GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester -III

Course Title: Technology for Injection Moulding
(Course Code: 4332306)

Diploma programme in which this course is offered	Semester in which offered
Plastics Engineering (Sandwich Pattern)	Third

1. RATIONALE

As a part of major processes through which plastic raw materials are converted into products, Injection molding process is very significant. If we look at the conversion of plastic raw materials to product, Injection molding process has a major share of around 35%. As Extrusion and Injection molding are two major plastic processing techniques, A Diploma plastic engineer must be able to understand all aspects of the injection molding process. Study of an Injection molding process need to be categories in to machine, process, troubleshooting & applications. One can find several products around daily activities ranging from tooth brush to automobile components.

2. COMPETENCY

The purpose of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Operate Injection molding machine
- Change mold on injection molding machine
- Set process parameters
- Troubleshoot defects found in injection molded products
- Utilize auxiliary equipments for better output and quality of products

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with this competency are to be developed in the student to display the following COs:

a) Operate an Injection molding machine
b) Troubleshoot injection molding process.
c) Perform post-injection molding operations.
d) Use auxiliary equipments for injection molding machine.
e) Select proper materials for injection molding process

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T/2+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	0	4	5	30*	70	25	25	150

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

***Legends:** **L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **CA** - Continuous Assessment; **ESE** - End Semester Examination.*

5. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) are the sub-components of the COs. *Some of the **PrOs** marked **'*'** are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.*

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Study of construction & working of an injection molding machine	01	04
2	Compare hydraulic and toggle clamping mechanism	01	04
3	Operate an injection molding machine & determine cycle time	02	04
4	Measure the effects of process variables on quality of products	02	04
5	Change the old mold with new product mold	02	02
6	Study recent advancements in an injection molding technology	01	04
7	Identify the defects in an injection molded products & suggest remedies	03	04
8	Operate scrap grinder machine for recycling of plastic waste	04	04
9	Demonstrate various auxiliary equipments	04	04
10	Identify the process problems & suggest remedies	03	04
11	Carry out maintenance activities of an injection molding machine	03	06
	Total		**44**

Note

i. *More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*

ii. *The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.*

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Prepare of experimental setup	20
2	Operate the equipment setup or circuit	20

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
3	Follow safe practices measures	10
4	Record observations correctly	20
5	Interpret the result and conclude	30
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to usher in uniformity of practicals in all institutions across the state.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Injection molding machine	1,2
2	Molds	1,2
3	Crane	1,2
4	Cooling tower	1,2
5	Weighing scale	4,5
6	Hopper loader	3,4
7	Scrap grinder	3,4
8	Testing equipments	4,5

7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above mentioned COs and PrOs. More could be added to fulfil the development of this competency.

a) Work as a leader/a team member.
b) Follow ethical practices.
c) Practice environmental friendly methods and processes to avoid metal waste.

The ADOs are best developed through the laboratory/field-based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year

8. UNDERPINNING THEORY

Only the major Underpinning Theory is formulated as higher level UOs of *Revised Bloom's taxonomy* in order development of the COs and competency is not missed out by the students and teachers. If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
Unit-I Injection Molding Machine	1.a Identify different types of an Injection molding machines 1.b Explain construction & working of various parts of an injection molding machine 1.c Compare different clamping mechanism 1.d Recent advancement in an injection molding machines	1.1 Introduction 1.2 Different types of injection molding machines 1.2.1. Ram type injection molding machine 1.2.2. Reciprocating screw type injection molding machine 1.3 Construction & working of various parts of an injection molding machine 1.3.1. Screw 1.3.2. Barrel 1.3.3. Hopper 1.3.4. Drive system 1.3.5. Magnetic screen 1.3.6. Band heaters 1.3.7. Thermocouples 1.3.8. Non return type ring valve 1.3.9. Nozzle 1.3.10 Mold 1.3.11 Limit switch 1.3.12 Clamping mechanism 1.4 Types of clamping mechanism 1.4.1. Toggle clamping 1.4.2. Fully hydraulic clamping 1.5 Maintenance of an injection molding machine 1.5.1 List out various maintenance activities 1.6 Recent advancement in an injection molding machine 1.6.1.Servo motor drive 1.6.2. PLC system
Unit-II Injection Molding Process	2.a Operate an injection molding machine 2.b Change the mold 2.c Set the process parameters 2.d Optimizing quality and production rate	2.1 Start-up, Running & Shut-down 2.1.1. Activities during the start-up of process 2.1.2. Activities during the running of the process 2.1.3. Activities during the shut-down of the plant 2.2 Cycle diagram 2.2.1. Various components of cycle diagram 2.2.2. Steps involved in process 2.2.3. Melting mechanism

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
		2.2.4. Shot capacity 2.2.5. Plasticizing capacity 2.3 Mold change 2.3.1. Activities during change of mold 2.3.2. Open daylight for the mold 2.3.3. Close daylight for the mold 2.4 Optimization of quality and productivity 2.4.1. Sampling plan 2.4.2. Standardization of process parameters 2.4.3. Minimizing wastage 2.4.4. Recycling of waste i.e. sprue & runner 2.4.5. Maximizing production rate
Unit-III Troubleshooting	3.a Identifying defects in an injection molded products 3.b Finding root cause for the defects 3.c Applying remedies to overcome defects 3.d Consultation with QC / QA lab	3.1 Various types of defects 3.1.1. Short shot 3.1.2. Warpage 3.1.3. Black spots 3.1.4. Blisters 3.1.5. Brittleness 3.1.6. Bubbles / Burn marks 3.1.7. Cracking 3.1.8. Discoloration 3.1.9. Flashes 3.1.10 Flow marks 3.2 Probable causes for the defects 3.2.1. Causes related to material 3.2.2. Causes related to machine / mold 3.2.3. Causes related to men/ operator skill 3.3 Remedies for different defects 3.3.1. Adjustment of process parameters i.e. melt temperature, melt pressure, screw speed etc. 3.3.2. Checking input raw material quality 3.3.3. Failure of components of machine like band heaters etc. 3.4 Role of QC / QA lab 3.4.1.Feed back from QC /QA lab 3.4.2. Interpretation of test results from QC/QA lab 3.4.3. Data building based on past run

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
		and standardization of process parameters for similar materials and products.
Unit-IV Auxiliary Equipments	4.a Identify the need of auxiliary equipments 4.b Explain role of various auxiliary equipments	4.1 Significance of an auxiliary equipments 4.1.1. Importance in quality improvements 4.1.2. Cost reduction 4.1.3. Increase in production rate 4.2 Types of auxiliary equipments 4.2.1. Hopper loader 4.2.2. Hopper drier 4.2.3. Chilling plant / Cooling tower 4.2.4. Scrap grinder

***Note**: The UOs need to be formulated at the 'Application Level' and above of Revised Bloom's Taxonomy' to accelerate the attainment of the COs and the competency.*

8. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Injection Molding Machine	14	6	9	10	25
II	Injection Molding Process	14	8	8	9	25
III	Troubleshooting	07	3	3	4	10
IV	Auxiliary Equipments	07	3	3	4	10
Total		**42**	**20**	**23**	**27**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*
***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary slightly from above table.*

9. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

1. Students will collect samples of various injection molded products.
2. Students will visit nearby injection molding process industry.
3. Students will showcase different types of defective products.

10. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) Guide student(s) in undertaking micro-projects.
c) ***'L' in section No. 4*** means different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) About ***20% of the topics/sub-topics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-learning***, but to be assessed using different assessment methods.
e) With respect to ***section No.11***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
f) Guide students on how to address issues on environment and sustainability.
g) Visit to nearby industries.
h) Video/animation films on working of an injection molding machine.
i) Video/animation films on remedies to overcome defects found in an injection molded products.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a) Injection molding machine construction: Neat sketch along with names of all parts.
b) Auxiliary equipments: Show utilities of all these auxiliary equipments.
c) Injection molding process: Draw a cycle diagram and explain in detail.

d) Activities during Mold change: Detailed statement indicating activities during changing of molds.
e) Chart preparation on troubleshooting in an injection molding.
f) Collect products made by injection molding process.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1.	Injection Molding Advanced Troubleshooting Guide: The 4m Approach	Randy Kerkstra Steven Brammer	Publication:Hanser ISBN :978-1-56990-834-1 Year:2021
2.	Injection Molding Handbook 2E	Osswald, T., Turng, L., Gramann, P.	Publication**:** Hanser ISBN: 9781569904206 Year:2007
3.	Injection molding machine	A.Whelan	Publication: Elsevier applied science publishers ISBN: 0-85334-245-8 Year: 1984
4.	Injection molding theory and practice	Irvin I. Rubin	Publication: Wiley ISBN: 978-81-265-4576-6 Year:2014
5.	Injection Molding:Technology and Fundamentals	Musa R. Kamal , Avram I. Isayev	Publication:Hanser ISBN: 978-3446416857 Year:2009
6.	Injection molding handbook	Dominick V. Rosato, Donald V. Rosato, Marlene G. Rosato	Publication: Springer Science+Business Media, LLC ISBN 978-1-4613-7077-2 Year:2000
7.	Plastics Materials and Processes	Seymour S. Schwartz, Sidney H. Goodman	Publication: Van ISBN:9780442227777 Year:1982

14. SOFTWARE/LEARNING WEBSITES

1. Moldex3D 2022
2. Autodesk Moldflow
3. CADMOULD
4. Moldflow Insight
5. SolidWorks Plastics

15. PO-COMPETENCY-CO MAPPING

Semester III	Technology for Injection Molding (Course Code:4332306)									
	POs and PSOs									
Competency & Course Outcomes	**PO 1 Basic & Discipline specific knowledge**	**PO 2 Problem Analysis**	**PO 3 Design/ development of solutions**	**PO 4 Engineering Tools, Experimentation &Testing**	**PO 5 Engineering practices for society, sustainability & environment**	**PO 6 Project Management**	**PO 7 Life-long learning**	**PSO 1** An ability to apply principles of material selection, product & mold/die design and development in plastic engineering	**PSO 2** An ability to conduct safe and environment friendly manufacturing and recycling of plastic products.	**PSO 3** (If needed)
Competency Operate, Set process parameters, Change mold & Troubleshoot defects in injection molding	2	3	2	3	2	1	3	2	2	-
Course Outcomes 1.Operate an Injection molding machine	1	2	2	3	1	1	1	1	2	-
2.Troubleshoot injection molding process	2	3	2	2	1	1	3	1	1	-
3.Perform post-injection molding operations	1	2	2	2	1	1	1	1	2	-
4. Use auxiliary equipments for injection molding machine	1	1	2	3	2	1	1	2	1	-
5. Select proper materials for injection molding	1	2	1	1	1	1	2	1	1	-

process										

Legend: '**3'** for high, '**2**' for medium, **'1'** for low or **'-'** for the relevant correlation of each competency, CO, with PO/ PSO

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

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