GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Diploma Engineering

Level: Diploma

Branch: Metallurgy Engineering

Subject Code : DI04021101

Subject Name : Powder Metallurgy

w. e. f. Academic Year:	2025-26
Semester:	4th
Category of the Course:	MOPEC

Prerequisite:	Students are expected to possess a foundational understanding of engineering materials, mechanics of materials, workshop practices, and engineering drawing.
Rationale:	Powder metallurgy (PM) has emerged as a significant manufacturing route for producing engineering components with superior dimensional accuracy, material efficiency, and tailored properties. This course introduces students to the fundamental aspects of powder metallurgy, covering powder production methods, characterization techniques, mixing and blending operations, compaction methods, and the science of sintering. Emphasis is placed on understanding the metallurgical mechanisms that influence densification, bonding, and microstructural development during processing. Students will also explore the advantages, limitations, and wide-ranging applications of PM in industries such as automotive, aerospace, defense, and biomedical engineering. Unlike conventional casting or forming, powder metallurgy offers unique opportunities for near-net-shape manufacturing, cost savings, and the development of advanced materials, including composites and specialty alloys. By studying this subject, diploma students will gain both theoretical insight and practical awareness of PM's industrial relevance, equipping them to contribute to sustainable, innovative, and efficient manufacturing practices in metallurgy.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	Explain the powder metallurgy process along with its advantages, limitations, and industrial applications.	U
02	Determine powder characteristics such as apparent density, tap density, and flow rate using standard test methods.	U
03	Describe the basic steps of the powder metallurgy process and various methods of metal powder production.	R
04	Apply knowledge of mixing–blending operations and basic powder compaction techniques in powder metallurgy.	A
05	Explain the mechanisms involved in the sintering process and its role in achieving desired material properties.	U, A

**Revised Bloom's Taxonomy (RBT)*

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Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE(E)	PA(M)	PA(I)	ESE(V)	
3	0	0	3	70	30	00	00	100

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1	**Introduction to Powder metallurgy process:** 1.1 Definition of Powder metallurgy. 1.2 Basic steps of Powder Metallurgy process. 1.3 Advantages, Limitation and Application of Powder metallurgy.	05	12
2.	**Characteristics of metal powder:** 2.1 Introduction: importance of powder characteristics in Powder metallurgy processes. 2.2 Particle characteristics like size, shape, and size distribution. 2.3 Powder mass properties like apparent density, tap density, flow rate. 2.4 Green and sintered compact properties like density, strength, common defects	08	18
3.	**Metal powder production methods:** 3.1 Atomization processes (gas, water, centrifugal). 3.2 Reduction of metal oxides. 3.3 Electrolytic deposition method. 3.4 Mechanical methods (crushing and milling). 3.5 Chemical methods (condensation of metal vapour) and carbonyl processes. 3.7 Selection of powder production method for specific applications.	10	22

4.	**Powder Mixing, Blending and Compaction Methods:** 4.1 Objectives and methods of powder mixing and blending. 4.2 Fundamentals of powder compaction: rearrangement, deformation, densification. 4.3 Types of compaction presses: mechanical, hydraulic, and pneumatic. 4.4 Compaction tooling and role of lubricants. 4.5 Single-action and double-action compaction. 4.6 Isostatic pressing and hot pressing: principles and applications.	08	18
5.	**Sintering & Sintered Products:** 5.1 Definition, objectives, and mechanism of sintering. 5.2 Stages of sintering and effect of process variables. 5.3 Sintering atmospheres and furnaces. 5.4 Liquid-phase sintering: principle and applications. 5.5 Defects in sintering and their remedies. 5.6 Study of sintered products: bearings, cutting tools, filters, friction parts, electrical contacts.	08	18
6.	**Advanced Powder Metallurgy Processes** 6.1 Introduction and need for advanced PM processes. 6.2 Hot Isostatic Pressing (HIP): principle, process, applications. 6.3 Metal Injection Moulding (MIM): steps and applications. 6.4 Additive Manufacturing using metal powders.	06	12
	Total	**45**	**100%**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
28	**42**	**30**	**0**	**0**	**0**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Introduction to Powder Metallurgy by A. K. Sinha (Dhanpatrai Publication, New Delhi, ISBN-10. 9383182148; ISBN-13. 978-9383182145.)
2. Powder Metallurgy: Science, Technology and Applications by P.C. Angelo, B. Ravisankar, R. Subramanian, ISBN-10. 939181848X, ISBN-13. 978-9391818487
3. Powder Metallurgy: Science, Technology and Materials by Anish Upadhyaya & G. S. Upadhyaya, ISBN-10. 1439857466, ISBN-13. 978-1439857465

4. Powder Metallurgy: An Advanced Technique of Processing Engineering Materials (2nd Edition) by B.K. Datta, ISBN-10. 8120349423, ISBN-13. 978-8120349421
5. Powder Metallurgy S.A. Tsukerman Publisher: Pergamon (22 October 2013) ASIN : B01DJDHOT4
6. Handbook of Powder Metallurgy Henry Herman Hausner, Publisher : Chemical Publishing Company (June 30, 1973) ISBN 10: 0820602191 ,ISBN-13: 978-0820602196

(b) Open source software and website:

1. https://nptel.ac.in
2. https://ocw.mit.edu
3. https://www.ipmaindia.com
4. https://imagej.net
5. https://openfoam.org
6. https://www.scilab.org
7. https://www.python.org
8. https://www.elmerfem.org
9. https://www.researchgate.net
10. YouTube Channels (IIT Bombay Metallurgy Lectures, ASM International Webinars)

Additional suggested project list:

1. Poster / Model / 3D Diagram of Powder Metallurgy Process
2. Collection and Identification of Different Metal and Non-Metal Powders
3. Case Study on Powder Production Methods (Atomization, Electrolysis, Milling, etc.)
4. Preparation of Green Compacts Using Simple Die
5. Comparative Study of Powder Production Methods
6. Applications of Powder Metallurgy in Indian Industry
7. Future Trends in Powder Metallurgy (HIP, MIM, Additive Manufacturing)
8. Measurement of Powder Flow Rate and Apparent Density
9. Design of Simple Powder Metallurgy Tooling (Die/Mould)
10. Survey on Recycling and Reuse of Metal Powders in Indian Industries

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