Basics of Mechanical Engineering-2

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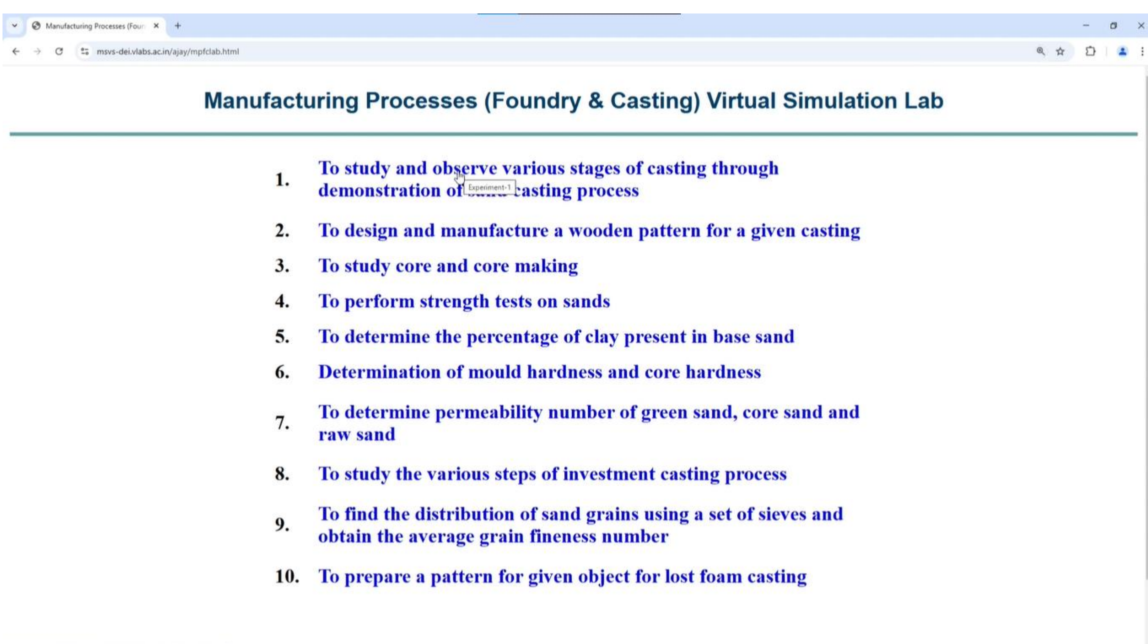
Week 04

Lecture 15

Virtual Lab. Demonstration (Casting)

Welcome to the last lecture on casting. We have discussed the casting processes, the various terminologies in casting, and certain numerical problems in the previous lectures. In this lecture, I will walk you through the virtual laboratory, which is the laboratory session. We will walk you through the virtual laboratory. VLab is a set of labs developed in India by different institutions.

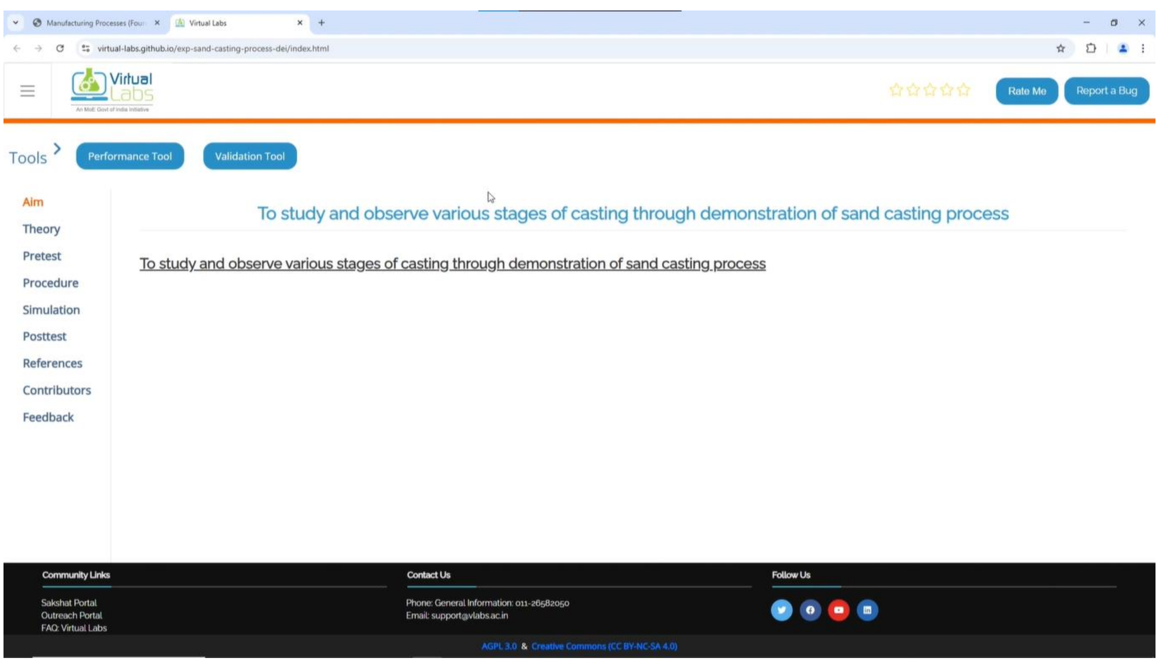
So that students who are not able to visit the lab in person can still gain that experience while working on a computer. So, you are in the course Basics of Mechanical Engineering 2. I am Dr. Amandeep Singh. To see the virtual labs, I will start with the basics of how to search for VLab on Google. So, I am here on Google Chrome, and I will type "V Lab casting." The first thing you see is the manufacturing processes section in casting.

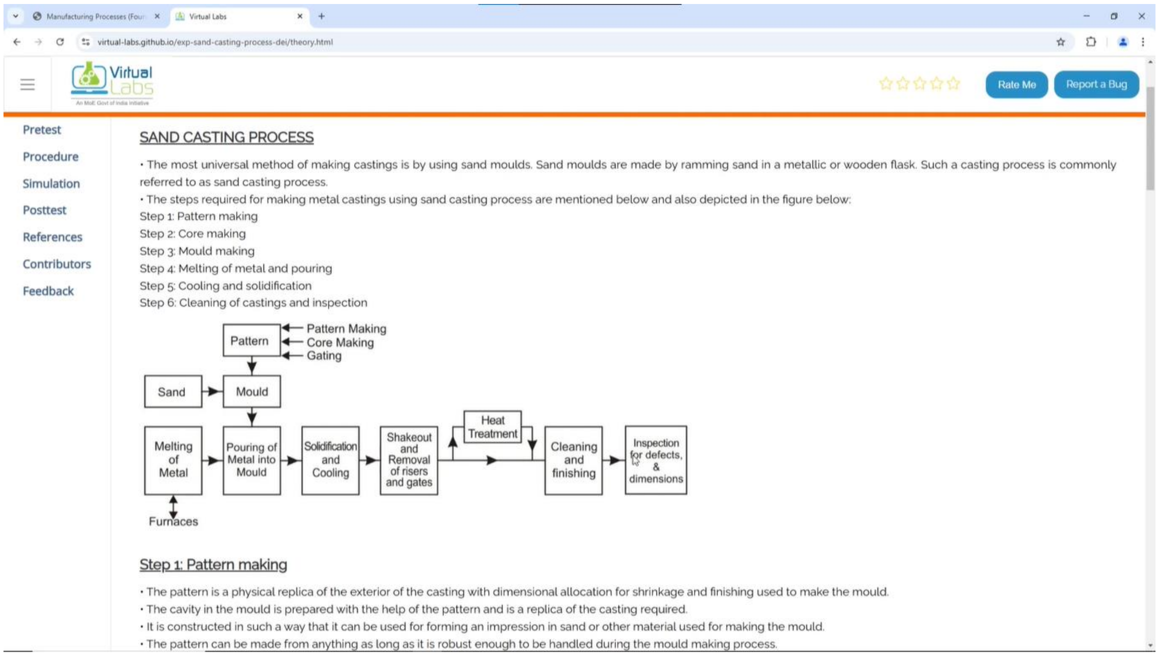


You will open this link. I will click it, and you can see that it has opened. I'm just zooming out so that it is clearer on your screen. There are certain experiments on foundry and casting in this virtual simulation lab, such as studying and observing various stages of casting through the demonstration of sand-casting processes, designing and manufacturing a wooden pattern for a given casting, and designing and cutting the wooden pattern. The size of the wooden pattern must include all the allowances required in the casting. So, for the final casting that is required, the wooden pattern must account for shrinkage and various allowances that need to be included.

Then, the third experiment is studying the core and core-making for the casting. The core is always harder than the rest of the casting body. So, this is also one of the experiments—to perform strength tests on sand. You know the properties of sand may include refractoriness, which is its behavior at high temperatures; cohesiveness, which is how sand particles stick together; dry strength; green strength; permeability; and porosity. All these properties are considered. This includes an experiment on permeability, as you can see in experiment number 7, which determines the permeability number of green sand, coarse sand, and raw sand.

There are several experiments here. I will walk you through two or three of them. The first experiment I will pick is studying and observing various stages of casting through the demonstration of the sand-casting process.





I have clicked on the experiment name itself. So, the experiment title was the link itself. So, you will see the screen that has opened. AIM: To study and observe various stages of casting through the demonstration of sand-casting processes. The complete theory of the sand-casting process is given here, including different steps such as pattern making, core making, mold making, melting, cooling, solidification, and cleaning of the casting. The complete theory of the sand-casting process is given here, including different steps such as pattern making, core making, mold making, melting, cooling, solidification, and cleaning of the casting. Each step is also represented here with a block diagram.

Pattern making itself is a process that includes pattern making, core making, and gating. Then, this goes to the mold, and sand is also added to the mold. Melting of the metal is done separately in furnaces. The pouring of the metal into the mold is done here. After pouring, the metal undergoes solidification and cooling, followed by shakeout and removal of risers and gates, which are added during the mold design. Then comes heat treatment, cleaning and finishing, and inspection for defects and dimensions. So that finally, it is used for the actual application wherever required. The first step is pattern making, and we have discussed its details in previous lectures.

I will not go through the whole theory here. Pattern making is the process of creating a physical replica of the casting with dimensional allowances for shrinkage and finishing, which is then used to make the mold. In core making, the pattern represents the overall body. If the casting you are going to make has a hollow section inside... For example, if you are making a hub or a pipe that is hollow inside, a core has to be used. Core making is an essential step, along with mold making, melting and pouring, and cooling and solidification. This step includes the time required for the casting to cool down. Then comes cleaning of the casting and inspection. This is casting terminology, which you have seen already. You can see the riser system here. This is the cope and drag system—the upper part is the cope, and the lower part is the drag. In this experiment, we will focus only on the cope and drag system.

Then comes cleaning of the casting and inspection. This is casting terminology, which you have seen already. You can see the riser system here. This includes the cope and drag system—the upper part is the cope, and the lower part is the drag. In this experiment, we will focus only on the cope and drag system. We also have the riser system here, along with the gating system, which includes the riser, the sprue, and the gate design.

All those parts are here. You can see that all these terms are further detailed in this flask—cope, drag, core print, parting line, draft, pouring cup, and sprue. The sprue itself includes examples of poor and good sprue designs. It has to have a taper, and you can see the taper here. Then, the sprue base, riser, runner, and gating system—including the types of gates such as top gate, bottom gate, and parting line gate—are all given here. We will just go through them. The next step given here is the pretest.

AIM, Theory, and Pre-test—Pre-test means testing your knowledge about casting before actually starting the simulation. The simulation allows you to perform casting in a virtual environment, and before doing that, you should have prior knowledge about casting, molds, and the cope and drag method. For that, a few questions are provided. For example, one question is: 'Which sand is generally used repeatedly for mold making?' The answer is silica sand, and I will mark this answer.

The purpose of the gate is to feed the casting at a rate consistent with the rate of solidification. Yes, this seems to be the right answer. Acting as a reservoir for molten metal? No. Helping feed the casting until all solidification takes place? No. Feeding molten metal from the pouring basin to the gate? No.

The answer is to feed the casting at a rate consistent with the rate of solidification. The purpose of the sprue is not to feed the casting at a rate consistent with the rate of solidification. Act as a reservoir. Help feed the casting until all solidification takes place. Feed molten metal from the pouring basin to the gate. The answer is: Feed the molten metal from the pouring basin to the gate. This is the purpose of this video.

The taper provided to the pattern for its removal is known as the draft. Yes, the taper provided to the pattern for its removal is known as the draft. Draft allowance is the angle or taper that is provided, which we have studied. So, this is the draft allowance. The function of cores in casting is to form extended parts? No, never. Form internal cavities? Yes, the core creates or provides the internal cavity.

The use of cores is not for directional solidification or to act as a reservoir. No problem. Go ahead and submit the quiz. Yes, I have gotten 5 out of 5. Make sure you get 5 out of 5. For each answer, you will also find the explanation. If you click the explanation link here, it will give you the complete reasoning for why this is the answer.

Even if you mark the wrong answer, it will still provide an explanation of the correct answer and which one you should have marked. So, you will get scores accordingly. I have gotten 5 out of 5 here. Next is the procedure. The procedure for the sand casting process is given here. Place, transfer, ram, sprinkle, fix, place, fill, remove, then remove the riser and sprue, then remove the pattern by removing guide pins, relocate, then after removal of the mold, pour, and after cooling, click. This is the complete procedure. We will go through the simulation and try to understand the whole procedure here.

The first part is "Place." It says to click on the drag to invert it. I clicked on the drag, and it is inverted here. This is the cope and drag method. Then, we click on the pattern to place it in the drag. The pattern is placed here. Then, we use the shovel to transfer the sand. This is the transfer step. Use the shovel to transfer the sand. Now, the sand is picked up with the shovel, and we will transfer it to the drag.

After the drag is filled with sand, we use a rammer to compact the sand. The sand is rammed, and in the sand-casting process, this ramming is generally done manually. However, automated systems are also available for ramming. The strength of the ramming must be sufficient, as it will later be dispersed. The core strength is higher than the pattern sand strength.

Core making is also done as a separate experiment. Here, the sand has been rammed. So, this is the drag. The upper part, the cope, also needs to be made. The sand has a cohesiveness property. If we make the cope and drag without applying any parting material in between, they will stick together. The sand particles will stick together, so we have to put dry sand as a parting material.

It is parting sand, which is completely dry and does not have cohesiveness. It is placed here and sprinkled. So, this is the sprinkle step. It is being sprinkled so that the upper part of the flask does not stick to the lower part. The sand does not get stuck to it. Now, we click on the molding flask so that the upper part is placed here. Then, it is locked using the pins. Again, using the shovel, the sand is picked up and placed here.

Now, it is partially filled, and the sprue needs to be placed in position. I clicked on the sprue, and it has been placed here. Now, using the shovel, I will fill it with sand. Now, the gate needs to be placed in position. This gate is a very generic conical gate. We can design our gate specifically based on our own pattern and design requirements. We have seen in the previous lecture how to design the size and dimensions of the gate.

Then, using the shovel, I will completely fill it. Now, using the rammer, I will compact the sand so that the system is ready. Now, we have to remove the sprue and the riser, which are now removed. Now, the molding flask is clicked to separate the cope from the drag. Why is it being separated now?

Because we need to create a runner. There is no connection between the sprue and the pattern. The sprue is there, and the pattern is there, but a connection needs to be created between them. So, we will use only a human finger to create this runner. There are tools, such as a single handheld shovel, to make this kind of runner as well. Now, we will click on the molding flask again, place it over the mold, and lock it.

Now, the filling part begins. As you saw in the block diagram, the furnace has the molten metal ready. The molten metal is brought using the ladle. Using the ladle we are pouring the molten metal. Now, the pouring part is done. Next, the cooling process has to take place. The cooling will happen, and after cooling, we have to remove the casting.

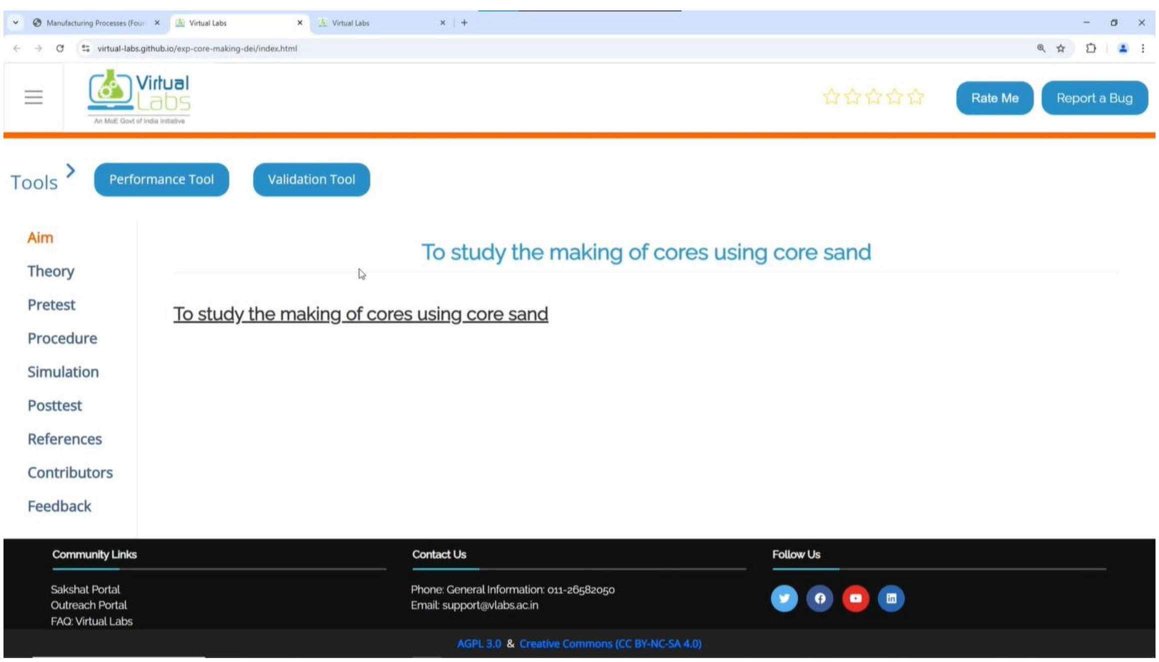
This is the casting that is now ready. This was the virtual simulation. Post-test, post-casting, let us take some certain questions. Property of sand due to which the gas and steam escape from the sand is, what is the property due to which it escapes? It is the porosity there. That means permeability is the property of the sand due to which the gas and steam escape through the sand itself.

Which of the following is not true about the riser? It permits molten metal to rise above the highest point in the casting. This is true. Filling up the mold cavity can be visually checked from it. Yes. The casting solidifies directionally towards the riser. Yes. The riser and runner extension are used for the same purpose. No.

So, this D is the correct answer. This is not true of the riser. Next question: Which of the following is not a casting defect? Hot cracks, swell, shrinkage, hot tears—hot cracks are not a casting defect. The amount of draft required does not depend upon shape and size; it depends upon the molding method.

Material of pattern, material of pattern is respectively there to the amount of draft. So, material of pattern does not have any linkage with the draft. So, this is the right answer. Method of production, yes, yes, it depends on the method of production as well, whether automated or manual. Which of the following is not a type of core according to its position?

Horizontal, vertical, inclined core is not there. So, let me submit. The score is 5 out of 5. This is the post-test. There are certain references — generally, Campbell is a very common and well-known author who designed the basic manufacturing processes. He has provided a lot of information specifically about casting. This is a highly referred book. So, this is the virtual laboratory experiment on studying various stages of casting through the demonstration of the sand casting process. One experiment is taken.



Let me now come to the previous tab. I have taken experiment number 1. The next experiment is to study core and core making. Pattern making is one thing. Core making requires higher strength, for which the kink pin is used with carbon dioxide gas. So, that the curing of the core happens and it does not disperse. Just suppose if some vibration or some small mishandling happens, the core should stay solid.

So, core making is a process that is also important. The aim is to study the making of a core using core sand, and the theory part explains the core and core making. Cores are sand blocks that are used to make hollow position in the casting, this we have discussed. The materials which are used in this experiment are water soluble binders, 2 to 4 percent by weight, oil binders, 1 to 3 percent by weight, pitch and resin binder. These kind of binders could be used. Then, binder — clay acts as a binder, which includes kaolinite, ball clay, fire clay, limonite, fuller's earth, and bentonite.

This all you can read about binders. We have already discussed about this in the 3D lectures. Pre-test questions. Pre-test questions before getting into the design are number one, thermosetting resin is used in core making process because Thermosetting resin is used, it imparts high strength, yes it imparts collapsibility to cores and yes it emits a minimum amount of mold and core gases, yes that means all of the above are the correct answers. Which of the following properties can be achieved using core binders?

Using core binders, which of the properties to be achieved? Cohesion is the most important because the core has to have a strength much higher than the mold. To locate and support the core within the mold, a region is added pattern. Core or mold called as, so this is called as core prints. Wire of which material is used for reinforcement of weak cores?

Which wire is generally used? It is steel wire. Which of the following is the oldest binder used in making course? The oldest binder is vegetable oil only. Let me submit. 5 out of 5.

Pre-test is taken. Procedure is given here. Certain steps. Click on the ladle to pour the binder. Click on the core sand to transfer it into the core box.

Click on the rammer to compact the core sand in the core box. Click on the pin to make a hole in the core. Click on the cylinder to pump carbon dioxide into the core. Click on the rammer to loosen the core from the core box. The core is finally prepared here. Let me come to the simulation and I will go through all these steps.

Pour, transfer, ram, hole, pump, and ram again to finally prepare the core. Simulation: It says to click on the ladle to add the binder. There is molding sand here. I need to click on the ladle to add the binder here. The binder materials, as discussed.

The binder materials could be water-soluble binders, oil binders, or pitch-based binders. So, those are added here. So then, this is the sand that is ready. This is a core box that will be used to prepare the core. I click on the core box, and the sand is now put into the core box that we are transferring.

This is the second step. Then, using the rammer, it is set. Using a pin, we create a hole. Why is this hole created? Because we need to pump in carbon dioxide.

Next is the adding of the carbon dioxide. Why do we need to add the carbon dioxide? It cures it faster. It makes it harder. So, carbon dioxide cylinder is here. We click on the cylinder and it will pump in the carbon dioxide, right?

When the carbon dioxide is pumped in, it strengthens or hardens the sand cores and within 20 to 40 seconds, it cures the core completely. Cures means the core is ready to be used. So now I'll click OK and using a rammer, I'm ramming it from outside because this core is to be now removed from the core box. It is rammed from outside. Now you see here the core is removed, right?

So this is ready. Just to show you once, OK, if I just zoom it in, all these steps are here. It is also showing what material is being used or what equipment are being used here. I will reset it and try to show you the step of the core removal once again. This is sand is ready, core box is there in which the sand is transferred.

Then, using a rammer, we try to get the sand rammed together. Then, using a pin, we make a hole for carbon dioxide. Then, we use a carbon dioxide cylinder to pump in the carbon dioxide so that the core is hardened. This is ramming, where the core is removed. This core is ready, right?

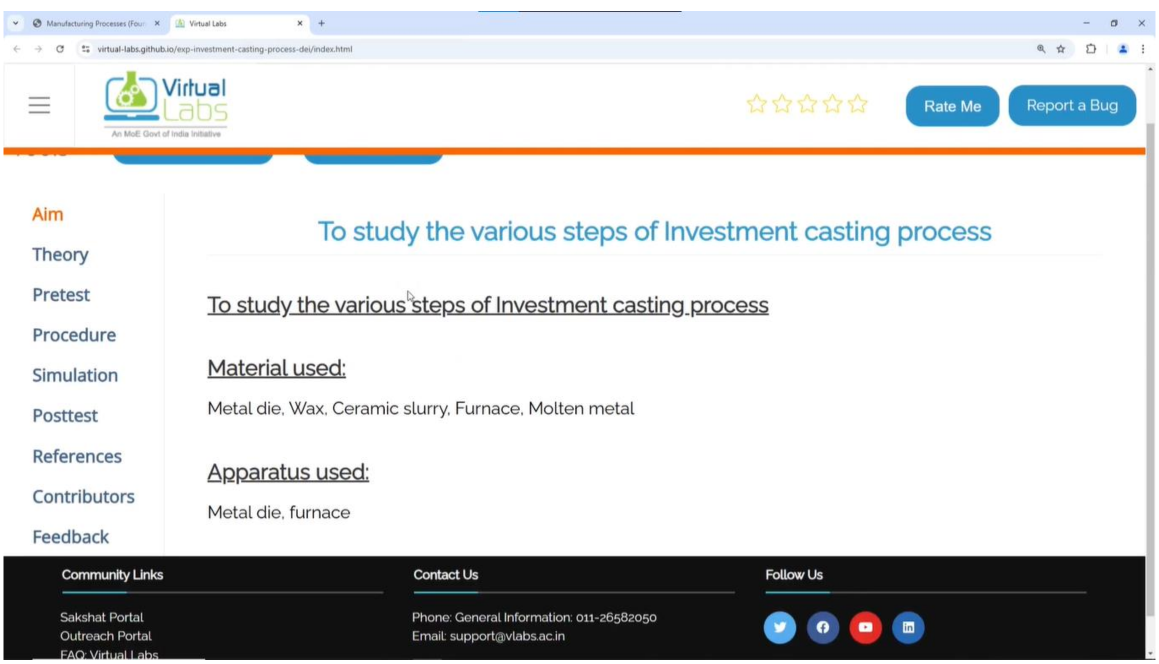
Now, the next step in the simulation is the post-test questions. The temperature up to which cores are baked by preheating them is—what is the general temperature to which it is heated? It is 650 degrees Fahrenheit. The force which is experienced by the cores while pouring molten metal is—this force is buoyant force. For the casting of aluminium, chaplets used are made up of—chaplets are small materials.

For example, it is a T- or I-shaped section. So, that is used to support the core in the hollow cavity. The core is to be supported, so those chaplets are used. These chaplets are generally made up of which material—they are asking. It is generally made up of aluminium. In the casting of aluminium, it is made up of aluminium only.

To remove the coarse from the finished casting, which of the following processes can be used? Generally, chemical dipping, blowing, and washing are all used. In solid silicate carbon dioxide cores, the purpose of passing carbon dioxide gas to the ram sand—this you now know very well—is to form silica gel, which binds sand grains in a strong solid form. This is the answer. Increasing permeability is less relevant.

Increasing collapsibility, increasing the strength of the core sand—the most relevant is the first part. Let me sum it up: 5 out of 5, this is now ready. Now, these are the references: other than Campbell, it has used books by Bile and Brown, which focus on foundry technology, and **The Foundryman's Handbook** by Ferris. So, this was the second experiment on core making. These are all very generic—or, I would say, traditional—experiments, which have been used for ages, for thousands of years.

Nowadays, investment casting or automated investment casting is also used, where multiple castings or products can be produced in a single pouring. Let me walk you through that one as well. I come to tab 1, and that investment casting process is here.



So, experiment number 8 is to study the various steps of the investment casting process. Click on that. So, the aim is to study the various steps of the investment casting process.

Materials used are metal die, wax, ceramic slurry, furnace, and molten metal. Apparatus used are metal die and furnace. Theory: A detailed text is provided here, which includes information on pattern preparation, mold creation, drying and pouring, solidification time, casting removal, finishing, and the need for or advantages of the investment casting process. So, parts in the investment casting process can be automated—this is one of the major applications. Close tolerance can also be achieved. Then, sections as narrow as 0.5 mm have been manufactured using investment casting.

Total weight up to maybe 25 to 30 kg has also been found suitable for the investment casting technique. The only disadvantages, which have been discussed previously, are that it is a slightly more complicated process than the regular single-piece casting process. It is relatively expensive. It is not suitable for heavy objects, and it is generally used for mass production when a larger number of components are required in a single go. Now, let me come to the pre-test questions. Zooming it out.

In an ideal case, the investment casting process can provide tolerances up to 0.08 millimeters. Products produced by the investment casting process are generally small or lightweight components that are required in large quantities. Heavy products, such as aluminum billets, cannot be produced using this method. This is not the right answer. Jewelry and surgical instruments—yes, this could be the right answer. So, this answer should be B, that is, jewelry and surgical instruments.

Next is automotive part that are made using investment casting process is wall pots, turbine blades both of them are used or both of them are made. Benefit of using investment casting process is good surface finish, high dimensional accuracy, allows casting of extremely complex parts all of these are the benefits. Let me come to the simulation part now. Now the apparatus being shown here, we have the apparatus that is the furnace, the metal die and these are the final castings that we will be having there. It says click on die for inside view of die while wax is being filled.

I click on the die, this is the inside view of the die, the wax is being filled here, right. So, let me see the patterns, how would it look like. The patterns are now here, and they are welded or locked using a hot flame. Click on the sprue and pattern assembly to dip it into the slurry to make a shell. I click on this, and we will place it in a flask. This is the slurry that is ready.

Click on slurry to take out sprue and pattern assembly. If I zoom it in, you can see everything is shown here. Things that are used. I click on the slurry. And now you can see it is here. Now, click on the sprue and pattern assembly to dip it into the stucco to make the shell. Click it here, it goes in, and the shell is formed. So, this shell is now ready.

Now we put it in the furnace, and it is heated. Click on the ladle now to pour metal into it. The molten metal is being poured. It is being filled here. We get the final patterns here.

We shake the shell to take the patterns out. And these patterns are ready now here. Now we can reset and redo it, restart the simulation to understand everything. You can do it multiple times. Let me move to the next step after the simulation: the post-test questions.

Which liquid is used for the formation of slurry in investment casting? Is it water, carbon disulfide, sodium silicate, or glycerin? It is sodium silicate. The purpose of dipping and stuccoing is performed continuously in investment casting to achieve the required strength. Strength comes through the thickness.

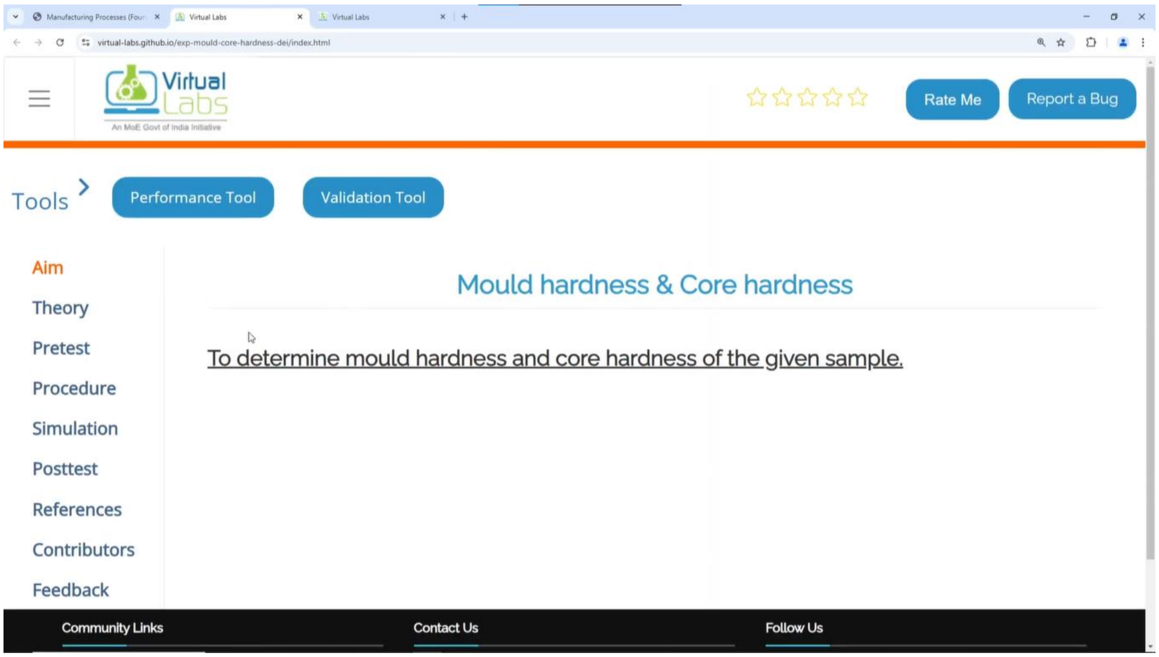
So, the answer is the desired thickness of the mold is required. That is to be achieved. To remove wax, to cool the wax pattern, to remove impurities—no, these are not the answers. To get the desired thickness is the right answer. Post-processes such as grinding, sandblasting, cutting, etc., are used in the investment casting process.

Yes, those are used because post-processing is required to achieve the final finish, corners, and sizes. This could involve sandblasting to descale it, grinding to get the desired surface finish, or cutting to remove any unwanted material or projections. So, these are all used. The answer is true. Remnant wax from the mold is removed by which of the following materials?

Gases, remnant gases that remain, need to be removed. Trichloroethylene is used for this purpose; nitroglycerin, phosphoric acid, and water are not the correct answers. Trichloroethylene is used. I submit the quiz and get the answers correct—4 out of 4. References used here are by Karunakar and by Singh and Ahuja to develop the simulation process.

So, these were mainly the casting processes which I have discussed. Now, the properties of the pattern and the properties of the sand are also to be tested. There are certain experiments in this direction as well. If you see here, experiment number 4 is to perform strength tests on sands. Experiment number 5 is to determine the percentage of clay present in the sand.

Experiment number 6 is to determine the mold hardness and core hardness. Then, to determine the permeability. All these are regarding the properties. Then, to find the distribution of sand grains using a set of sieves. Sand properties are again being discussed here. So, these are all properties. Let me take only one experiment out of these.



I will pick experiment number 6, which is to determine the mold hardness. So, mold hardness test. Here, the aim is to determine the mold hardness and core hardness of the given sample.

The theory is given here, which includes information about mold hardness and the mold hardness tester. It is essentially a type of dial gauge that uses a plastic sleeve and a metallic sleeve. This indicator will let you know the hardness number. The hardness number ranges between 0 and 100. To understand more about hardness testing, you can watch the videos on hardness testing in the course Basics of Mechanical Engineering 1, which was a precursor to this course.

So, this is hardness. Then, for core hardness, a separate dial gauge setup is there, which will also give you a range between 0 and 100. So, I will just go through the pre-test questions and walk you through the experiment simulation. Peter's question: The first question is, which of the following types of instruments is categorized for mold hardness tester and core hardness tester? So, I have told you those are the dial indicators.

So, dial indicators are used. Study about these different kinds of instruments: null deflection, indicating, integrating, recording. You can also visit one of the other courses, Engineering Metrology, by Professor Ram Kumar and me. There, the different kinds of instruments are discussed. Here, an indicating instrument is used to understand the mold hardness and core hardness. Mold hardness test is comparable to Vickers hardness test, Rockwell hardness test, Brinell hardness test, or Knoop hardness.

It is comparable to the Brinell hardness. Moulding sand that is naturally moist has different kinds of sand. Green sand, dry sand, parting sand. Moulding sand is generally green sand, which is a mixture of clay and water. So that the mould does not disperse unless the casting is completely done.

So this is green sand. The reason for using tungsten carbide in scratch-type testers is its hardness. I will show you this scratch-type testing. Tungsten carbide is used because it is hard. There is an indenter, the pin, and the pin tip has to be hard.

This tip is made of tungsten carbide. It is a hard metal, which is why it is used. This is right. Let me come to the procedure. It is showing the mold hardness test and the core hardness test.

There are certain steps here. For instance, for the mold hardness test, we choose the sand for which mold hardness is to be found. We click on the shawl, then click on the rammer so that the sand is rammed properly. We click at the center of the molding flask to take reading. We click at the one corner of the molding flask to take reading.

We take another corner for we take readings at multiple points, multiple surfaces of the pattern. Pattern, for example, it is a conical shape. We take at the flank. We take at the tip. We take at the other base, other surface. So, all these surfaces give us the reading. So, the average value of these five readings which are taken is calculated to find the final hardness number. Let me come through the simulation, mode hardness.

First step is to pick a sand, green sand or baking sand. By using the shawl, I will pick sand and transfer it to the molding flask. Next step is to ram it down. Preparing the mold to be tested. Next step is to test it.

Using this, take the reading at five different locations. Here reading is taken at five different locations, one is center and four corners. The result would be average of this. I click on the result, average of this is my hardness number. This is simply we are taking the readings using the dial gauge.

I will just talk you also through the core hardness, simulation core hardness. So, these are two cores, green sand core and dry sand core which are used and this is the core hardness tester. Let me pick green sand core. This core is there just using the hardness tester. It will test one surface first, then move to the second surface for testing, and finally go to the third surface.

It is the base here, test. These three surface readings have been obtained. I click on the result to take the average. Hardness number here is 28. So, this is regarding the core hardness.

Let me come to the post-test questions. Question 1: The range of measurement for the mold hardness tester and core hardness tester is, as already discussed, between 0 to 100. Next, which tool is used to transfer molding sand into the molding flask? It is simply the shovel that is used. How many indentations were made in the mold hardness test?

We took five readings: one at the center and four at the corners. What is measured by the core hardness tester? It measures the interior hardness of the core. The tip of the mold hardness tester is generally made of alloy steel. I submitted the quiz and got 5 out of 5.

References: Use Sarkar's book to design the hardness testing experiment. With this, I am concluding my lectures on casting processes. We will meet next week and discuss forming processes.

Thank you.