

**VIT**Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

SLOT: G2

REG. NO.:

**SCHOOL OF MECHANICAL ENGINEERING
CONTINUOUS ASSESSMENT TEST (CAT) -II
WINTER SEMESTER 2023-2024**

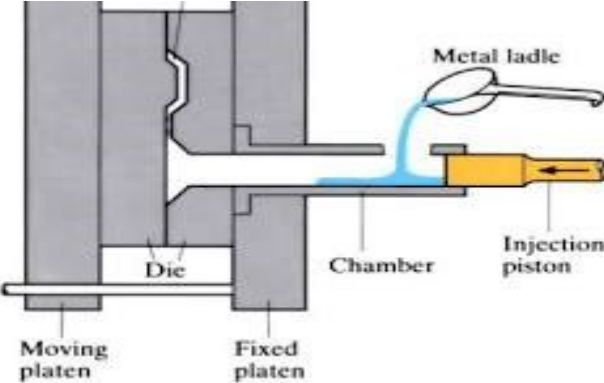
Programme Name & Branch : B.Tech. Mechanical Engineering
Course Code : BMEE302L
Course Name : Metal Casting and Welding
Faculty Name(s) : Dr.S. Senthil Kumaran, Dr Narendra Kumar U,
Dr. Arivazhagan N, Dr. Anoj Giri, Dr. Sreekanth M. S

Class Number(s) : 4586, 4585, 4581, 4576, 6107

Exam Duration : 90 minutes

Maximum Marks: 50

General instruction(s):**Answer ALL the Questions**

Q. No	Question	Marks
1.	Determine the most suitable casting method for creating high-density components with complicated shapes and complex characteristics to obtain a near-net-shape product in the automotive industry. Include a pertinent diagram along with a brief explanation of the operating concept, benefits, limitations, and application. Answer: High-Pressure Die Casting (HPDC) High-pressure die casting (HPDC) is a rapid manufacturing process for creating high-volume, intricate metal parts with good surface finish and dimensional accuracy. Here's a breakdown of the process with a diagram: Working Diagram:  High Pressure Die Casting Process Process Explanation: 1. Die Preparation: The steel die cavity is cleaned and lubricated to ensure smooth operation and part quality.	10



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REG. NO.:

**SCHOOL OF MECHANICAL ENGINEERING
CONTINUOUS ASSESSMENT TEST (CAT) -II
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2. **Metal Melting:** Molten metal, typically aluminum, magnesium, or zinc alloys, is prepared in a holding furnace.
3. **Metal Injection:** A plunger forces the molten metal at high pressure (thousands of psi) through a gooseneck into the die cavity.
4. **Solidification:** The metal rapidly cools and solidifies within the clamped die.
5. **Part Ejection:** Once solidified, the die opens, and ejector pins push the cast part out.
6. **Trimming:** Excess material from the sprue (injection channel) and overflows (flash) is removed.

Benefits:

- **High Production Rate:** HPDC is ideal for mass production due to its fast cycle times.
- **Dimensional Accuracy:** The metal is forced into the die cavity under high pressure, resulting in precise components with minimal post-machining needed.
- **Good Surface Finish:** The smooth die surfaces create cast parts with a good surface finish, reducing finishing needs.
- **Thin Walls:** HPDC allows for the creation of parts with thin walls, leading to lightweight components.

Limitations:

- **High Initial Cost:** Die casting machines and tooling require significant upfront investment.
- **Limited Material Selection:** The process is primarily suited for alloys with good castability, like aluminum and magnesium.
- **Part Complexity:** While complex shapes are achievable, there are limitations compared to investment casting for extreme intricacies.
- **Porosity:** Rapid solidification can trap air pockets, requiring proper venting in the die design.

Applications in Automotive Industry:

- **Engine components:** Intake manifolds, cylinder head covers, pistons (sometimes)
- **Body components:** Door handles, wheels (aluminum), brackets, housings.
- **Interior components:** Instrument bezels, seat parts, control levers.

HPDC is a versatile and efficient method for producing high-quality automotive parts in large quantities. However, it's crucial to consider the



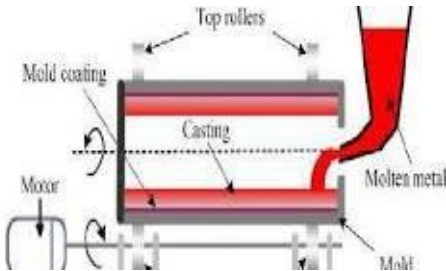
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	limitations regarding material selection and part complexity when choosing the most suitable casting process.	
2.	Simplify the most suitable casting technique for fabricating the hollow pipes or tubes, including an appropriate image and a detailed description of the merits and downsides for each application. Answer: Centrifugal casting is a unique metal casting process that utilizes centrifugal force to distribute molten metal within a mold. This technique is particularly effective for producing high-density, cylindrical components with superior strength and minimal porosity. Working Diagram:  Process Explanation: Mold Preparation: A permanent mold, typically made from steel, cast iron, or graphite, is preheated. The mold can be oriented horizontally or vertically depending on the desired part geometry. Metal Melting: Molten metal, often ferrous or non-ferrous alloys suitable for centrifugal casting, is prepared in a furnace. Metal Pouring: The molten metal is poured into the rotating mold at a controlled rate. Centrifugal Force: As the mold spins at high speeds (hundreds to thousands of rpm), centrifugal force pushes the molten metal outwards, filling the mold cavity. Solidification: The metal cools and solidifies against the mold walls, with denser material concentrated towards the center.	10



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CONTINUOUS ASSESSMENT TEST (CAT) -II
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Mold Stopping and Part Removal: Once solidified, the mold rotation ceases, and the cast part is removed. Machining might be required for specific tolerances.

Benefits:

- **High Density:** Centrifugal force promotes denser metal distribution, minimizing air pockets and leading to strong, reliable components.
- **Directional Solidification:** The outward solidification pattern minimizes internal defects and improves mechanical properties.
- **Superior Surface Finish:** The centrifugal force creates a good surface finish on the outer diameter of the cast part.
- **Suitable for Long, Cylindrical Parts:** This process excels at producing pipes, tubes, bushings, liners, and other elongated shapes.

Limitations:

- **Limited Part Geometry:** Centrifugal casting is primarily suited for cylindrical or axisymmetric shapes. Complex geometries are challenging.
- **Mold Cost:** While permanent molds offer reusability, their initial construction can be expensive.
- **Production Speed:** Compared to high-volume casting methods, centrifugal casting has a slower production rate.

Applications in Automotive Industry:

Engine components: Cylinder liners, piston rings, bearing races.

Drivetrain components: Bushings, sleeves, gear blanks.

Suspension components: Shock absorber components, wheel hubs (depending on design).



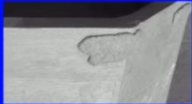
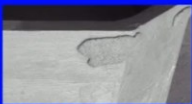
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	Centrifugal casting offers a valuable approach for creating high-quality, cylindrical components in applications demanding strength, density, and good surface finish. However, its limitations in part complexity and production speed necessitate careful consideration during the selection process.	
3.	How do mould material defects affect the quality of the casting? Identify five suitable defects based on the aforementioned problem and provide specifics regarding their causes and corrective measures to prevent further casting defects. Answer: SCAB CAUSES: 1. Low moisture content in the moulding sand (below 3 %). 2. Insufficient clay in the moulding sand.  Typical appearance of a Scab SCAB REMEDIAL MEASURES: Proper moisture and clay contents are to be taken.  Typical appearance of a Scab METAL PENETRATION CAUSES: 1. Larger sand grains. 2. Insufficient compaction of sand.  Typical appearance of Metal Penetration METAL PENETRATION REMEDIAL MEASURES: 1. Use fine sand grains. 2. Reduce casting temperature. 3. Apply sufficient compaction of mould. 4. Use additives in the moulding sand.  Typical appearance of Metal Penetration FLASH CAUSES: Sand is not properly compacted along the parting line. Small gap exists between cope and drag.  Typical appearance of a Flash FLASH REMEDIAL MEASURES: Moulding sand should be leveled properly along the parting line.  Typical appearance of a Flash RUN-OUT CAUSES: 1. The cope rises up during pouring of the metal, due to hydrostatic pressure of the poured metal. 2. Insufficient weight of the cope.  Typical appearance of a Run-out RUN-OUT REMEDIAL MEASURES: Place some weight over the cope before pouring of molten metal. 	10



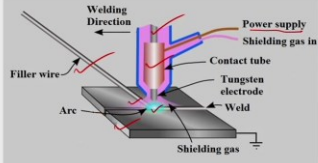
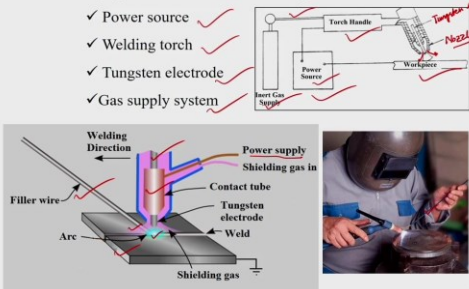
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	LUG CAUSES: Some portions of the cast contour are broken off in the mould area (after withdrawal of pattern).  Typical appearance of a Lug LUG REMEDIAL MEASURES: Check for pressure points and broken off edges before pouring.  Typical appearance of a Lug	
4.	Analyze welding processes that do not use consumable electrodes. Provide a concise overview of the operating concept using an appropriate diagram. Describe its unique application, as well as the pros and cons of the welding technique. Answer: Introduction of GTAW ❖ The GTAW process was initially called "Heliarc" as it used an electric arc to melt the base material and helium to shield the molten puddle. ✓ Heat for fusion is generated from an arc between a nonconsumable tungsten electrode and the base metal. ✓ An inert gas is used as a shielding medium for the arc and the molten weld pool. ✓ The shielding gas also protects the electrode at the prevailing high temperature. ➢ The tungsten gets readily oxidized if it comes in contact with oxygen. ✓ Argon or helium is used for shielding in GTAW. TIG Welding Setup □ The equipment used for TIG welding consists of: ✓ Power source ✓ Welding torch ✓ Tungsten electrode ✓ Gas supply system 	10



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	The heat from the arc melts the base metal. If needed, a separate filler rod can be fed into the weld pool to add material and build up the weld joint. Once the desired weld is complete, the arc is extinguished, and the weld pool cools and solidifies. Advantages: High-Quality Welds: TIG produces clean, strong welds with minimal spatter and distortion, making it ideal for critical applications. Versatility: TIG can weld a wide variety of metals, including thin materials, stainless steel, aluminum, and magnesium. Precise Control: The welder has excellent control over the heat input and weld pool, allowing for intricate welds and tight seams. Clean and Aesthetic Welds: The inert gas shield minimizes oxidation and spatter, resulting in a clean and aesthetically pleasing weld finish. Disadvantages: Slower Welding Speed: Compared to arc welding with consumable electrodes, TIG is a slower process due to the separate filler metal addition. Skilled Labor Required: TIG welding requires a high level of skill and experience to achieve consistent results. Higher Cost: TIG equipment tends to be more expensive than some arc welding setups. Applications: Aerospace: Engine components, aircraft structures, demanding applications requiring high strength and precision. Automotive: Exhaust systems, body panels, intricate components for performance vehicles. Food & Beverage: Stainless steel piping, equipment requiring sanitary welds. Medical Devices: Catheter tubes, implants, demanding applications for biocompatible materials. Chemical Processing: Piping for corrosive chemicals, heat exchangers. Overall, TIG welding is a valuable process for creating high-quality, precise welds in various industries where strength, cleanliness, and precise control are paramount.	
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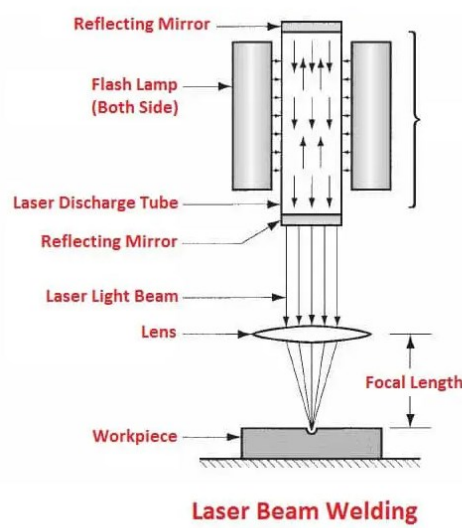
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5.	Decide and describe the suitable welding process that achieves high power density with minimal thermal input, accompanied by an appropriate diagram. Justify the application, its benefits, and its drawbacks. Answer: Laser Beam Welding (LBW): Precise & Powerful Joining Laser beam welding (LBW) utilizes a highly concentrated laser beam to create strong, precise welds on various metals. Here's a detailed explanation: Operating Concept (Diagram):  The diagram illustrates the operating concept of Laser Beam Welding. It shows a vertical assembly starting with a 'Flash Lamp (Both Side)' flanked by two 'Reflecting Mirrors'. A 'Laser Discharge Tube' is positioned between the mirrors. A 'Laser Light Beam' is shown as multiple parallel arrows originating from the tube and passing through a 'Lens' which focuses them into a small spot on a 'Workpiece'. The distance between the lens and the workpiece is labeled 'Focal Length'. The resulting weld on the workpiece is labeled 'Laser Beam Welding'. Laser Generation: A high-powered laser source, like CO₂ or fiber laser, generates a concentrated beam of light. Beam Focusing: Mirrors or lenses within the system focus the laser beam into a very small, intense spot. Melting Metal: The focused beam strikes the workpiece, melting the metal through its concentrated heat energy.	10
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	Keyhole Formation (Optional): At high power densities, the molten metal vaporizes at the point of impact, creating a deep, narrow cavity (keyhole) within the workpiece. Coalescence: The molten metal around the keyhole solidifies to form a strong weld joint. Justification for High Power Density: Focused Beam: The laser beam is meticulously focused to a tiny area, concentrating the energy and maximizing power density at the point of impact. High Beam Intensity: Lasers generate light with a very high intensity, leading to rapid heating and melting of the metal. Benefits: High Weld Strength: Deep penetration (with keyhole mode) and minimal heat distortion create strong, high-quality welds. Minimal Heat Affected Zone (HAZ): The focused beam minimizes the area of the workpiece affected by heat, reducing warping and metallurgical changes. Clean and Precise Welds: No spatter or fumes are generated, resulting in clean and precise welds with minimal post-processing needed. High Welding Speed: LBW can achieve faster welding speeds compared to some other high-precision processes like TIG welding. Wide Material Compatibility: LBW can weld a variety of metals, including steels, aluminum, titanium, and others. Automation Suitability: LBW is highly compatible with automation due to its precise and controllable nature. Drawbacks:	
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WINTER SEMESTER 2023-2024**

High Initial Cost: Laser welding systems are expensive to purchase and maintain compared to traditional arc welding equipment.

Limited Joint Accessibility: The laser beam needs direct line-of-sight to the weld joint, limiting its use in complex geometries.

Reflectivity Issues: Highly reflective materials like aluminum can require special techniques to ensure proper beam absorption for welding.

Safety Concerns: The intense laser beam requires strict safety precautions to protect operators from eye and skin injuries.

Applications:

Automotive: Body panels, chassis components, engine parts demanding high strength and precision.

Aerospace: Aircraft structures, engine components, critical applications requiring high performance and reliability.

Medical Devices: Pacemakers, stents, implants, applications demanding biocompatible materials and high precision.

Consumer Electronics: Microcircuits, small electronic components requiring precise and clean welds.

In conclusion, Laser Beam Welding offers a unique approach for high-precision, high-strength joining in various industrial applications. However, its high cost, limited accessibility, and safety considerations necessitate careful evaluation against other welding processes.

(Or)

Electron Beam Welding (EBW): High Power, Deep Penetration, Minimal Heat Affected Zone

For achieving high power density with minimal thermal input, Electron Beam Welding (EBW) emerges as the most suitable process. Here's a breakdown:



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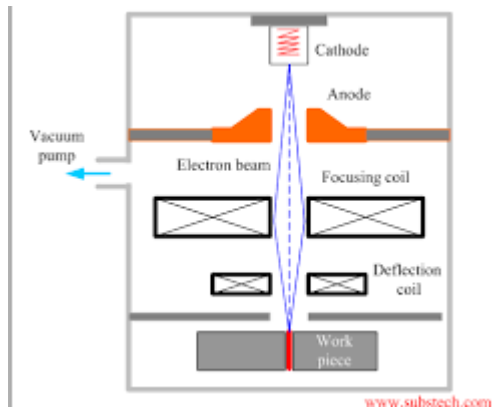
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CONTINUOUS ASSESSMENT TEST (CAT) -II
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Operating Concept (Diagram):



Electron Gun: Electrons are emitted from a cathode and accelerated in a high vacuum environment within the electron gun.

1. **Beam Focusing:** Electromagnetic coils focus the electron beam into a very narrow, high-energy stream.
2. **Workpiece Chamber:** The workpiece is placed in a vacuum chamber to allow for unimpeded electron travel.
3. **Beam Impact:** The focused electron beam strikes the workpiece, causing rapid melting due to its high power density.
4. **Deep Penetration:** The concentrated energy creates a deep, narrow weld pool with minimal heat transfer to the surrounding metal.
5. **Solidification:** Once the beam is deflected, the molten metal solidifies to form a strong weld joint.

Justification for High Power Density and Minimal Heat Input:

- **Vacuum Environment:** The absence of air molecules allows for efficient transfer of electron beam energy to the metal, maximizing power density at the point of impact.
- **Focused Beam:** The electromagnetic coils concentrate the electron beam into a very small area, resulting in high power density and minimal heat spread to surrounding areas.

Benefits:

- **Deep Penetration:** EBW allows for deep, narrow welds without affecting a large area of the workpiece. This is crucial for joining thick sections or dissimilar metals with varying melting points.
- **Minimal Heat Affected Zone (HAZ):** The focused beam minimizes heat transfer to surrounding areas, reducing distortion and preserving the material properties near the weld.



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CONTINUOUS ASSESSMENT TEST (CAT) -II
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- **High Weld Strength:** Deep penetration and minimal HAZ contribute to strong, high-quality welds.
- **Clean and Precise Welds:** The vacuum environment and focused beam lead to clean welds with minimal spatter and post-processing requirements.
- **Wide Material Compatibility:** EBW can weld a variety of metals, including high-melting point materials, reactive metals, and dissimilar metals.

Drawbacks:

- **High Cost:** EBW systems are expensive due to the complex equipment and vacuum chamber requirements.
- **Limited Accessibility:** The need for a vacuum chamber limits EBW to applications where the workpiece can be placed within the chamber.
- **Safety Concerns:** X-ray radiation generated during the process necessitates strict safety protocols and operator protection measures.

Applications:

- **Aerospace:** Engine components, aircraft structures, demanding applications requiring high strength and deep penetration.
- **Nuclear Power:** Fuel rod cladding, reactor components requiring high integrity and resistance to harsh environments.
- **Medical Devices:** Pacemakers, implants, applications demanding biocompatible materials and high precision.
- **Electronics:** High-reliability electronic components, microcircuits.

In conclusion, Electron Beam Welding excels at joining metals with high power density and minimal thermal input. Its deep penetration, clean welds, and wide material compatibility make it valuable for critical applications in various industries. However, the high cost, limited accessibility, and safety concerns necessitate careful consideration when compared to other welding processes.



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