GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Design For Injection Mold
(Course Code: 4342302)

Diploma programme in which this course is offered	Semester in which offered
Plastics Engineering (Sandwich Pattern)	4th Semester

1. RATIONALE

A Plastic diploma engineer has to identify and select appropriate mold material. He has to plan and supervise design, fabrication, operation and maintenance of various types of injection moulds. This competency requires in depth knowledge of different types of Injection Moulds like two plate mold, three plate mould and moulds for products having undercuts and threads. Hence the course has been designed to develop this competency and its associated cognitive, practical and affective domain learning outcomes.

2. COMPETENCY

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

- **Design and draw machine Injection mould for a given product.**

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) Select appropriate mould material for given requirements.
b) Prepare mould design checklist for given product.
c) Design & draw two plate and three plate injection mould.
d) Design & draw split mould.
e) Design & draw specialized injection mould.

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 thesub-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	Draw plan and sectional elevation of different injection moulded parts with actual dimensions.	II	2
2	Sketch various types of balanced layout for multi impression mold.		2
3	Draw sectional elevation and plan of two plate mold for given plastic products.	III	12
4	Draw detail drawing of two plate injection mould for given plastic products.		8
5	Draw sectional elevation and plan of three plate mold.		4
6	Sketch various runner ejection techniques.		2
7	Sketch various undercut products for split mold.	IV	2
8	Draw sectional elevation and plan of split mold.		4
9	Sketch various split actuation methods.		2
10	Sketch various split safety arrangements.		2
11	Sketch various internally and externally threaded components.	V	2
12	Draw constructional details of any one hot runner mold.		2
	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	Product drawing planning.	20
2	Mold drawing layout planning.	30
3	Selection of scale as per drawing sheet dimensions.	10
4	Use of proper instruments.	20
5	Give proper dimensioning and annotations.	20
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specificationsfor 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	Interactive board with LCD overhead projector	1,2,6,7,9,10,11
2	Drawing board, drafter and other drawing instruments	1,3,4,5,8,12
3	Measuring Instruments – Vernier Caliper, Micrometer	1,7,11
4	Two Plate Injection Mold	1,2,3,4
5	Three Plate Injection Mold	1,2,3,5,6
6	Split Mold	1,2,3,7,8,9,10
7	Hot Runner Mold	1,2,12

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 Mold Materials	1a. Identify mould material selection requirements 1b. Identify types of mold materials 1c. Classify steels 1d. Select suitable mould material	1.1 Introduction of Injection Mould and its products 1.2 Mold material selection criteria 1.3 Mould Material Selection Requirements with respect to : • Product Design • Mould Design • Mould Making • Moulding 1.4 Types of Mould Materials : • Plain Carbon Steels- Low Carbon Steel, Medium Carbon Steel, High Carbon Steel • Alloy steels • Stainless steel • Prehardened Steel • Carburizing tool steels • Oil and air hardening tool steels
Unit – II General Mould Design Considerations	2a. Identify injection machine requirements for mould 2b. Describe gate and runner balancing on basis of number of impressions 2c. Describe venting and taper location recess methods 2d. Describe Mould Assembling and Maintenance procedure 2e. State steps for Mould Cost estimation	2.1 Injection machine requirements with respect to mould : • Clamping side requirements : Clamping methods- Direct bolting and clamping, Clamping force, Tie-bar distance, Opening stroke, Maximum and minimum mold height • Injection side requirements: Plasticizing capacity, Shot Capacity, Injection Pressure 2.2 Design considerations for Injection molds: • Preliminary mold design • Detailed mold design 2.3 Number of impressions considerations

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
		2.4 Gate balancing and runner balancing for balanced impression layout 2.5 Shrinkage Calculation – Linear and Volumetric Shrinkage 2.6 Venting- Significance and methods of venting 2.7 Taper Location Recess: • Taper location in Core Plate • Taper location in Cavity Plate • Comparison of Taper location in Core and Cavity Plate 2.8 Limits, Fits & Tolerances For Mould Parts 2.9 Mould Cost Estimation process steps 2.10 Mould Assembling Procedure steps 2.11 Mould Designer's Check List points with respect to mold, product and injection machine 2.12 Mould Maintenance
Unit – III Two Plate and Three Plate Injection Moulds	3a. Describe the construction of Two Plate Mould 3b. Describe the construction of Three Plate Mould 3c. Differentiate the two-plate and three plate injection mould. 3d. Draw two-plate and three plate mould.	3.1 Two-Plate Mould: • Introduction of Two Plate Injection Mould • Construction and working of Two Plate Mould – Single impression mold, multi-impression mold 3.2 Three-Plate Mould: • Introduction • Construction and Working: Stripper Plate Mould, Double Daylight Underfeed Mould, Double Daylight Underfeed-Stripper Plate Mould • Types and working of Opening Control Devices • Types of Runner Ejection Techniques 3.3 Comparison of Two Plate Mould with Three Plate Mould

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
Unit – IV Split Molds	4a. Identify products requiring split moulds 4b. Describe sliding split and guiding plate designs 4c. Describe Split actuation methods 4d. Differentiate various split locking and safety methods 4e. Draw split mould.	4.1 Significance of Split Mould Design 4.2 Undercut Product Examples Requiring Split Molds 4.3 Sliding Splits & Guiding Plate Designs 4.4 Constructional Details of Split Mould : • Split Actuation Methods • Split Locking Methods • Split Safety Arrangements
Unit – V Specialized Molds	5a. Identify threaded components 5b. Describe molds for threaded components 5c. Select suitable mold for threaded component 5d. Describe types of hot runner molds 5e. Understand need for stack and interchangeable insert molds.	5.1 Moulds For Threaded Components • Introduction • Methods for Internally Threaded Components: Fixed Threaded Core Design, Stripping Method, Loose Threaded Core and Unscrewing Method • Methods for Externally Threaded Components: Fixed Threaded Cavity Design, Automatic Unscrewing, Stripping Method and Threaded Splits 5.2 Hot Runner Moulds • Introduction • Internally Heated Hot Runner Systems • Externally Heated Hot Runner Systems • Insulated Hot Runner Molding System • Advantages and Disadvantages 5.3 Introduction of Stack Moulds 5.4 Introduction of Interchangeable Insert Moulds

***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.*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Injection Mold Materials	7	2	3	2	7
II	General Mould Design Considerations	21	4	10	7	21
III	Two Plate and Three Plate Injection Moulds	14	4	6	4	14
IV	Split Moulds	14	4	6	4	14
V	Specialized Moulds	14	4	6	4	14
Total		**42**	**18**	**31**	**21**	**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.*

10. 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 prepare chart of mold material classification.
2. Students will prepare injection machine requirements with respect to mold.
3. Students will collect products suitable for two plate and three plate molds.
4. Students will collect products suitable for split molds.
5. Students will collect products with internally and externally threaded components.
6. Students will visit nearby mould making industry.

11. 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 mold making industries.
h) Video/animation on working of different type of injection molds.

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:

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1.	Injection Mold Design	Pye R.G.W	Affilited East-West Press Pvt. Ltd, New Delhi, 2018, 5551234102501
2.	The Complete Part Design Handbook	Campo, E.	Hanser Publications, Ohio, 2006, 9783446412927
3.	How to Make Injection Molds	Menges, G., Michaeli, W., Mohren, P.	Hanser Publications, Ohio, 2001, 9781569902820
4.	Injection Mold Design Handbook	Caoen B., Rees H.	Hanser Publications, Ohio, 2022, 9781569908150

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
5.	Injection Mold Design Engineering 2e	Kazmer, D.	Hanser Publications, Ohio, 2016, 9781569905708
6.	Plastics Mold Engineering Handbook	Dubois J.H., Pribble W.I	Springer US, 2013, 9781468465808
7.	Plastics : Product Design and Process Engineering	Harold Belofsky	Hanser-Gardner Publications, 1995, 9781569901427
8.	Injection Mould Design Fundamentals	Denton E.N & Glanvill A.B.	Industrial Press, 2011, 9780831110338
9.	Plastic Materials & Processes	Schwartz S.S. & Goodman S.H.	Van Nostrand Reinhold, 1982, 9780442227777
10.	Plastic Engineering Handbook	Berins M.L	Van Nostrand, 1991, 9780412991813
11.	Injection Moulding Handbook	Rosato D.V & Rosato D.V	Springer Science & Business Media, 2012, 9781461545972
12.	A Textbook of Workshop Technology	Khurmi R.S & Gupta J.K	S. Chand and Company Limited, 2018, 9788121908689

14. SOFTWARE/LEARNING WEBSITES

1. https://www.cavitymold.com/injection-mold-steel-types
2. https://www.plasticmoulds.net/mould-steel.html
3. https://www.injectionmould.org/2019/03/13/mold-venting/
4. https://www.youtube.com/watch?v=DSQcd-iP92M&ab_channel=KennyHan
5. https://www.youtube.com/watch?v=uEO_jDE5oQ8&ab_channel=LucasSantos
6. https://www.smlease.com/entries/plastic-design/two-plate-vs-three-plate-mold
7. https://www.plasticmoulds.net/two-plate-moldthree-plate-moldhot-runner-mold.html
8. https://www.youtube.com/watch?v=6-yschQdn1s&ab_channel=PLASTOTECH
9. https://www.youtube.com/watch?v=gzuU52voc3o&ab_channel=JITINDIA
10. https://www.scribd.com/presentation/355502430/Types-of-Moulds-split-Mould
11. https://www.youtube.com/watch?v=b1U9W4iNDiQ&ab_channel=tronicarts-Multimedia-Agentur
12. https://www.youtube.com/watch?v=kNEoBvKy_nw&ab_channel=JITINDIA
13. https://makenica.com/hot-runner-systems-in-injection-molding
14. https://www.youtube.com/watch?v=mneg6ID4fsw&ab_channel=Tech2Research

15. PO-COMPETENCY-CO MAPPING

Semester IV	Design For Injection Mold (Course Code: 4342302)									
	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 **Design and draw machine Injection mould for a given product.**	2	1	2	1	1	1	1	3	1	-
Course Outcomes 1. Select appropriate mould material for given requirements.	2	1	2	1	1	1	2	3	1	-
2. Prepare mould design checklist for given product.	3	1	2	1	1	1	1	3	1	-
3. Design and draw two plate and three plate injection mold.	2	1	2	1	1	1	1	3	1	-
4. Design and draw split mold.	2	1	2	1	1	1	1	2	1	-
5. Design and draw specialized injection mold.	2	1	2	1	1	1	1	2	1	-

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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