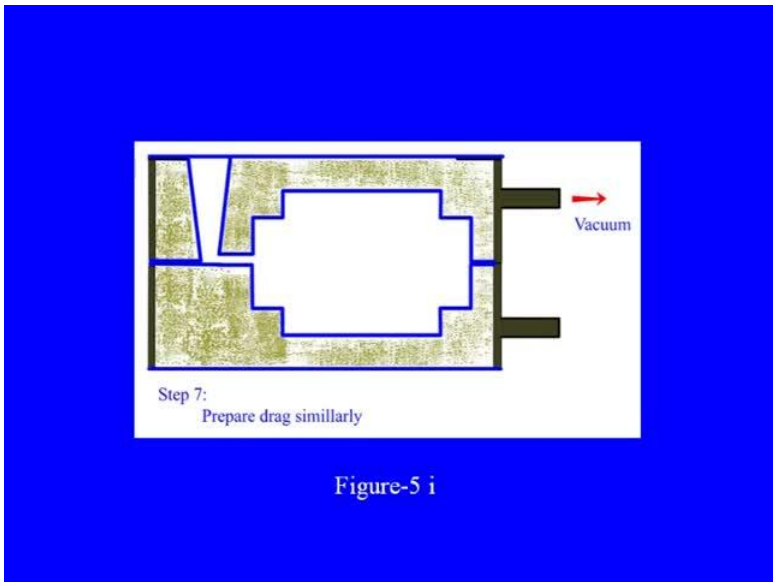

Figure-5 i

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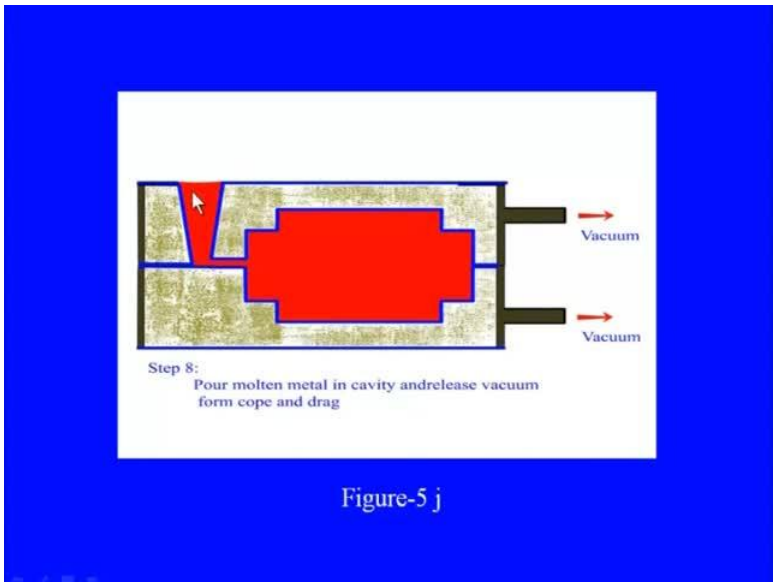

Figure-5 j

Then it is ready for the pouring, and the molten metal is poured and filled the cavity in this fashion, which gives the final casting.

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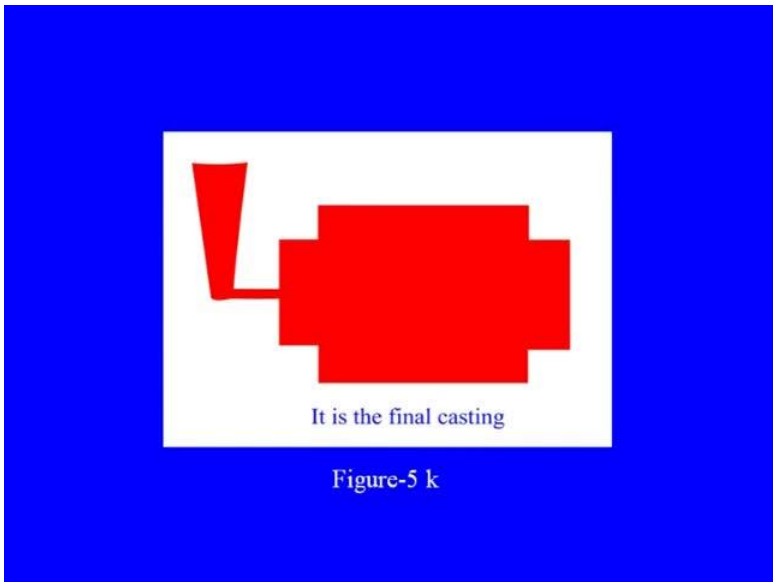

Figure-5 k

Let us see some more applications of V process. We have already indicated the V process can be used for very huge pearls to be produced, as well as some pearls, tiny pearls like those used in computers, some instruments or instrumentation and so on. These indicates that the V process is a very versatile process, which can be used for very large part as well as very small parts. Now, let us look at some of the applications, which are developed recently.

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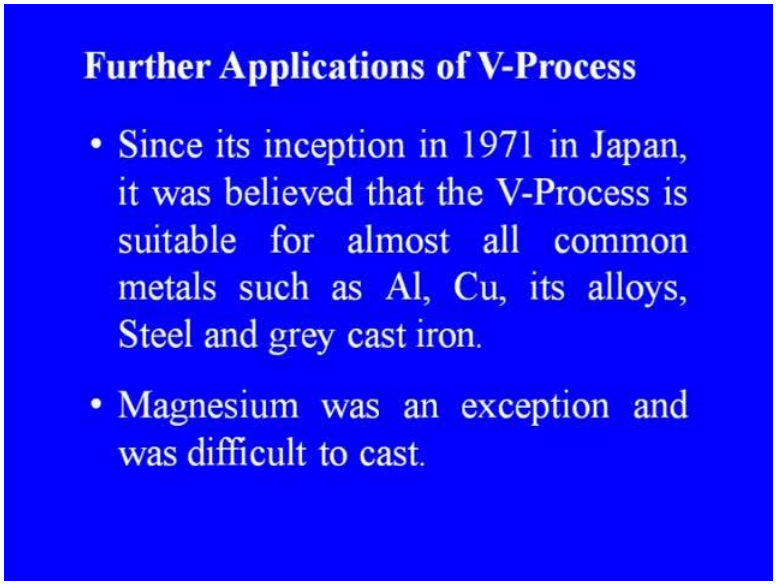

Since, its inception in 1971 in Japan, it was believed that the V process is suitable for almost all common metals such as, aluminium copper and its alloys, steel and grey cast iron. However, magnesium was an exception and was difficult to cast. Of course, magnesium is a met or metal, which is otherwise also difficult to process. It is highly reactive and therefore, it is partially dangerous to work with magnesium.

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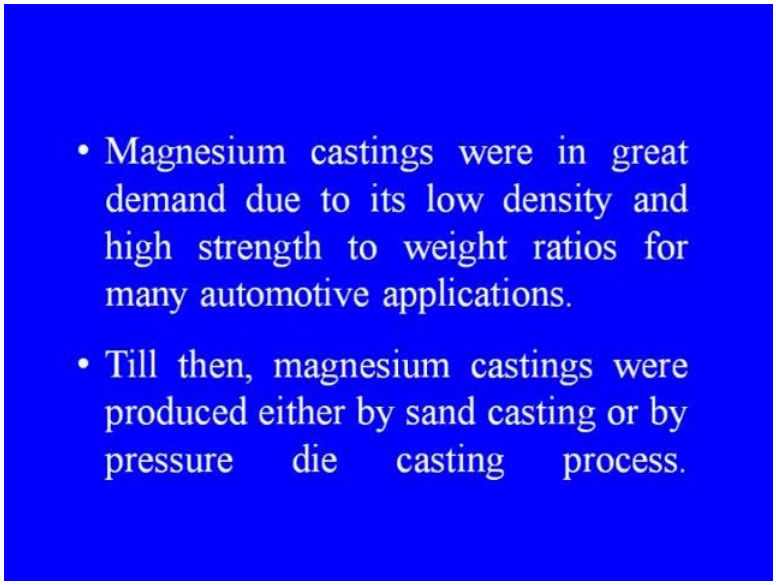

Castings were in great demand due to its low density and high strength and these alloy or these material is highly sort after in the automobile sector particularly because they are low weight. High strength material are required with magnesium and its alloys can offer till then magnesium castings were produced, either by sand casting or by pressure die casting process.

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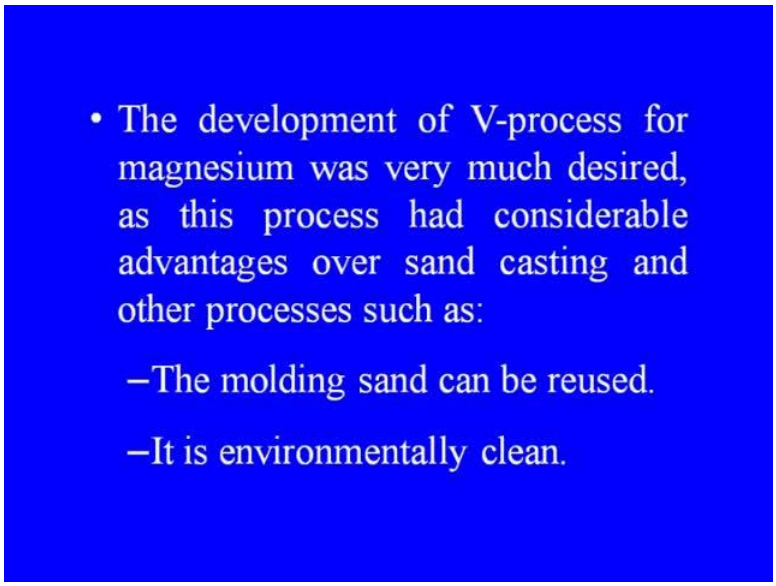

The development of V process for magnesium was very much desired. Therefore, as this process had considerable advantages over the casting sand casting and other processes such as, the molding sand can be reused. This we have already indicated is one of the advantages of V casting process were moldings can be used again and again. And of course, this process is environmentally clean to because industries are looking for more and more environmentally clean processes, which are potentially more friendly to the workers.

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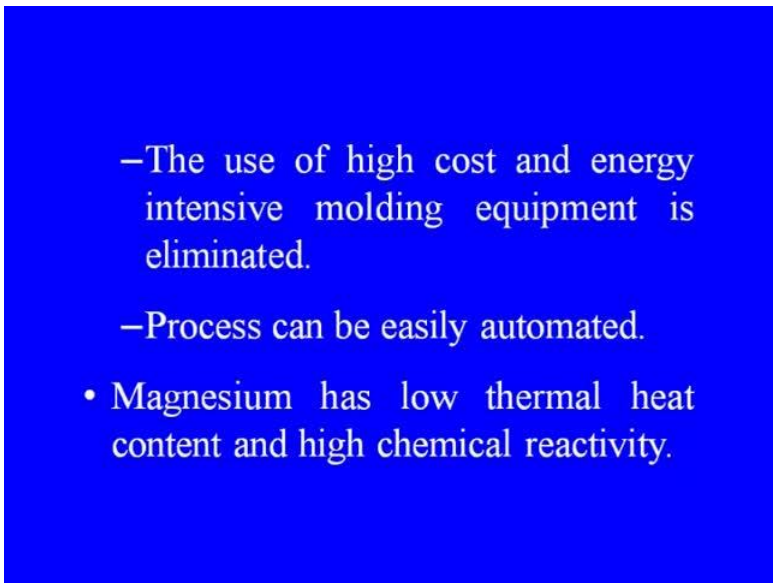

The use of high cost and energy intensive molding equipment is eliminated in V casting therefore, the cost the net cost becomes less the process can be easily automated. This is another important advantage of this process, as we know casting is a process, which involves high temperature and handling of heavy material raw, either raw material or the equipment. Therefore, there are limitations as for as the workers are concerned or human being is concerned while handling these type of situations.

Also high temperature is a potentially dangerous situation for the workers working with it and workers safety has to be given the priority while working in the work shop. Therefore, any process that provides flexibility for automation are welcome. Moreover magnesium has low thermal heat content and high chemical reactivity as I have already indicated.

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Through NASA's support and research agreement with the Auburn University, United states of America. The process was successfully developed and adopted in the year 2003 and 2004. A vacuum sealed process test bed was first developed at the materials processing centre of Auburn University mainly for aluminium alloys.

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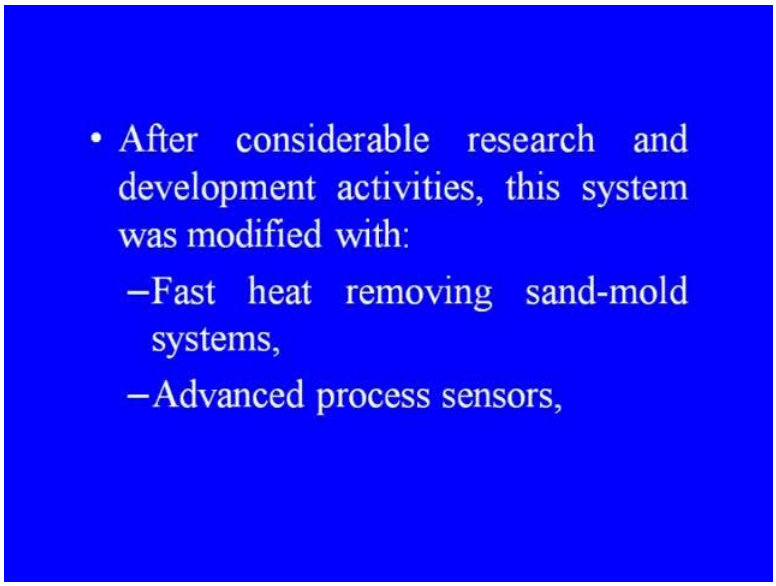

After considerable research and development activities this system was modified with, fast heat removing and sand mold systems then advanced process sensors. This I have indicated already the automation is favourable with this process and automation is basically achieved or implemented with the help of sensors. The sensors are responsible for collecting the real time information from the process. It feeds back to the controller regarding the status process, status say for example, temperature pressure etcetera depending on this the controller takes the decision. How the process is to be controlled? This is a very basic and very brief principle of automation. Therefore, this answers place a very vital role in this process.

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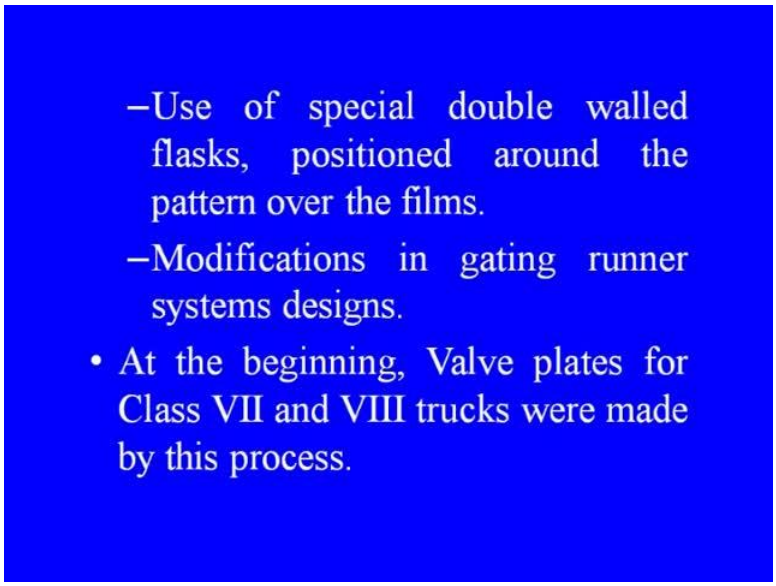

Then use of special double walled flask positioned around the pattern over the films. Then modifications in gating gating runner systems designs, these all were adopted in the V casting process at the beginning wall plates for class seven and class eight trucks in the United States were made by this process.

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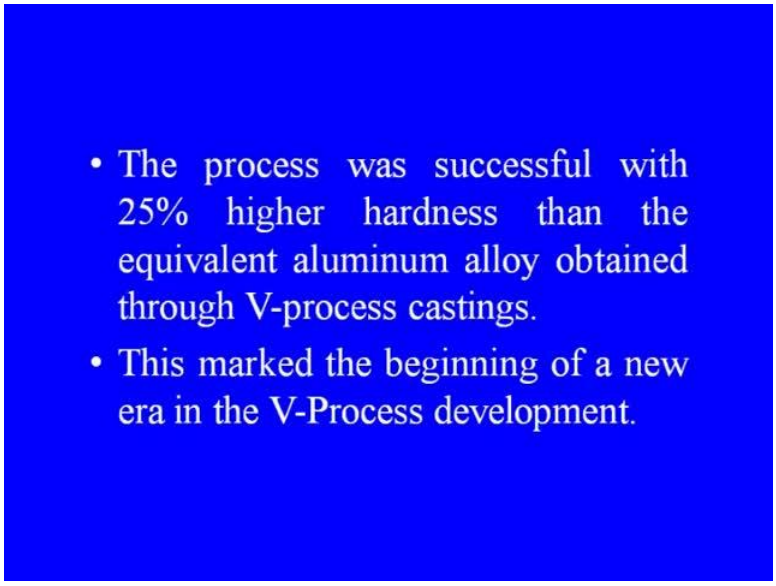

The process was successful with 25 percent higher hardness than the equivalent aluminium alloy obtained through V process castings. This is quite significant, this method marked the beginning of a new era in the V process development.

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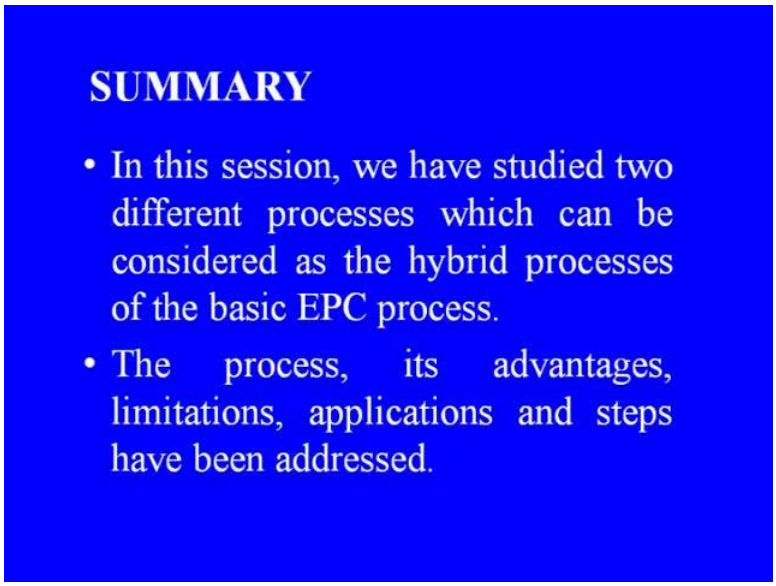

Now, let us summarise what we have discussed in this session. In the present session we have studied two different processes, which can be considered as the hybrid processes of the basic evaporative pattern casting process. The processes, their advantages, limitations, applications and steps have been addressed. Some special applications of this V casting process particularly with reference to magnesium alloy casting have also been discussed. We hope this session was informative and interesting.

Thank you.