

GUJARAT TECHNOLOGICAL UNIVERSITY

METALLURGY ENGINEERING (21)

POWDER METALLURGY

SUBJECT CODE: 2162103

B.E. 6th SEMESTER

Type of course: Engineering Science

Prerequisite: Knowledge of Elements of Metallurgy and basic science skills

Rationale: The Powder Metallurgy course is to prepare students for careers in metallurgy engineering where knowledge to provide them with an insight into the emerging technology of powder metallurgy as an alternative route to conventional metal processing. It is important to understand and appreciate the importance of powder metallurgy as an effective and profitable material processing route to produce a variety of products for engineering industries. The course provides detailed knowledge of powder production and processing as well as to choose the right method to suit application in hand. The various techniques are used for powder production and the versatile nature of these techniques to produce a wide range of powders. Characterization of powder, subsequent compaction methods and sintering knowledge is very much important in Powder Metallurgy. By this course to recognize technical attraction of Powder Metallurgy for Production of metals and alloys in the form of semi-dense finished parts or fully dense structural shapes. The major goal of program is to hasten development of the necessary scientific and engineering base i.e., to establish the powder fabrication route as a technologically and economically viable means of materials production.

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks					Total Marks	
L	T	P		Theory Marks			Practical Marks			
			ESE (E)	PA (M)		ESE (V)		PA (I)		
				PA	ALA	ESE	OEP			
4	0	2	6	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	Introduction Historical and modern developments in Powder Metallurgy. Advantages, limitations and applications of Powder Metallurgy. Basic Steps for Powder Metallurgy.	04	06
2	Characteristics of metal powder Chemical composition, Particle size, shape and size distribution, Characteristics of powder mass such as apparent density, tap density, flow rate, friction index. Properties of green compacts and sintered compacts.	07	10
3	Metal powder production methods Atomization, Reduction from oxide, Electrolysis, Crushing, Milling, Condensation of metal vapour, Hydride and carbonyl processes, Mechanical Alloying, New developments.	10	18
4	Powder Characterization Powder conditioning, fundamentals of powder compaction, density distribution in green compacts, compressibility, green Strength, pyrophorocity and toxicity.	09	16
5	Powder Compaction Methods Basic aspects, types of compaction presses, compaction tooling and role of lubricants, Single and double die compaction, isostatic pressing, hot pressing.	10	18

6	Powder Forming Powder rolling, powder forging, powder extrusion and explosive forming technique.	05	07
7	Sintering Definition, stages, effect of variables, sintering atmospheres and furnaces, Mechanism, liquid-phase sintering, Secondary operations.	09	16
8	Sintered Products Study of sintered bearings, cutting tools, metallic filters, friction and antifriction parts and electrical contact materials. Defects in Powder metallurgy processed materials and their processing to minimize defects : Friction stir processing etc.	06	09
Total		60	100

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	30	30	10	10	05

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Introduction to Powder Metallurgy, A. K. Sinha, Dhanpatrai Publication
2. Powder Metallurgy: Science, Technology, and Materials, Anish Upadhyaya, Gopal Shankar Upadhyaya, CRC Press
3. Powder Metallurgy: Science, Technology and Applications, P. C. Angelo, R. Subramanian
4. Powder Metallurgy, W.D.Jones
5. Principles of Powder Metallurgy, T.Shukerman
6. Handbook of Powder Metallurgy :- H.H.Hausner
7. Powder Metallurgy, ASM Handbook, Vol-VII.

Course Outcome:

After learning the course the students should be able to:

1. Acquire the knowledge of Powder Metallurgy History, Applications and its importance.
2. Measure the various powder characteristics like apparent density, tap density, flow rate, friction index.
3. Acquainted the knowledge of metal powder production methods.
4. Aware about the powder characterization techniques.
5. Understand the basic methods of Powder compaction for green compact.
6. Familiar about compaction tooling and role of lubricants in compacting.
7. Explain various powder forming techniques other than the compaction.
8. Explain the mechanism of sintering and types sintering for development of mechanical properties.
9. Understand the application in various fields of powder metallurgy
10. Understand causes of defects in Powder metallurgy processed materials and method to minimize defects.

List of Experiments:

1. To study the introduction to Powder Metallurgy.
2. To study the sieve analysis of metal powder.
3. To measure the particle size and shape of metal powder by Optical Microscopy.

4. To study the powder characteristics like particle size, particle shape and size distribution on tap density and apparent density.
5. To study the powder characteristics like particle size, particle shape and size distribution on flow rate of metal powder.
6. To study the powder characteristics like particle size, particle shape and size distribution on friction index of metal powder.
7. To manufacture Copper powder production by electrolysis method
8. To perform powder compaction of different metal powder by hydraulic press.
9. To study the mechanism of sintering.
10. To study the microstructure of sintered products.
11. To measure the mechanical properties of sintered products.
12. To study the mechanical alloying for the production of powder alloying.

Design based Problems (DP)/Open Ended Problem:

1. Flow chart of Powder Metallurgy Process.
2. Chart of Powder production Methods.
3. Chart for Powder Forming Processes.
4. Chart of Powder Compaction methods.
5. Model preparation of Powder Atomization from waste materials.
6. Collection of Various Metal powders.
7. Presentation on recent application of Powder Metallurgy in several fields.
8. Any other problem decided by faculty based on syllabus.

Major Equipment:

1. Planetary ball mill
2. Hydraulic press
3. Sintering furnace
4. Hall flow meter
5. DC Power Source of 5 to 10 amp for Electrolysis.
6. Objective lens of square grid and horizontal grid for measuring particle size of powder.
7. Sieve Shaker.

List of Open Source Software/learning website:

1. <http://nptel.ac.in/>
2. <http://www.ipmd.net/>

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.