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|  SUBJECT----- **welding metallurgy- PhD student****Dr.shawnim R.jalal**Part 1: Course InformationDescription1. Describe basic physical metallurgy starting at the atomic level, withbonding, defect structure, phase diagrams and diffusion and movestowards the development of metal microstructure.2. Describe how metals solidify, how phases nucleate and grow, and themechanisms by which metal alloys are strengthened. Describe thedevelopment of the fusion and heat-affected zones during the weldingof metales.3. Describe how weld variables such as pool shape, travel speed, coolingrate and other variables affect the subsequent weld microstructure.4. Determine how the weld variables and weld microstructure affect themechanical properties of the weld will be able to identify the microstructure of acceptable welds. |  |  |  |
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|  **Part 2 --- Objective**Provide an overview of joining processes; discuss in detail the weld the welding process and the physics of welding. Introduce students to different welding processes weld testing and advanced processes to be able to appreciate the practical applications of welding. Each student will be able to correctly answer a minimum of 70% of the questions regarding the aspects ofwelding metallurgy on minor and major quizzes.Each student will have a basic understanding of fundamentals and practical experiences in as many weldingprocesses as possible |
|  **Part 3---- Learning Outcomes:**a. Apply fundamental principles of metallurgy to the metals and manufacturing industry.b. Distinguish between properties of various metals.c. Classify metals based on industry requirements and metallurgical properties.d. Explain the adverse effects of welding and thermal processes on metals. **Part4---- References** 1. A Ghosh and A K Mallik, *Manufacturing Science*, Wiley Eastern, 1986. 2. P Rao, *Manufacturing Technology: Foundry, Forming And Welding*, Tata McGraw Hill, 2008. 3. M.P. Groover, *Introduction to manufacturing processes*, John Wiley & Sons, 2012 4. Prashant P Date, *Introduction to manufacturing technologies Principles and technologies*, Jaico publications, 2010 (new book)5-. J S Campbell, *Principles Of Manufacturing Materials And Processes*, Tata McGraw Hill, 1995.6. P C Pandey and C K Singh, *Production Engineering Sciences*, Standard Publishers Ltd., 2003.7. S Kalpakjian and S R Schmid, *Manufacturing Processes for Engineering Material*s, Pearson education, 2009.8-Modern welding technology by Howard.B.cary 2002.9-Welding metallurgy vol.1 by George E.lInnert,2004.10-Eng.metallurgy part1 by Higgins 2009. |

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|  **Part 5----COURSE DETAIL** |
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| **Sl. No**  | **Topic** |
| 1. | **Introduction:** Evolution of welding; classification of welding processes; heat sources and shielding methods. |
| 2. | **Physics of Welding Arc** Welding arc; voltage distribution along the arc; thermionic and non-thermionic cathodes; theories of cathode and anode mechanism; arc characteristics and its relationship with power source; arc efficiency; heat generation; effect of type of shielding gas on arc; isotherms of arcs. |
| 3. | **Welding Power Sources** Conventional welding power sources; constructional features; static and dynamic characteristics; duty cycle; influence of inductance on arc and power source characteristics; internal and external regulation; specific power source requirements; special welding power sources. Microstructure & PropertiesMetallurgical Processes .The Fusion Zone Effect of Travel Speed ,Effect of, R, and Composition .Effect of Cooling Rate |
| 4. | **Arc Welding Processes** Consumable electrode welding processes. Manual metal arc (MMA) welding; Gas metal arc welding; pulsed MIG welding; Submerged arc welding, Significance of flux-metal combination; Electroslag welding: heat generation; principle; Gas tungsten arc welding; selection of polarity, Plasma arc welding; transferred and nontransferred plasma arc welding; selection of gases; welding parameters; keyhole technique. |
| 5. | **Heat flow in welding** Effect of welding parameter on heat distribution; calculation of peak temperatures; thermal cycles; cooling rate and solidification; Residual stresses and their distribution in welds; influence of residual stresses in static and dynamic loading, distortion |
| 6. | **Design of weld joints** Introduction to design; engineering properties of steels; Type of welds and weld joints; description of welds: terminology, definitions and weld symbols; edge preparation; sizing of welds in structure; Design for Static loading, Weld Calculations in lap, butt and fillet welds; design for fatigue loading, Introduction to Fatigue; nature of the fatigue process; fatigue strength; factors affecting fatigue life; improvement methods for fatigue strength; reliability analysis and safety factors applied to fatigue design. |
| 7. | **Testing and inspection of weld joints** Chemical tests; Metallographic tests; Hardness tests; Mechanical test for groove and fillet welds-full section, reduced section and all-weld- metal tensile tests, root, face and side bend tests, fillet weld break tests, creep & fatigue testing. Non-Destructive Testing of Weldments; Visual inspection; Dye-penetrant inspection; Magnetic particle inspection; Ultrasonic inspection-principle of ultrasonic testing, Radiographic inspection –principle of radiography, X-ray tubes, gamma-ray sources, defect discernibility; Eddy current inspection; Leak tests: N.D.T. Standard procedure for specification and qualification of welding procedure; WPS and PQR, WPQ  |
| 8. | **Weldability of metals** Solidification of weld metal; heat affected zone (HAZ), factors affecting properties of HAZ; gas-metal, slag-metal and solid state reactions in welding and their influence on soundness of weld joint; lamellar tearing and hydrogen damage; weldability; definition, factor affecting the weldability of steel Carbon equivalent. weldablity of steel, cast iron and aluminium alloys of commercial importance, failure analysis of welded joints. |
| 9 | **Temperature Changes in Welding**a. Heat and time in welding1. Rate of heating2. Generation of heata. Heat input formula3. Maximum temperature4. Temperature distribution5. Time at temperaturea. Temp colors6. Cooling rates in weldinga. Heat source or nuggetb. Effect of base metal mass7. Temperature gradienta. Preheatingb. Postheating |
| 10 |  Effect of Alloying Elements”  *on* “Mechanical properties and residualStresses” |
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