GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Blow Rotational and Thermoforming Process
(Course Code: 4342301)

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

1. RATIONALE

Blow molding, Rotational molding and Thermoforming Process are important Processes of plastic engineering field. Blow moulding, Rotational moulding and Thermoforming processes widely employed for the production of hollow and thin walled plastic products due to ease and faster rate of production. A diploma plastic engineer has to understand and operate the machines, perform processes, troubleshoot parameters, deal with processing problems and finally produce a moulded product. Hence the course has been designed to develop this competency and its associated cognitive, practical and affective domain learning outcomes in the students.

2. COMPETENCY

The course should be taught and curriculum should be implemented with the aim to develop required skills in the students so that they are able to acquire following competency:

- **Operate and supervise the blow moulding, rotational moulding and thermoforming process.**

3. COURSE OUTCOMES (COs)

The theory should be taught and practical should be carried out in such a manner that students are able to acquire required learning out comes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

a) Operate blow moulding, rotational moulding & thermoforming machines.
b) Troubleshoot blow moulding, rotational moulding & thermoforming processes.
c) Apply post moulding techniques for blow moulded rotational moulded & thermoformed parts.
d) Select suitable raw materials for blow moulding, rotational moulding & thermoforming processes.
e) Select rotational, blow & thermoforming moulding for manufacturing of various 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	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	Demonstrate the constructional details of a blow moulding machine.	1	2
2	Determine cycle time for a given product for blow moulding process.	1	4
3	Set process parameters on a blow moulding machine.	1	4
4	Control wall thickness of parison by parison programming system.	1	4
5	Identify problem associate with Blow moulding process.	1	4
6	Demonstrate the constructional details of a rotational moulding machine.	2	2
7	Determine cycle time for a given product for rotational moulding process.	2	4
8	Set process parameters on a rotational moulding machine.	2	4
9	Identify various problems during Rotational moulding process.	2	4
10	Prepare comparison chart for blow moulded and rotational moulded products.	2	2
11	Demonstrate the constructional details of a Thermoforming machine.	3	2
12	Determine cycle time for a given product for Thermoforming process.	3	4
13	Set process parameters on a Thermoforming machine.	3	4
14	Identify various problems during Thermoforming process.	3	4
15	Plan preventive maintenance schedule for blow moulding machine	1	4
16	Plan preventive maintenance schedule for rotational moulding machine	2	4
	TOTAL		**56**

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.	30
3	Follow safe practices measures.	10
4	Record observations correctly.	20
5	Interpret the result and conclude.	20
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 practical's in all institutions across the state.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Blow moulding machine with parison programming system	1,2,3,4,5
2	Rotational moulding machine	6,7,9,10
3	Thermoforming machine with heating system for sheet	11,12,13,14
4	Scrap grinder	4,5
5	Weighing scale	5,9,14
6	Stop watch	2,7,12

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 Blow Moulding	1a. Describe basic principle of Blow moulding processes 1b. List and compare types of Blow moulding process with the Advantages & disadvantages.	a) **Blow Moulding Process** • Basic principle of Blow moulding • Types of Blow moulding Process Injection Blow Moulding Extrusion Blow moulding- intermittent & continuous • Compare Injection Blow moulding & Extrusion Blow moulding • Advantages & disadvantages of process • Applications of Blow moulding process
	1c. List Various types of materials used for blow moulding	b) **Materials For Blow Moulding** • Polymer selection criteria • Various types of materials
	1d. Explain about various parts of the Extruder & its functions.	c) **Blow Moulding Machine** • Extruder & its requirements • Die head & parison die • Die orifice and mandrel design
	1e. Explain in details about parison blowing systems.	d) **Parison** • Parison formation • Parison blowing systems • Needle inflation • Mandrel inflation-Top mandrel, Bottom mandrel, Top mandrel with calibration • Parison programming and Parison wall thickness control
	1f. Describe Process parameters of moulding	e) **Processing Parameters** • Various Blow moulding

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
	operations 1g. Discuss about troubleshooting in Blow Moulding	processing parameters • Effects of process variables such as raw material, parison die, air entrance, mould cooling & parison wall thickness control • Post molding operations • Trouble shooting
Unit – II Rotational Moulding	2.a Describe Rotational moulding process with its Advantages, disadvantages and Applications.	**(a) Rotational Moulding Process** • Process steps • Advantages and disadvantages of Rotational moulding • Application
	2.b List Types of materials and their selection criteria for Rotational moulding	**(b) Materials** • Moulding material characteristics. • Types of moulding materials and their selection criteria.
	2.c Identify various parts of Rotational moulding machine	**(c) Rotational Moulding Machine** • Rock and roll machine • Clamshell • Vertical machine • Shuttle machine • Fixed arm Carousel type machine • Independent arm type machine • Oil jacketed machine • Electrically heated machine
	2.d List the Mould material 2.e Describe Heating & cooling of mould	**(d) Rotational Moulds** • Basics of Rotational molds design • Mould materials • Heating & cooling of mould
	2.f Set processing parameters 2.g Solve processing problems in Rotational moulding 2.h Differentiate the blow and rotational moulding	**(e) Part Design** **(f) Process Variables** **(g) Trouble Shooting** **(h) Comparison With Blow Moulding**

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
UNIT III Thermo Forming	3.a Explain Thermoforming processes in details.	a) **Thermoforming Process** • Various stages of thermoforming process • Explain various methods of forming • Vacuum Forming • Pressure forming • Advantages and disadvantages of thermoforming • Applications of thermoforming Process b) Materials • Material requirements • Types of material
	3.b Discuss about various Thermoforming machines	c) **Thermoforming Machines** • Single-stage sheet fed machine • Multiple stage sheet fed machine • In-line sheet fed machine • Continuous roll fed machine • Packaging machines
	3.c Explain processing requirements for thermoforming	d) **Processing Requirements** • Heating methods • Temperature control • Vacuum/air pressure • Cooling • Trimming
	3.d Explain about various process parameters with troubleshooting of Thermoforming process 3.e Differentiate the blow, Rotational and thermoforming process.	e) **Process Variables** f) **Trouble Shooting** g) **Comparison With Blow, Rotational Molding And thermoforming process**.

***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 Moulding	18	18	10	07	35
II	Rotational Moulding	14	08	06	06	20
III	Thermoforming	10	07	04	04	15
Total		**42**	**33**	**20**	**17**	**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 collect Blow moulded, Rotational moulded and Thermoformed products like bottle, jar, jerry can disposable dish etc. and would comment on their quality.
2. Students will collect information related to the experiment through internet.
3. Students will visit nearby industry having blow, rotational and thermoforming operations.

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 blow, rotational and thermoforming industries.
h) Video/animation on working of different type of blow,rotational and thermoforming processes.

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:

1. Students will collect samples of blow moulding, rotational moulding and thermoforming products.
2. Students will showcase different types of defective products and prepare its remedies.
3. Students will prepare report of maintenance schedule for blow moulding, rotational moulding and thermoforming process.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1.	Blow Moulding of Plastics	Fisher E.G	Butterworth-Heinemann, 1971, 9780592054384
2.	Blow Moulding Handbook	Rosato A., Rosato D.	Hanser Publishers, 2004, 9781569903438
3.	Plastic Blow Moulding Handbook	Lee N.C	Springer, 2012, 9789401169905
4.	Rotational Moulding	Beall G.	Hanser Publication, 1998, 9781569902608
5.	Rotational Moulding of Plastics	Crawford R.J, Throne J.L	Wiliam Andrew, 2001, 9781884207853

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
6.	Moulding of Plastics	Bikales N.M	Wiley Interscience, 1971, 9780471072331
7.	Handbook of Plastic Technology	Allen W.S	CBS Publishers & Distributors, 2020, 9788123910002
8.	Plastic Materials & Processes	Schwartz S.S. & Goodman S.H.	Van Nostrand Reinhold, 1982, 9780442227777
9.	Plastic Engineering Handbook	Frados J.L	Van Nostrand Reinhold Company, 1976, 9780442224691
10.	Plastic Engineering Handbook	Berins M.L	Van Nostrand, 1991, 9780412991813
11.	Technology of Thermoforming	Throne J.L	Carl Hanser Verlag GmbH & Co. KG, 1991, 9783446178120
12.	Thermoforming- A Plastics Processing Guide	Gruenwald G.	Taylor and Francis, 1998, 9781566766258

14. SOFTWARE/LEARNING WEBSITES

a) http://www.bpf.co.uk/
b) https://www.youtube.com/results?search_query=blow+moulding
c) https://www.youtube.com/results?search_query=rotational+moulding
d) https://www.youtube.com/results?search_query=thermoforming
e) http://www.technologystudent.com/
f) http://www.notesandsketches.co.uk/Index.html
g) http://www.paulsontraining.com
h) http://www.traininteractive.com
i) https://www.tecni-form.com/rotomoulding/
j) https://www.indiaroto.com/
k) http://en.wikipedia.org/wiki/Rotational_molding
l) https://rotomolding.blogspot.com/
m) https://www.4spe.org/

15. PO-COMPETENCY-CO MAPPING

Semester IV	Blow Rotational and Thermoforming Process (Course Code: 4342301)
	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 and supervise the blow moulding, rotational moulding and thermoforming process.**	1	2	2	3	1	1	2	3	1	-
Course Outcomes 1. Operate blow moulding, rotational moulding & thermoforming machines.	1	2	3	3	1	1	2	3	1	-
2. Troubleshoot blow moulding, rotational moulding & thermoforming processes.	2	2	3	1	1	1	1	2	1	-
3. Apply post moulding techniques for blow moulded rotational moulded & thermoformed parts.	1	1	1	1	1	1	1	1	1	-
4. Select suitable raw materials for blow moulding, rotational moulding & thermoforming processes.	1	2	3	3	2	1	1	2	1	-
5 Select rotational, blow & thermoforming moulding for manufacturing of various products.	1	1	1	1	2	1	2	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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