GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)
Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
VI– Semester
Course Title: **Design for Blow and Thermoforming Mould**
(Course Code: 4362301)

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

1. RATIONALE

It is very interesting to find numerous products in the area of packaging of soft drink, mineral water bottle, pharmaceutical and cosmetic items which are made by blow molding and thermoforming process. Hence, it is desirable to have competencies in designing and developing variety of moulds for the same. A Plastic Diploma engineer has to monitor operations and maintenance of Blow and Thermoforming moulds. This competency requires the knowledge of constructional details of Blow and Thermoforming Moulds. 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 manufacture blow & thermoforming moulds as per need of consumer.**

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 suitable blow mold material.
b) Design blow molds for various products.
c) Design efficient cooling system for blow mould.
d) Select suitable thermoforming mold material.
e) Design thermoforming moulds for various thermoformed products.

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	2	4	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	Design and draw sectional elevation, plan and inverted plan of blow moulds. (For different shapes to be casted, number of sheets would depend upon complexity of shapes. Faculty should give enough number of sheets to students to justify the time allocated)	I/II	12
2	Draw detail drawings of mould drawn in above.	II/III	08
3	Design and draw sectional elevation, plan and inverted plan of Thermoforming mould. (For different shapes to be casted, number of sheets would depend upon complexity of shapes. Faculty should give enough number of sheets to students to justify the time allocated)	IV/ V	08
	TOTAL		28

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	Select proper blow mold construction materials	10
2	Deploy blow mold design considerations in design	30
3	Provide effective cooling channels & use of ancillary elements	20
4	Select proper thermoform mold construction materials	10
5	Design thermoform mold for various products	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.
2.1	Blow molding machine	1,2
2.2	Thermoforming machine	3
2.3	Drawing table	1,2,3
2.4	T square	1,2,3
2.5	Set square	1,2,3

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 wastages

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 Blow mould Materials	1a. Identify blow mold material requirements 1b. Classify mould materials 1c. List different types of materials 1d. Select proper mold material	1.1 Introduction of Blow Moulds 1.2 Mould Material Selection Requirements 1.3 Types of Mould Materials 1.4 List of materials 1.5 Advantages & disadvantages of materials
Unit- II Blow Mould Design Considerations	2a. Design injection blow mould. 2b. Design extrusion blow molds. 2c. Describe Flash removal methods 2d. Describe Mould cleaning methods 2e. Employ design features in mould	2.1 Injection Blow Mould • Mould Construction, Injection Blow Mould Design, Core rods / Parison Stick Design 2.2 Extrusion Blow Mould • Design procedure of Extrusion Blow Mould. • Mould Cavity Design • Method for deciding clamping force • Design consideration for mould parting line • Mould finish and Mould Venting • Cavity surface considerations • Welding edges & flash pockets in pinch-off • Neck insert design considerations

		• Radii and corner edge designs • Molded holes and handle design • Shrinkage considerations • Blow and swell ratio • Moulds for undercut products (moving section moulds) • Flash removal methods • Mould cleaning methods
Unit – III **Blow Mould Cooling and Ancillary Elements**	3a. Draw cooling channels for various sections of mould. 3b. Describe ancillary elements for blow mould. 3c. Explain role of ancillary elements 3d. Optimize cooling rate	3.1 Mould Cooling • Significance of mould cooling. • Cooling designs for neck, pinch-off and main body. 3.2 Ancillary Elements • Base plates • Alignment pins • Striker plates • Ejection Methods
Unit – IV **Thermoforming Mould Materials**	4a. Describe thermoforming mould materials requirements 4b. Classify mould materials for prototype and production tooling 4c. List variety of materials 4d. Select proper material	4.1 Thermoforming Mould Materials • Introduction of Thermoforming Moulds • Mould Material requirements • Types of mould materials for prototype and production tooling
Unit – V **Thermoforming Mould Design Considerations**	5a. Describe various components of thermoforming moulds. 5b. Design thermoforming mould. 5c. Describe Mould cooling	5.1 Vent Holes/Vacuum Holes: Number of vents ,Size, Position and types 5.2 Shrinkage and Draft Angle Considerations 5.3 Plug Design (For Plug

	designs. 5d. Describe mould ejection techniques. 5e. Describe application of Mould Releasing Agents. 5f. Describe Multi impression Moulds methods.	Assist Mould)- Plug material, Shape of plug, Plug design concepts 5.4 Sheet clamping mechanisms 5.5 Draw ratios and its importance 5.6 Chamfers and radii 5.7 Surface treatments 5.8 Surface texture 5.9 Mould cooling designs 5.10 Use of moving elements - collapsing cores, Unscrewing devices, cammed sections and slides 5.11 Ejection techniques 5.12 Application of Mould Releasing Agents 5.13 Moulds for undercuts 5.14 Multi-impression Moulds • Factors to be considered for deciding correct impression layout • Method of determining the number of impressions for a given forming platform size and product size • Design and draw thermoforming mould for multi-impressions.

***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	Blow mould Materials	4	3	3	2	08
II	Blow Mould Design Considerations	13	8	8	6	22
III	Blow Mould Cooling and Ancillary elements	8	4	4	4	12
IV	Thermoforming mould materials	4	3	3	2	08
V	Thermoforming Mould Design Considerations	13	6	8	6	20
Total		**42**	**24**	**26**	**20**	**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 select material for blow mould.
2. Students will design blow mould.
3. Students will collect various blow molded products
4. Students will design thermoform mold

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) Collect information on tool room available locally.
h) Visit to nearby tool room related to industry
i) Video/animation on design of different type of blow moulds.

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.	Blow Moulding Handbook	Rosato/Rosato	Van Nostrand Reinhold, 1989, 9783446150713
2.	Plastic Blow Moulding Handbook	Norman Lee	Van Nostrand Reinhold, 1990, 9789401169905
3.	Blow Moulding	Fisher	Butterworth & Co.,1971, 9780592054384
4.	Technology of Thermoforming	James L. Throne	Hanser Gardner Publications, 1996, 9781569901984
5.	Fundamentals of Plastics Thermoforming	Peter Klein	Morgan & Claypo Publishers, 2009, 9781598298840

14. SOFTWARE/LEARNING WEBSITES

1. https://www.youtube.com/watch?v=N3FXPDx4_3c
2. https://techcenter.lanxess.com/scp/americas/en/docguard/Part_and_Mould_Design_Guide.pdf?docId=77015
3. http://www.plastiglas.com.mx/images/content/PLASTIGLAS_INST/uploads/1168103546998Thermoforming.pdf
4. http://www.thermoform.com/tempsite/profileFlip/PP_designguide.pdf
5. http://www.multifab-inc.com/guidelines.pdf
6. https://multifabmanufacturing.com/assets/Uploads/Multifab-Thermoforming-Guidelines-Rev-3-12-18.pdf
7. https://geminigroup.net/wp-content/uploads/2018/06/Blow-Molding-Design-Guide-by-Regency-Plastics.pdf
8. https://www.scribd.com/presentation/145410205/Blow-Mould-Design
9. https://www.youtube.com/watch?v=jXxBJ0DRoJE

15. PO-COMPETENCY-CO MAPPING

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

Semester VI	Design for Blow and Thermoforming Moulds (Course Code: 4362301)									
	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 manufacture blow & thermoforming moulds as per need of consumer.**	1	2	3	2	2	2	2	3	1	-
Course Outcomes										
1. Select suitable blow mold material.	1	2	2	1	1	1	2	3	1	-
2. Design blow molds for various products.	1	2	3	2	1	1	2	3	1	-
3. Design efficient cooling system for blow mould.	1	3	2	2	1	1	2	2	1	-
4. Select suitable thermoforming mold material.	1	2	2	1	1	1	2	3	1	-
5. Design thermoforming moulds for various thermoformed products.	1	2	3	2	1	1	2	3	1	-

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

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