

PRACTICAL WORKBOOK

MY- 303: Foundry: Principles, Methods & practice



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DEPARTMENT OF METALLURGICAL ENGINEERING
NED UNIVERSITY OF ENGINEERING AND TECHNOLOGY

Practical Workbook

My-303: FOUNDRY: PRINCIPLES, METHODS AND PRACTICES



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PRACTICAL NO. 1**OBJECTIVE**

Determination of fineness (grain size) of sand by “Sieve Analysis Method”.

APPARATUS

Set of Sieves, Oven, Shaking Device, Electronic Weighing Balance, and Molding Sand.

THEORY

The grain size of the sand is expressed by a number called “grain fineness number”. A given grain fineness number corresponds to standard sieve of 200 mm diameter which has the identical number of meshes in it.



To determine this number for a given sand sample, it is customary to use a standard sieve set which contain several sieves having one above the other, a varying but known number of meshes. The coarsest sieve is placed at the top and finest at the bottom.

PROCEDURE

1. Weigh a 100 gram sample of the sand when it is perfectly dry (free of clay & moisture)
2. Place the sample of the sand into the coarsest (top most) sieve.
3. Place the set of sieves on shaking device to shake Shown in **figure-1** above.
4. Shake the sample in set of sieve on shaking device for definite length of time for 15 minutes.
5. After shaking start removing sieves form top sieve to bottom, weigh the quantity Of remaining sample on each sieve.
6. The weight collected from each sieve is multiplied with sieve mesh number.
7. Finally divide the total product by the total sample weight & this produces the fineness number, which in the AFS (American Foundry Society). After calculating the number is called AFS number

Sieve number	Sand retained on sieve (gm)	Multiplied by previous sieve number	Product
10	Nil	-	-
16	Nil	-	-
22	0.2	0.2*16	3.2
30	0.8	0.8*22	17.6
44	6.7	6.7*30	201.0
60	22.6	22.6*44	1104.4
100	48.3	48.3*60	2898.0
150	15.6	15.6*100	1560.0
200	1.8	1.8*150	270.0
Pan	4.0	4.0*200	800
-----	-----	Product	6854.2
-----	-----	-----	-----

AFS fineness number = Product / Weight of sample

AFS fineness number = 6854.2/100

AFS fineness number = 68.542

EXERCISE

Q.1 What is the effects of sand grain size on sand casting?

Q.2 Differentiate between the properties of coarse and fine grained sand?

Q.3 Give general introduction about sieves used in this process?

Q.4 Discuss the general idea of sieve analysis?

Q.5 Do you know about any alternate procedure to check the fineness number?

Practical No. 2

Objective

To carry out compression test of Green sand by using Green compression strength machine.

Theory

General Principal

This machine is designed to determine compression strength of prepared specimens of green sands and unbaked core sands by applying a progressively increasing spring load to the specimen until it collapses.

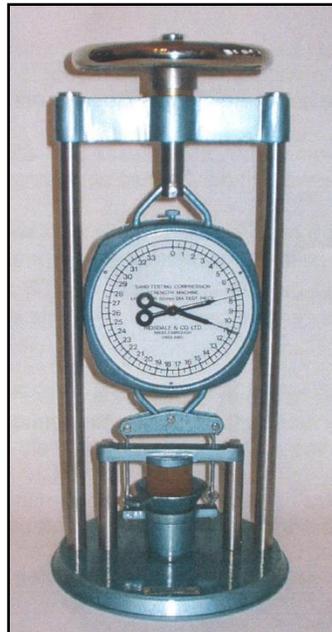


Figure: Green Compression Strength Machine

Description

The machine consists of a spring balance and a pair of self-aligning compression heads all supported in a strong metal frame. By means of a hand-wheel, a load can be applied to a sand specimen held in the compression heads, via the spring balance. The load required to cause the specimen to collapse is recorded on the dial of the spring balance by means of a slave pointer which indicates the compression strength in kN/m^2 . Three ranges of spring balance are available for this machine:-

$0\text{-}33 \text{ kN/m}^2$, $0\text{-}90 \text{ kN/m}^2$ and $0\text{-}220 \text{ kN/m}^2$ on a 50 mm diameter x 50 mm height specimen.

A sample holder is provided with each machine to facilitate the positioning of the specimen in the compression heads and in the case of the low capacity balance a special sample plate is supplied on to which the specimen can be stripped directly from the split specimen tube when dealing with very weak sand mixes.

Test Procedure

- (a) Prepare a test specimen on a Metric Standard Rammer. For routine purposes this can be made on a green sand test specimen after the permeability has been determined. For research work a fresh specimen should be prepared.
- (b) Carefully transfer the test specimen to the compression machine by means of the sand pan provided and place centrally on the lower compression head.
- (c) If the sand is very weak prepare a specimen in a split specimen tube and use a low capacity spring balance, with a more open scale, having a maximum reading of 33 kN/m² on a metric 50 mm diameter x 50 mm height specimen. In this case the specimen should be stripped directly on to the special sample plate provided with the low capacity balance.
- (d) Rotate the hand-wheel in a clockwise direction until the weight of the specimen is supported by the spring balance. Zero the moving pointer by means of the knurled screw on the top of the balance. Set the slave pointer to zero.
- (e) Ensure that the compression heads are free to self-align and turn the hand-wheel in a clockwise direction until the load begins to be applied to the specimen. Turn the handle slowly, at the rate of about 25 kN/m² in 10 seconds, until the specimen collapses. (This is achieved most easily by using both hands on the rim of the hand-wheel).
- (f) Record the compression strength as indicated by the slave pointer.

Maintenance

Keep the machine clean and the hand-wheel shaft lightly oiled. Ensure that the lower compression head is free to move and therefore self-aligning.

Observations

Compressive Strength = _____

Results

The compressive strength of Green sand is calculated as _____

Practical No. 3

OBJECTIVE

To carry out on floor mold strength testing by using Mold Strength Tester.

THEORY

General Principle

The Mould Strength Tester is used to measure the green compression strength of moulds on the foundry floor. Any reasonable flat or gently curved mould surface may be used. The tester can be operated at any angle, thus making it possible to take strength measurements on vertical surfaces of a mould.

A reading is obtained, which is comparable to the green compression strength test, obtained on a standard test specimen, rammed to the same degree as the mould.



Figure: On Floor Mold Strength Tester

Description

This instrument is a dial gauge indicator calibrated in kN/m^2 with a specially shaped, spring loaded probe, marked with a graduation line 9.5 mm from the tip.

It is designed as a pocket instrument and has a capacity of 0-200 kN/m^2 .

Test Procedure

- (a) Release the bezel clamping screw and rotate the milled bezel until the indicating pointer is at zero. Re-clamp the bezel. Turn the centre button to bring the slave pointer to rest against the indicating pointer.
- (b) Holding the tester at right angles to the mould surface, press the probe slowly into the sand. The force applied should be only enough to keep the probe just moving into the surface.
- (c) Stop applying pressure when the graduation on the probe is level with the mould surface. The green compression strength of the mould is indicated by the maximum reading slave pointer.

NOTE

Since this test is subject to an operator variable, it is suggested that the operator make practice tests on a metric 50 mm diameter x 50 mm length test specimen, resting on the stripping post before it is stripped from the specimen tube. Other specimens of the same sand can be tested with the Green Compression Strength Machine, or the Universal Sand Strength Testing Machine, so that the operator can observe the desired loading rate and have reference values for evaluating his test procedure.

Observation

On Floor Green Strength = _____

Results

On Floor Green strength calculated as = _____

Practical No. 4

OBJECTIVE

To carry out permeability testing of Green sand by using Permeability meter.

THEORY

General Principle

Permeability is defined by the AFS as that physical property of moulded sand which allows gas to pass through it. It is determined by measuring the rate of flow of air through the metric standard rammed specimen under a standard pressure.

The general formula for the calculation of permeability may be expressed as follows:-

$$P = \frac{V h}{a p t}$$

Where:

P = permeability.

V = Volume of air in ml passing through the specimen.

h = height of test specimen.

p = pressure of air in cm of water.

a = area of cross section of specimen in cm².

t = time in sec.

Since the standard method requires that 2000 ml of air should be forced through a specimen 50 mm (5.0 cm) and 50 mm diameter (19.63 cm² area), by substituting these values for v, h, and a, and measuring the time in seconds, the formula becomes :-

$$P = \frac{30557}{\text{air pressure in cm of water} \times \text{time in seconds}}$$

To determine permeability it is, therefore, only necessary to measure accurately the time taken for 2000 ml of air at a known pressure to pass through a standard test specimen.

By means of this instrument a measured volume of air can be passed through a rammed sand specimen and the permeability of the sand determined by recording the time taken for the air at a measured pressure to pass through the specimen.

Alternatively, for routine control purposes, calibrated orifices may be used to meter the rate of flow of air to the sand specimen and by measuring the pressure between the orifice and the specimen, the permeability may be obtained by referring to the attached table or using the transparent direct reading scale.

Description

The body of the Permeability Meter is an aluminium casting consisting of a water tank and base. Inside the water tank floats a balanced air drum carefully weighted and designed to maintain a constant air pressure of 10 cm during its fall.

The outlet from the air drum is connected to a centre post in the base via a three-way air valve. The centre post incorporates a pipe for measuring pressure, which is connected to the water manometer and an expandable 'O' ring for sealing the specimen tube. It also accommodates the orifices.

Two calibrated orifices marked 30 and 270 respectively, and an open orifice marked '0' are supplied.



Figure: Permeability Meter.

A transparent scale is mounted in front of the manometer to measure the air pressure or permeability when using the orifice method.

Installation

- (a) Place the Permeability Meter on a level bench and fill tank with water to WATER LEVEL mark.
- (b) Rotate knurled ring clockwise and remove the aluminium cover from the centre post. Open priming cup and pour distilled water into it until the water appears in the glass tube below line '0'. Any initial resistance to the entry of the water can be overcome by pressing the ball of the thumb on the open end of the priming cup.* Close the tap.
- (c) With the manometer scale on the dial in the vertical position, turn the adjusting screw until the zero on the dial is level with the water in the manometer tube.
- (d) Turn air valve to 'VENT' and raise air drum until it is above the water level. Turn valve to 'CLOSED' and allow the drum to descend slowly into the water. Turn the air valve gradually towards 'VENT' and allow the air drum to descend until the 'X' mark on the drum is level with the top edge of the tank. Turn valve to 'CLOSED'.
- (e) Place the aluminium cover on the centre post and form an air-tight seal by rotating the knurled ring in an anti-clockwise direction.
- (f) Turn the air valve to a position midway between 'CLOSED' and 'VENT'. The water level in the manometer should now read 10.0 cm pressure and remain steady. If the drum should descend this would indicate air leaks in the system.

* The addition of a small amount of detergent will facilitate the filling of the manometer tube.

Test Procedure

DIN Standard Time and Pressure Method

- (a) Check that the open orifice is in position in the centre post.
- (b) Prepare a standard specimen of sand. Before stripping from tube, place in position on the centre post and seal by rotating the knurled ring anti-clockwise.
- (c) Raise the air drum as in Section III, paragraph (d).
- (d) Allow the air drum to descend by turning the air valve to a position midway between 'CLOSED' and 'VENT'. Time the descent of the air drum between the zero and the 2000 ml mark with a stop watch and record the pressure indicated on the manometer during the descent of the drum.

- (e) Calculate the permeability by applying the formula given in

Routine Method using calibrated orifice

- (b) Screw the appropriate orifice into the air outlet pipe in the centre post. Tighten firmly onto the rubber washer using the fingers only.
- (c) Raise the air drum as in Section III, paragraph (d), and place the specimen and tube in position on the centre post. Seal by rotating the knurled ring anti-clockwise.

Allow the air drum to descend by turning the air valve to a position midway between 'CLOSED' and 'VENT' and either :-

- (i) Record the pressure on the manometer and refer to the table for the Permeability number, or,
- (ii) Rotate the transparent scale until the line on the circumference cuts the meniscus of the water in the manometer and read the permeability direct. If the small orifice is used read the outer scale on the dial, and if the large orifice is used read the inner scale.

Observations

For Open Orifice:

t = _____ p = _____

For Large Orifice:

t = _____ p = _____

For Small Orifice:

t = _____ p = _____

Calculations**Results**

Permeability through Open orifice: _____

Permeability through Large orifice: _____

Permeability through Small orifice: _____

PRACTICAL NO. 5

OBJECTIVE

To carry out the sand casting process

APPARATUS

Sand, Core, Melting furnace, pouring ladle, molded flask etc.

THEORY

Sand casting (figure 9-a) diagram, the most widely used casting process, utilizes expendable sand molds to form complex metal parts that can be made of nearly any alloy. Because the sand mold must be destroyed in order to remove the part, called the casting, sand casting typically has a low production rate. The sand casting process involves the use of a furnace, metal, pattern, and sand mold. The metal is melted in the furnace and then ladled and poured into the cavity of the sand mold, which is formed by the pattern. The sand mold separates along a parting line and the solidified casting can be removed. The steps in this process are described in greater detail in the next section. Sand casting is used to produce a wide variety of metal components with complex geometries. These parts can vary greatly in size and weight, ranging from a couple ounces to several tons. Some smaller sand cast parts include components as gears, pulleys, crankshafts, connecting rods, and propellers. Larger applications include housings for large equipment and heavy machine bases. Sand casting is also common in producing automobile components, such as engine blocks, engine manifolds, cylinder heads, and transmission cases.

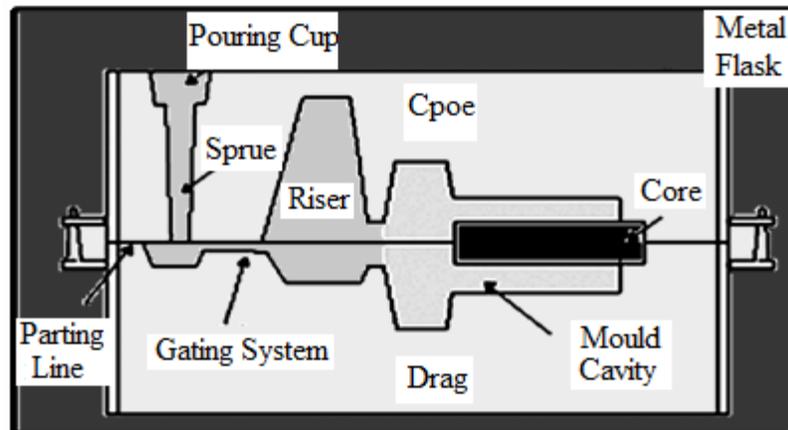


Fig: Sand Casting Diagram

PROCEDURE

1. **Pattern making:** First of all we will make a pattern. Take a piece of wood, and by using tools and techniques to make a pattern of required shape and size.
2. **Preparation of sand;** Preparation of sand includes washing of sand, by which we remove clay and other undesirable particles from the sand, to make it suitable for molding and casting.
3. **Core making:** Core is made of sand which is separately made in core boxes (made of wood/metal) by Co₂ process; this is called as sodium silicate process. It involves a mixture of sand & 1.5-6% liquid silicate. Then carbon dioxide gas is passed through the sand which facilitates high strength that avoids sand erosion.
4. **Core dressing:** Editing and remaking of core. Usually broken or inaccurate cores are scraped. But in some circumstances the cores are dressed, the dressing operation include trimming sizing & coating.
5. **Molding:** The pattern is placed in the mold box & then sand filled around it. The green is used having 5-6% Bantonite, 5-6% coal dust & moisture. When the mold is completely filled, pattern is withdrawn from the mold which leaves a cavity.
6. **Melting:** One of these furnaces can be used for melting purpose. Cupola, induction and gas fired pit furnace etc. In this process we convert the solid state of metal into liquid state through a furnace by heating.
7. **Pouring:** The molten metal is transferred to ladle & then into the cavity, when transferred to cavity is known as pouring (figure 8-b). The temperature of molten metal is little above the melting point to avoid solidification in ladle. the pouring must be uniform and flow should not be disturbed otherwise layer of metal are formed results in the defects in casting. Simultaneously, ferro-silicon is added which provides extra luster to casting.

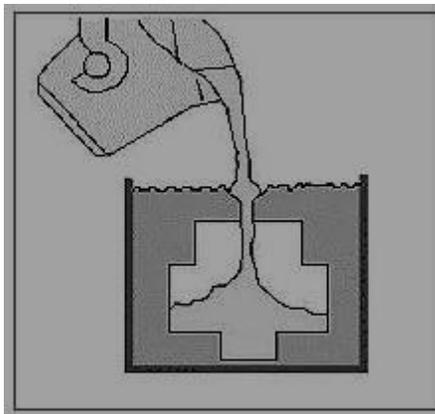


Fig: Pouring

8. **Fettling:** As the casting is extracted from the mold it is no longer fit for use as for as it has sprue, riser, runner etc. So these parts are removed by machining, cutting or grinding process. This process of removing gating & feeding system is known a fettling.
9. **Shaking of mold:** After fettling, the casting still have excess amount of sand in it & also cores are to be removed from the casting. So casting is vibrated on vibrating machine to remove sand & cores on it.
 - a. Removal of runners, in gates, feeders and flow off.
 - b. Removal of external joint line flash.

- c. Removal of internal flash and fins.
- d. Removal of core sand by pneumatic chipping hammer.

10. **Sand or Shot blasting:** After the two cleaning processes, castings still have fins, burrs etc. So the castings are transferred into a separate chamber where sand blasting or steel blasting is carried out these processes completely cleans the casting from fins, burrs and sharp edges.

EXERCISE

Q.1 What are the functions of core prints?

Q.2 How does risers help to reduce shrinkage allowances?

Q.3 What are main sand casting defects? Discuss few of them.

Q.4 Differentiate between green & synthetic sand? Which one is better for sand casting? And why?

Q.5 Discuss how can we minimize or prevent the Sand casting defects.

PRACTICAL NO. 6

OBJECTIVE

Examination of the micro-structure of castings.

APPARATUS

Abrasive cutting wheel, Mounting machine, Plastic resins (phenolic resins), Grinding and Polishing machine, Etchant, Metallurgical Micro-scope, Hand gloves, Goggles etc

PROCEDURE

1. Sampling

Take a metal piece, cut the metal in small pieces which can be used for sampling by using abrasive cut off machine.

2. Cutting

When cutting a specimen from a larger piece of material, care must be taken to ensure that it is representative of the features found in the larger sample, or that it contains all the information required to investigate a feature of interest. One problem is that preparation of the specimen may change the microstructure of the material, for example through heating, chemical attack, or mechanical damage. The amount of damage depends on the method by which the specimen is cut and the material itself. Cutting with abrasives may cause a high amount of damage, while the use of a low-speed diamond saw can lessen the problems. There are many different cutting methods, although some are used only for specific specimen types. MTI provides the SYJ-150 low speed diamond saw for cutting OM (optical microscope), SEM (scanning electron microscope), and even TEM (transmission electron microscope) specimen.

3. Mounting

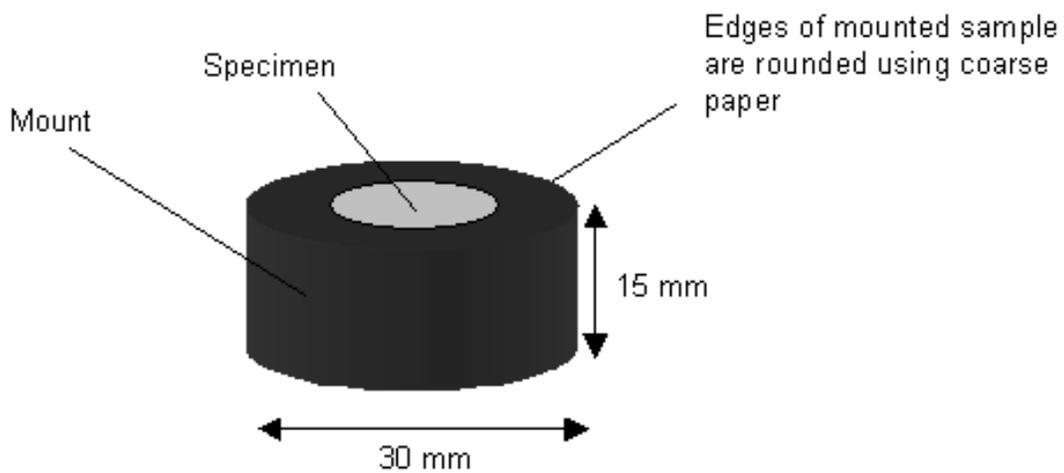
Mounting of specimens is usually necessary to allow them to be handled easily. It also minimizes the amount of damage likely to be caused to the specimen itself. The mounting material used should not influence the specimen as a result of chemical reaction or mechanical stresses. It should adhere well to the specimen, and if the specimen is to be electro polished later in the preparation then the mounting material should also be electrically conducting. Specimens can be hot mounted (about 150 °C) using a mounting press (fig: a) either in a thermosetting plastic, *e.g.* phenolic resin (fig: b), or a thermo softening plastic *e.g.* acrylic resin. If hot mounting will alter the structure of the specimen a cold-setting resin can be used, *e.g.* epoxy, acrylic or polyester resin. Porous materials must be impregnated by resin before mounting or polishing, to prevent grit, polishing media or etchant being trapped in the pores, and to preserve the open structure of the material.



(Fig: a) Hot Mounting Machine



(Fig: b) Plastic Resins



(Fig: c) A Mounted Specimen (shows typical dimensions)

A mounted specimen (fig: c) usually has a thickness of about half its diameter, to prevent rocking during grinding and polishing. The edges of the mounted specimen should also be rounded to minimize the damage to grinding and polishing discs.

4. Grinding:

Surface layers damaged by cutting must be removed by grinding by grinding machine (fig: d). Mounted specimens are ground with rotating discs of abrasive paper, for example wet silicon carbide paper (emery paper). The coarseness of the paper is indicated by a number: the number of grains of silicon carbide per square inch. So, for example, 180 grit paper is coarser than 1200 grit.

The grinding procedure involves several stages, using a finer paper (higher number) each time. Each grinding stage removes the scratches from the previous coarser paper. This can be easily achieved by orienting the specimen perpendicular to the previous scratches. Between each grade the specimen is washed thoroughly with soapy water to prevent contamination from coarser grit present on the specimen surface. Typically, the finest grade of paper used is the 1200, and once the only scratches left on the specimen are from this grade.



(Fig: d) Grinding Machine

5. Lapping:

The lapping process is an alternative to grinding, in which the abrasive particles are not firmly fixed to paper. Instead a paste and lubricant is applied to the surface of a disc. Surface roughness from coarser preparation steps is removed by the micro-impact of rolling abrasive particles.

5. Polishing:

Polishing (fig: e) discs are covered with soft cloth impregnated with abrasive diamond particles and an oily lubricant or water lubricant. Particles of two different grades are used : a coarser polish - typically with diamond particles 6 microns in diameter which should remove the scratches produced from the finest grinding stage, and a finer polish – typically with diamond particles 1 micron in diameter, to produce a smooth surface. Before using a finer polishing wheel the specimen should be washed thoroughly with warm soapy water followed by alcohol to prevent contamination of the disc. The drying can be made quicker using a hot air drier.



(Fig:e) Polishing Machine

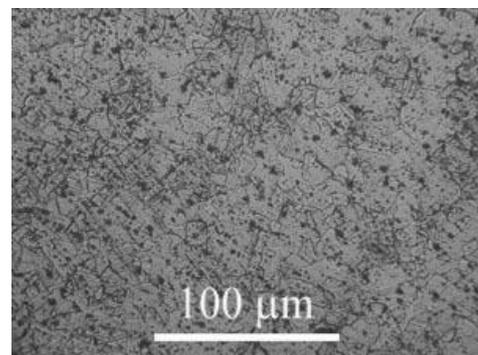
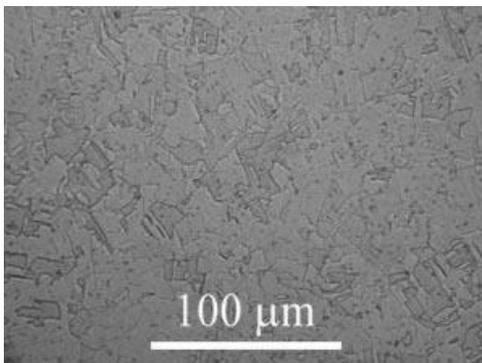


(Fig: f) Etching

6. **Etching:** Etching (fig: f) is used to reveal the microstructure of the metal through selective chemical attack. In alloys with more than one phase etching creates contrast between different regions through differences in topography or the reflectivity of the different phases. The rate of etching is affected by crystallographic orientation, so contrast is formed between grains, for example in pure metals. The reagent will also preferentially etch high energy sites such as grain boundaries. This results in a surface relief that enables different crystal orientations, grain boundaries, phases and precipitates to be easily distinguished. The specimen is etched using a reagent. For example, for etching stainless steel or copper and its alloys, a saturated aqueous solution of ferric chloride, containing a few drops of hydrochloric acid is used. This is applied using a cotton bud wiped over the surface a few of times (Care should be taken not to over-etch - this is a difficult point to determine, however, the photo below may be of some help). The specimen should then immediately be washed in alcohol and dried.

Following the etching process there may be numerous small pits present on the surface. These are etch pits caused by localized chemical attack, and in most cases they do not represent features of the microstructure. They may occur preferentially in regions of high local disorder, for example where there is a high concentration of dislocations.

If the specimen is over etched (*Left figure*), i.e., etched for too long, these pits tend to grow, and obscure the main features to be observed - as seen in the images below:



Cleaning specimens in an ultrasonic bath can also be helpful, but is not essential. Ideally the surface to be examined optically should be perfectly flat and level. If not, then as the viewing area is moved across the surface it will pass in and out of focus. In addition, it will make it difficult to have the whole of the field of view in focus - while the centre is focused, the sides will be out of focus. By using a specimen leveling press (shown below) this problem can be avoided, as it presses the mounted specimen into plasticene on a microscope slide, making it level. A small piece of paper or cloth covers the surface of the specimen to avoid scratching.

7. Micro-Scopic study:

An optical microscope or a light microscope magnifies objects which are far too small to be seen by the naked eye. In an optical microscope, light must gathered from a small area of a well illuminated thin specimen in close distance. As a result, an optical microscope employs small and spherical objective lenses. This allows for a much shorter focal length and hence a much shorter distance is needed within the tube of the microscope to bring the image of the object into focus. A second lens normally referred to as the eyepiece or an ocular lens is used to magnify the image as the image is brought to the eye.

EXERCISE

Q.1 Which method is best suitable for cutting the specimen?

Q.2 How much temperature and pressure required for mounting the specimen?

Q.3 Explain different types of mounting material, which is the best mounting material and why?

Q.4 What is the purpose of etching and show the chemical composition of nital etchant?

Q.5 What will happen if the specimen is over etched?

Practical No. 7

OBJECTIVE

To carry out vulcanization of silicon rubber for mold making.

THEORY

Vulcanization is a chemical process for converting rubber or related polymers into more durable materials via the addition of sulfur or other equivalent "curatives" or "accelerators". These additives modify the polymer by forming crosslink's (bridges) between individual polymer chains. Vulcanized materials are less sticky and have superior mechanical properties.

Process

Vulcanization is generally irreversible, similar to other thermosets and in contrast to thermoplastic processes (the melt-freeze process) that characterize the behavior of most modern polymers. The cross-linking is usually done with sulfur, but other technologies are known, including peroxide-based systems.

Vulcanization of silicones

"Room-temperature vulcanizing" (RTV) silicone is constructed of reactive oil base polymers combined with strengthening mineral fillers. There are two types of room-temperature vulcanizing silicone.



Figure: Vulcanization Equipment

Practical No. 8

OBJECTIVE

To carry injection molding of wax.

THEORY

Injection molding (British English: **molding**) is a manufacturing process for producing parts by injecting material into a mold. Injection molding can be performed with a host of materials, including metals, glasses, elastomers, confections, and most commonly thermoplastic and thermosetting polymers. Material for the part is fed into a heated barrel, mixed, and forced into a mold cavity where it cools and hardens to the configuration of the cavity.^{[1]:240} After a product is designed, usually by an industrial designer or an engineer, molds are made by a mold maker (or toolmaker) from metal, usually either steel or aluminum, and precision-machined to form the features of the desired part. Injection molding is widely used for manufacturing a variety of parts, from the smallest components to entire body panels of cars.

Parts to be injection molded must be very carefully designed to facilitate the molding process; the material used for the part, the desired shape and features of the part, the material of the mold, and the properties of the molding machine must all be taken into account. The versatility of injection molding is facilitated by this breadth of design considerations and possibilities.

Injection molding apparatus

An injection molding apparatus capable of producing disposable wax patterns or the like and which apparatus includes a logic control and a servo-control especially designed to provide a substantially automatic molding process and to continuously monitor and to dynamically control certain variable parameters which are encountered during the molding process, as for example, in the present embodiment of apparatus, the control of the dynamics of fluid (wax) flow and pressure for providing substantially an automatic molding process.

The servo-control is a "closed loop" servo type of control which, in the present embodiment of apparatus, continuously provides signals which relate to the fluid (wax) flow, i.e. velocity and acceleration, and fluid pressure which is then occurring in the molding cycle, and which signals are then compared with preselected input or reference signal levels whereupon a difference therebetween is then used to adjust or drive the fluid flow and pressure control systems of the apparatus toward a dynamic or balanced state which reduces this difference in signals between the input and measured signal levels to zero.

The logic control for use with the molding apparatus is of the type that enables a substantially automatic molding cycle to be programmed for said apparatus whereby uniform product output is repeatedly obtained.



Figure: Wax injection molding Apparatus

Procedure

Remarks

Practical No. 9

OBJECTIVE

To carry out investment casting.

THEORY

Investment casting is an industrial process based on and also called lost-wax casting, one of the oldest known metal-forming techniques. From 5,000 years ago, when beeswax formed the pattern, to today's high-technology waxes, refractory materials and specialist alloys, the castings allow the production of components with accuracy, repeatability, versatility and integrity in a variety of metals and high-performance alloys. Lost-foam casting is a modern form of investment casting that eliminates certain steps in the process.

The process is generally used for small castings, but has been used to produce complete aircraft door frames, steel castings of up to 300 kg (660 lbs) and aluminium castings of up to 30 kg (66 lbs). It is generally more expensive per unit than die casting or sand casting, but has lower equipment costs. It can produce complicated shapes that would be difficult or impossible with die casting, yet like that process, it requires little surface finishing and only minor machining.

Process

Steps In The Investment Castings Process

The investment casting process begins with fabrication of a sacrificial pattern of the same basic geometrical shape as the intended finished cast part. Patterns are normally made of investment casting wax that is injected into a metal wax injection die (Fig. 1).

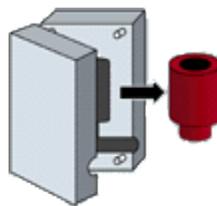


Fig. 1 Wax Injection

Once a wax pattern is produced, it is assembled with other wax components on a central wax stick, called a sprue, to form a casting cluster or assembly (Fig. 2).



Fig. 2. Assembly.

The entire wax assembly is then dipped in a ceramic slurry and covered with a sand stucco (Fig. 3), and allowed to dry.

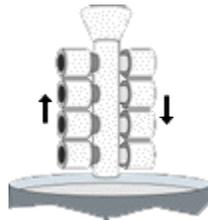


Fig. 3. Shell Building

The dipping and stuccoing process is repeated until a shell of ~6-8 mm (1/4-3/8 in) is applied. Once the ceramic has dried, the entire assembly is placed in a steam autoclave to remove most of the wax. The remaining amount of wax soaked into the ceramic shell is burned out in a furnace (Fig. 4).



Fig. 4. Dewax

At this point, all of the residual pattern and gating material is removed, and the ceramic mold remains. The mold is then preheated to a specific temperature and filled with molten metal, creating the metal casting (Fig. 5).

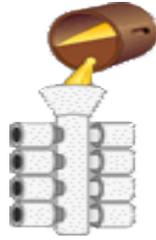


Fig. 5. Metal Casting Pouring

Once the casting has cooled sufficiently, the mold shell is chipped away from the casting (Fig. 6).

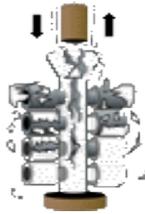


Fig. 6. Knockout

Next, the gates and runners are cut from the casting (Fig. 7).



Fig. 7. CutOff

After minor final post processing (sandblasting, machining), the castings - identical to the original wax patterns - are complete and ready for shipment (Fig. 8).



Fig. 8 Finished Casting

