Learning Unit	
Subject	Technical Studies_Polymers
Title	Polymers - The world of plastics
Author	Cibeli Garcia
School	FORAVE – Associação para a Educação Tecnológica do Vale do Ave
Description of the unit	In this unit, a different approach will be taken regarding products made from plastic materials. Students will understand that plastics are of great importance to our society. A debate will be held on plastics, the circular economy and the environment. After a brief presentation about what polymers and plastics are, students will participate in an activity to identify the different polymers used in different parts made from plastics. A practical class will be held in the laboratory where students will try to identify the different types of polymers. Students will also collaborate in a practical activity that involves the production of a bioplastic using potato starch. Finally, students will collaborate in selecting the most suitable manufacturing process for different types of plastic parts. At the end of the lesson, students will have an understanding of what polymers are and what types of polymers exist, what plastics are, how they are produced and classified, and what their main applications are. In addition, they will also come to the realisation that plastics can be allies of resource efficiency, minimising environmental impacts and costs.
Contents	● The importance of plastics ● Definition of polymer ● Identification of polymers ● Applications of polymers ● Polymer moulding processes and operating principles – notions ● Equipment used in polymer moulding processes
Learning Outcomes / Skills	Students should be able to: - Discuss the importance of plastics and their relationship with the environment. - Identify polymers. - Identify the applications of polymers. - Identify the different polymer transformation processes. - Identify the equipment used during the different polymer transformation processes.
Target students/class	Secondary school (15 – 17 years old)
Prerequisites	Students must have a critical mind, have prior knowledge of good conduct in a chemistry laboratory, work properly in groups and enjoy challenges.

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Learning Unit	
Time expected	5 hours
Interdisciplinary links	Science ICT
Methodology	Survey of prior knowledge through a conversation at the beginning of each class or activity so that the teacher can understand what the students already know about the theme, topic or exploration that will be carried out. Memorization through the creation of images, showing videos, taking quizzes, which the student associates with something they have to memorise. Reflection to help students find alternative ways when they are stuck in a problem, encouraging them to come up with solutions for a given challenge or situation. Explanation using dialogue; Explanation with schemes; Explanation with visual supports; Explanation with questions; Individual work; Group work; Activity/Worksheets; Use of audiovisual media and information and communication technologies.
Human Resources (internal and/or external)	Polymers Teacher and Chemistry Teacher
Resources	Computer with internet access, projector, chemistry laboratory instruments, worksheets, pencil or pen.
Lesson Plan	**<u>1st lesson</u>:** **Summary: The importance of Plastics** Students' attendance record and summary. Survey of prior knowledge based on a conversation at the beginning of each class or activity so that the teacher can understand what the student already knows about the topic. Exploration of the topic based on some studies which reveal that replacing plastics with other alternative materials would have an environmental cost of around four times higher, with a consequent increase in energy consumption, water consumption, greenhouse gas emissions greenhouse, the global weight of urban solid waste, etc... Worksheet. Debate on the answers of the worksheet. **<u>2nd lesson</u>:** **Summary: Definition and Identification of polymers** Students' attendance record and summary. Explanation of the experiment that consists of the preliminary identification of polymers. Practical implementation of experiments: a. Choose the sample to be identified;

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Learning Unit	
	b. Check the appearance of the surface; c. Observe its level of transparency and compare it with the data in a given table; d. Observe its rigidity by applying force (table); e. Using scissors, divide the sample into smaller samples; f. Hold one of the samples with tweezers, inside a hood, and expose it to the flame until it ignites. g. Observe the characteristics of the flame, such as colour, presence of smoke, smoke colour and dripping. The results must be compared to the data in a given table. h. Write the report of the experiment. **<u>3rd lesson</u>:** **Summary: Production of biodegradable plastic from potato starch** Students' attendance record and summary. Explanation of the experience involving the production of biodegradable plastic from potato starch. Preparation of materials and reagents and practical implementation of the experiment. Discussion with students about this experiment and its results. **<u>4th lesson</u>:** **Summary: Understanding polymer moulding processes and operating principles.** Students' attendance record and summary. Survey of prior knowledge so that the teacher can understand what the student already knows about the topic. PowerPoint presentation, videos, and diagrams on the different polymer transformation processes. Worksheet - students have to identify the types of processes used in the manufacture of different types of plastic materials. **<u>5th lesson</u>:** **Summary: Correction of the worksheet from the previous lesson. Identification of the equipment used during the different polymer transformation processes.** Students' attendance record and summary. Update/ Revision. Correction of the worksheet from the previous lesson. Worksheet - students have to identify the different equipment used during the different polymer transformation processes. Correction of the worksheet. Clarification of doubts.

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Learning Unit	
21st Century Skills	Critical thinking: students will be able to analyse the data collected during practical experiments, identifying polymers and producing bioplastic. Creativity: students will be able to publish posts about positive and negative aspects of plastics. Collaboration: students will be able to collaborate between groups in practical classes and help each other to make a final PowerPoint presentation of their group work. Communication: Students will be able to communicate during the assessment of each task. Information research: students are asked to do research from various sources of information. Media and technological proficiency: students will create PowerPoint presentations and films using different applications and online tools.
Assessment	Formative Assessment: ● Attendance ● Responsibility ● Autonomy ● Participation in classes ● Participation in the activities ● Critical spirit, participation, behaviour. Summative assessment: ● Oral questions
Remarks	If students show positive participation and interest, there may be a visit to a polymer processing company.

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Plastics Transformation Processes

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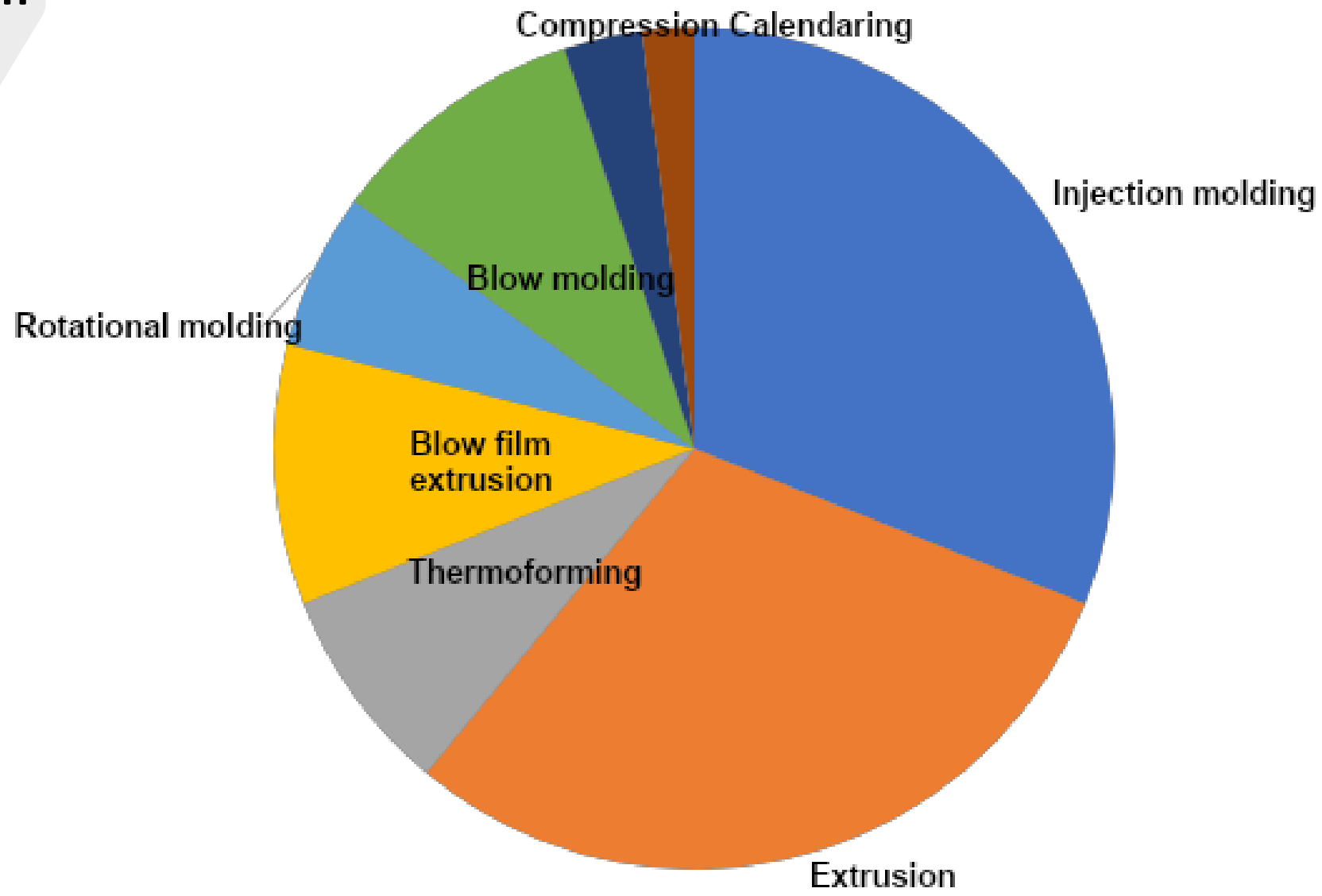
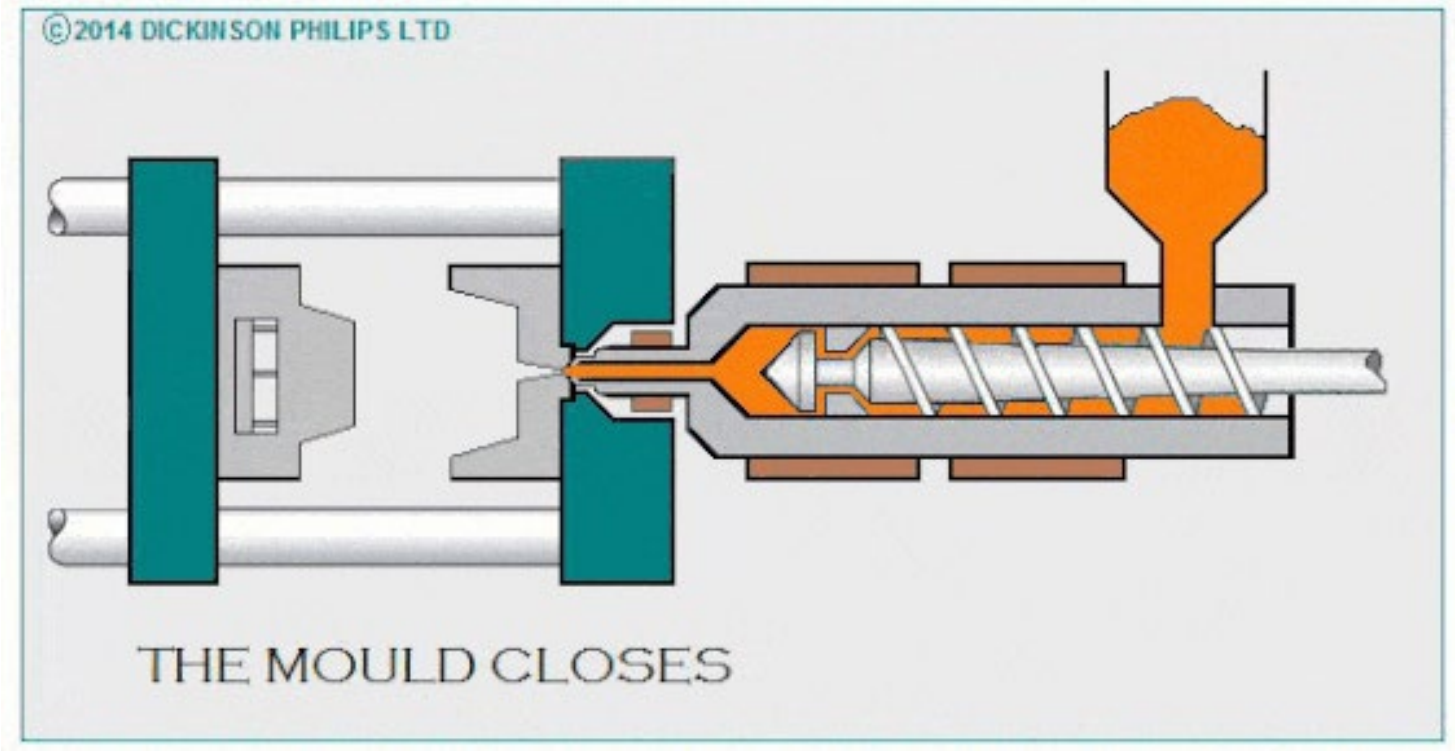
Plastics Transformation Process

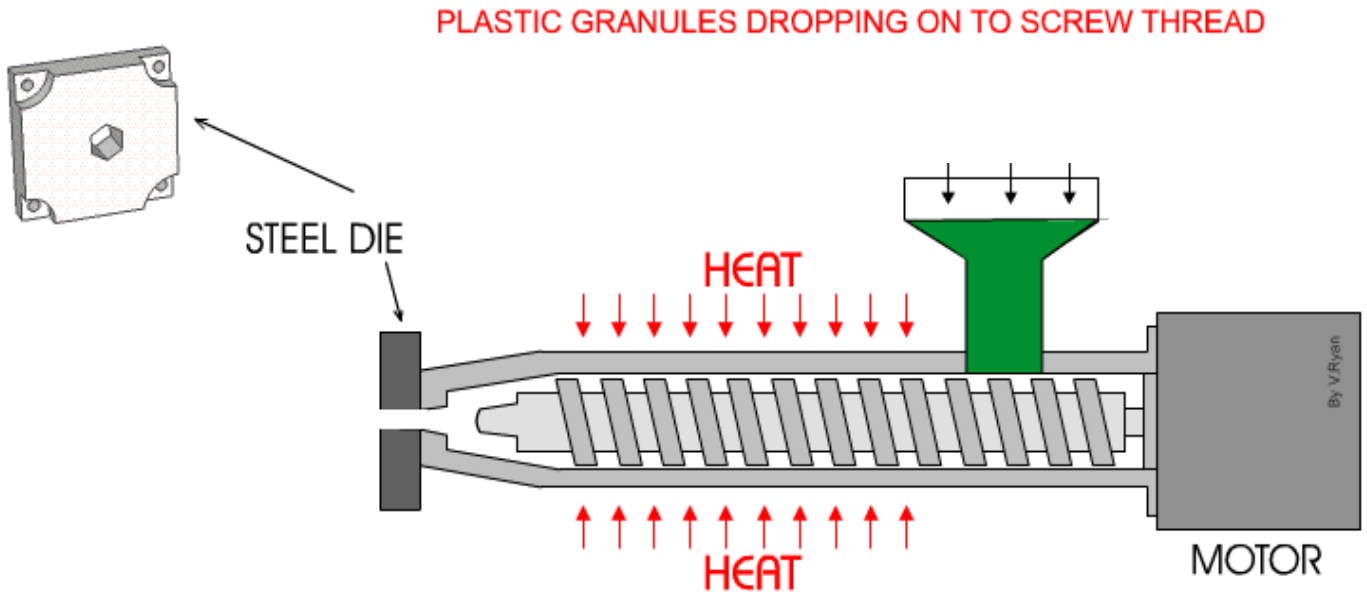


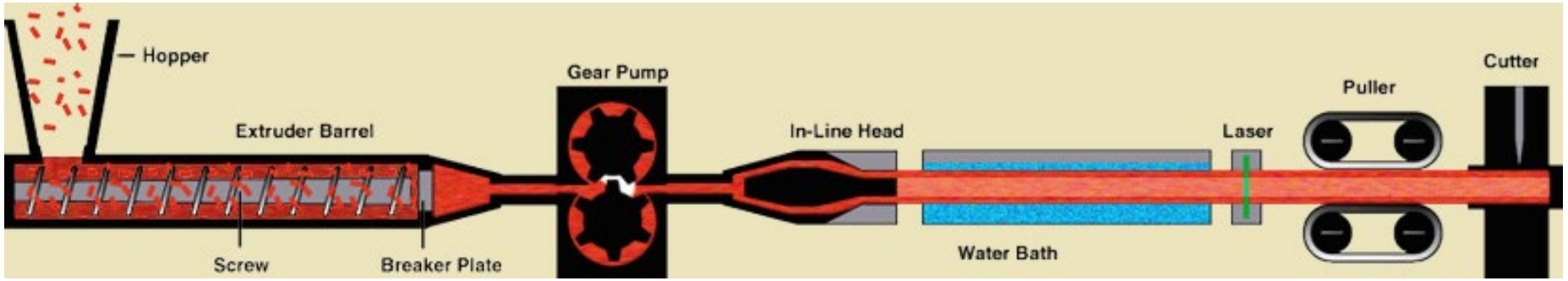
Injection Molding



Injection Molding

Extrusion


PLASTIC GRANULES DROPPING ON TO SCREW THREAD
STEEL DIE
HEAT
HEAT
MOTOR
By V.Ryan

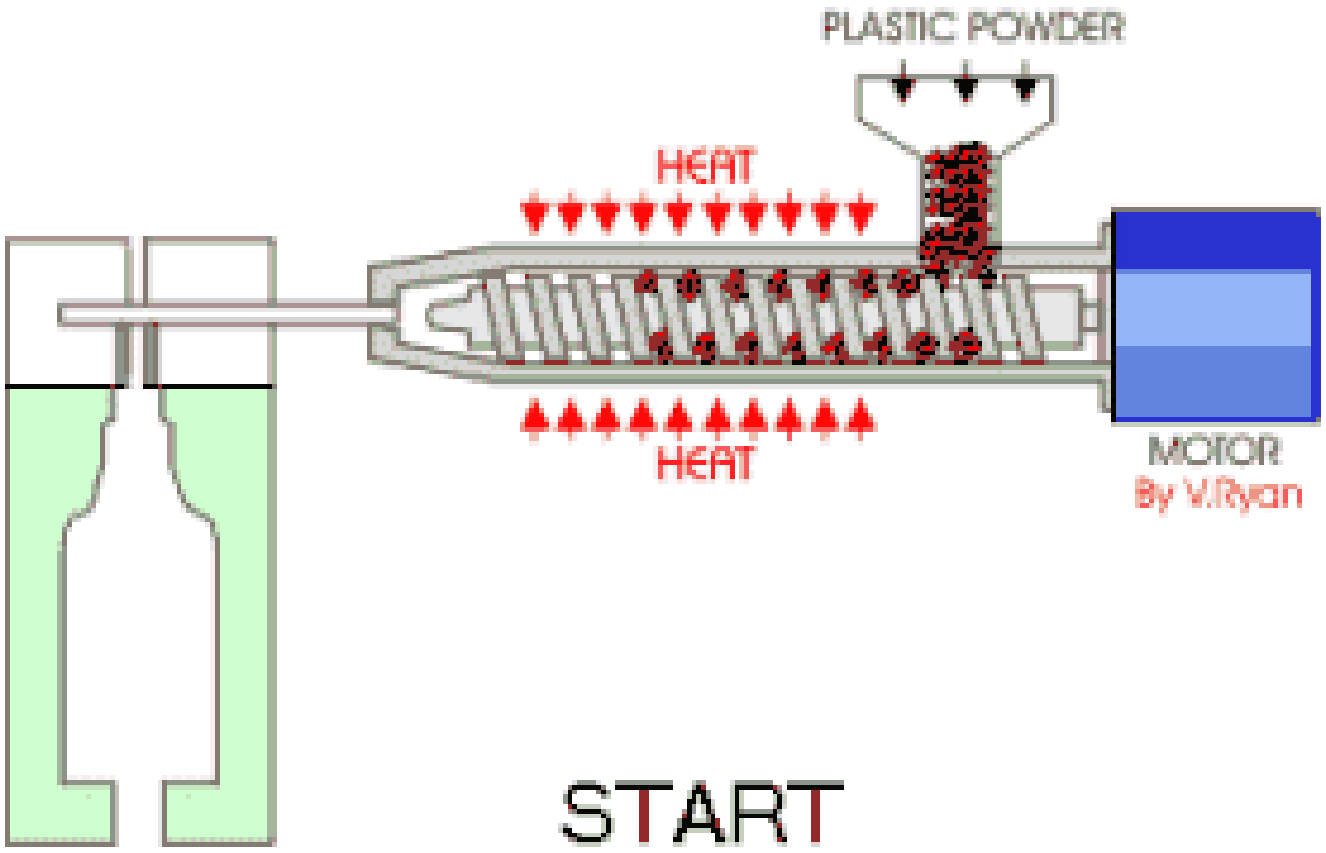

Hopper
Extruder Barrel
Screw
Breaker Plate
Gear Pump
In-Line Head
Water Bath
Laser
Puller
Cutter

Extrusion

Plastic films and sheeting

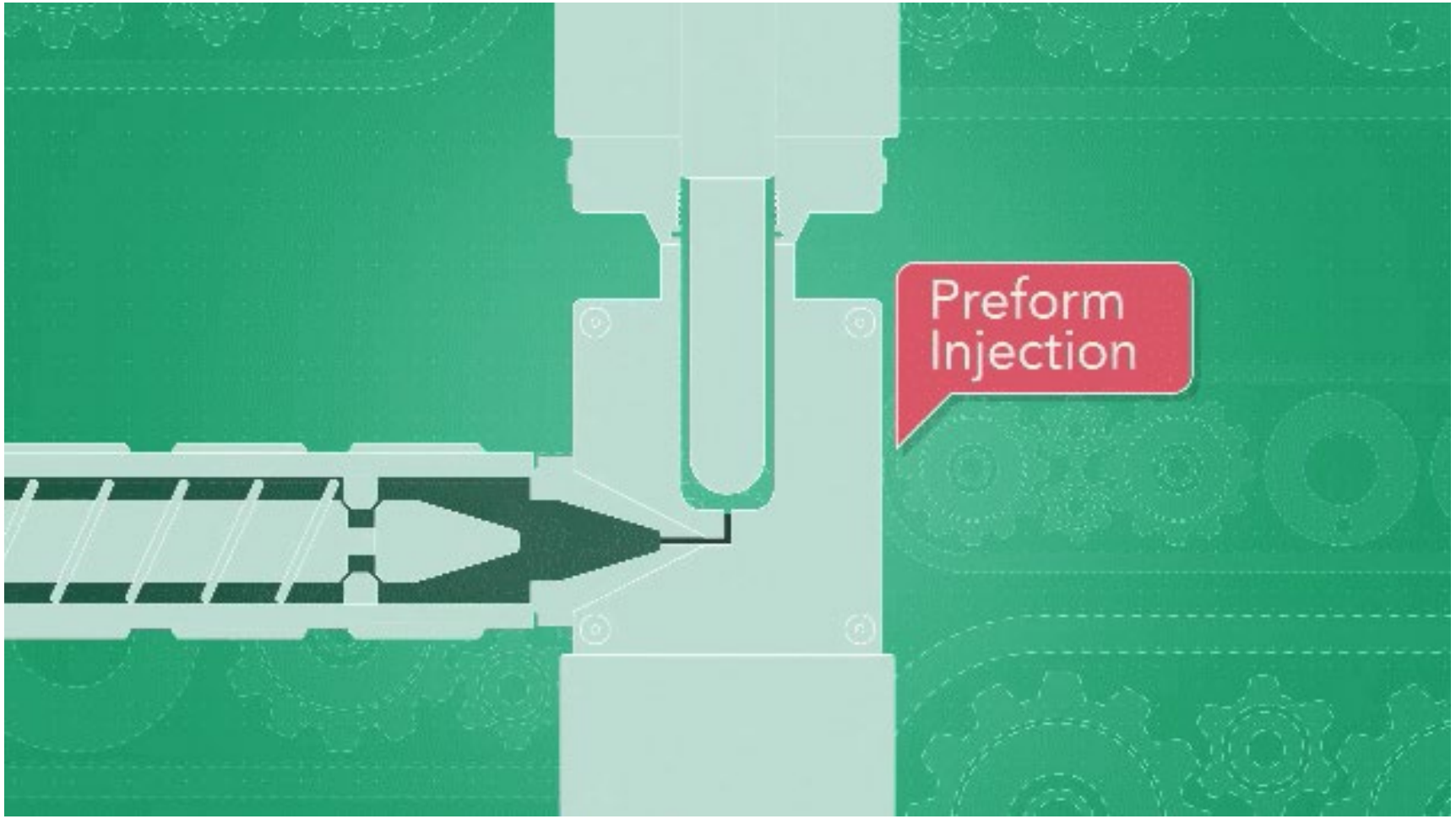
Window frames

Extrusion Blow Molding (Parison)

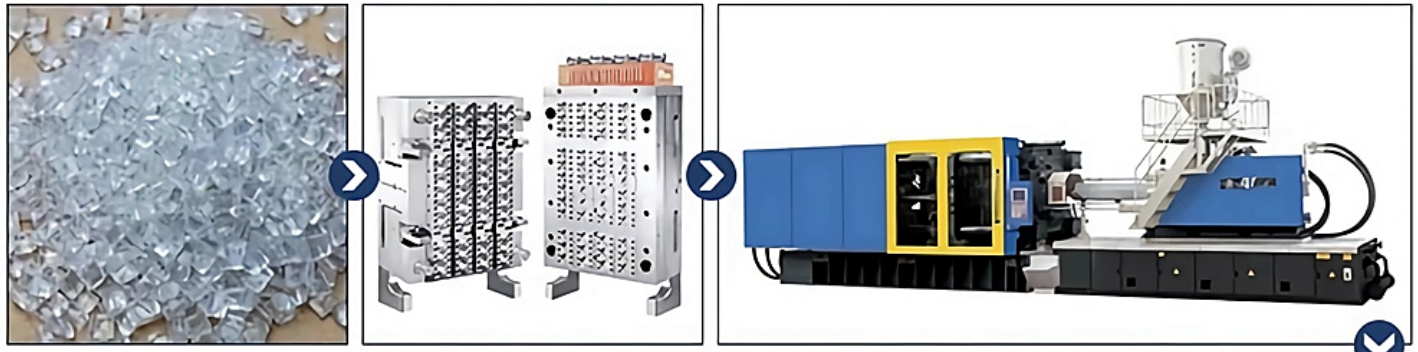


Extrusion Blow Molding (Parison)

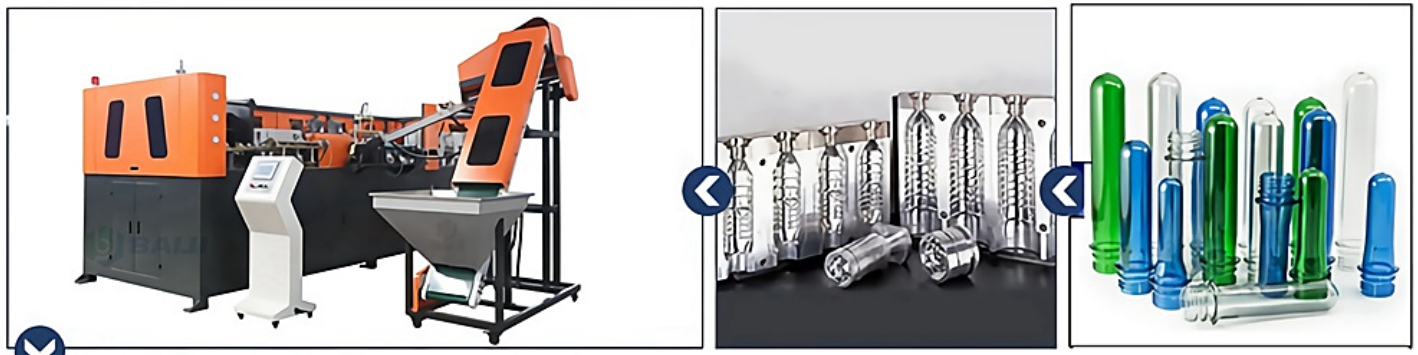
Injection Blow Molding (Preform)



Injection Blow Molding (Preform)

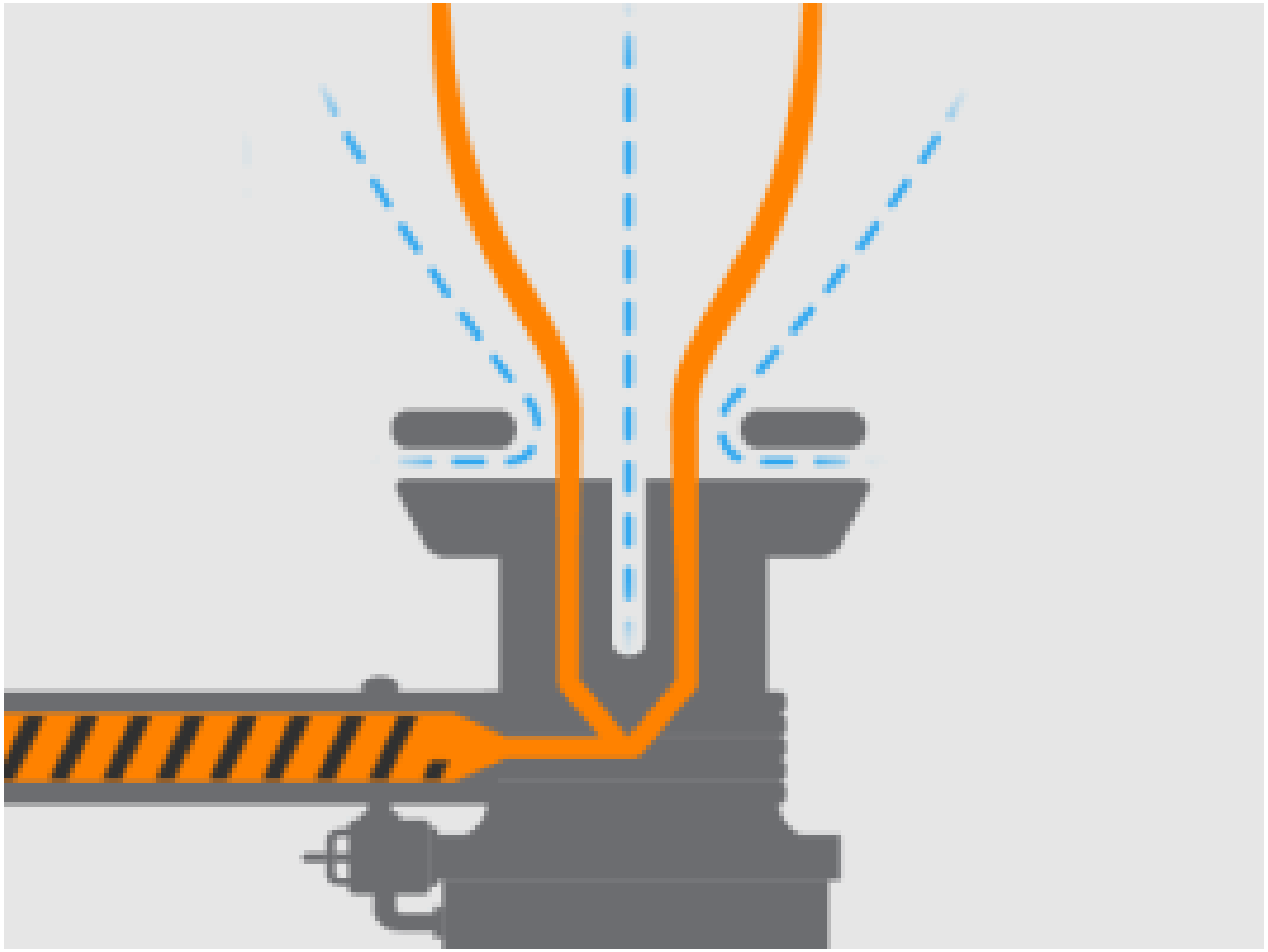


PET granule | PET preform mould | preform injection mould machine



PET bottle blowing machine | PET bottle blowing mould | PET preform

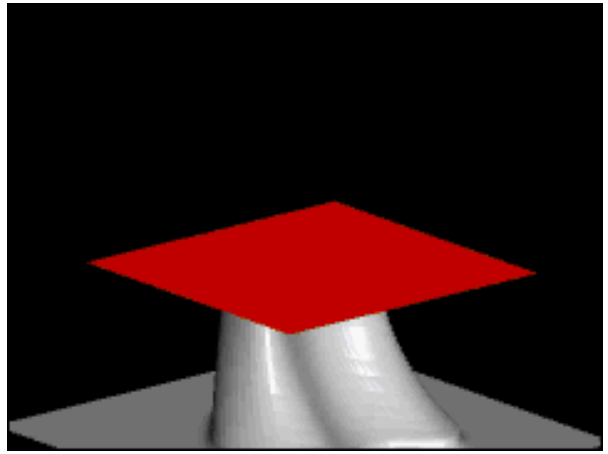
Blow Film Extrusion

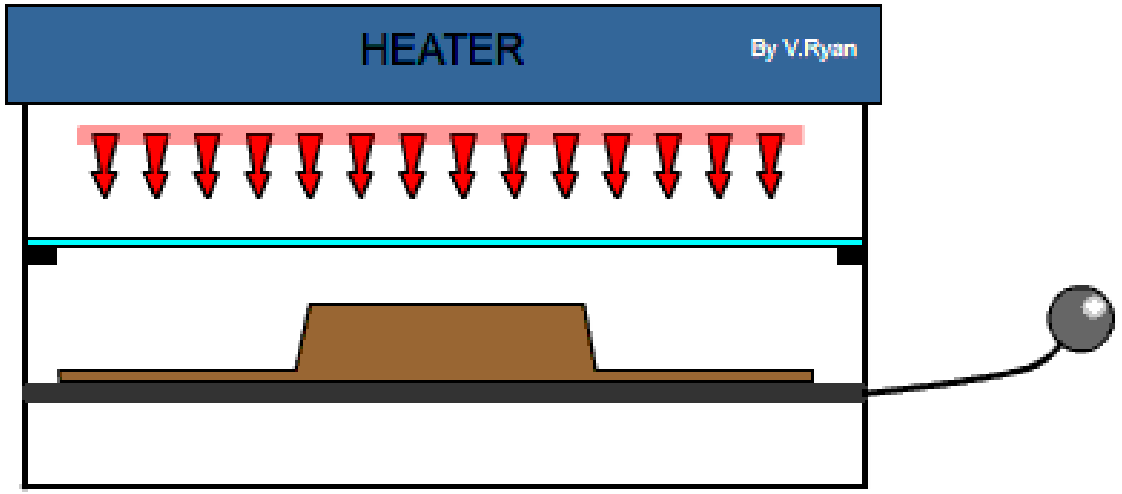


STEM EDUCATION from school to a tech world

Blow Film Extrusion

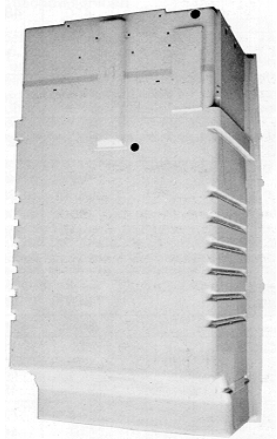
Thermoforming

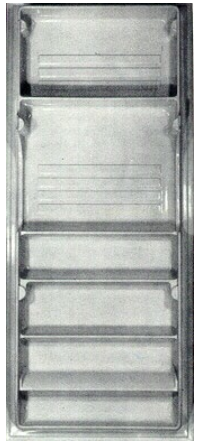




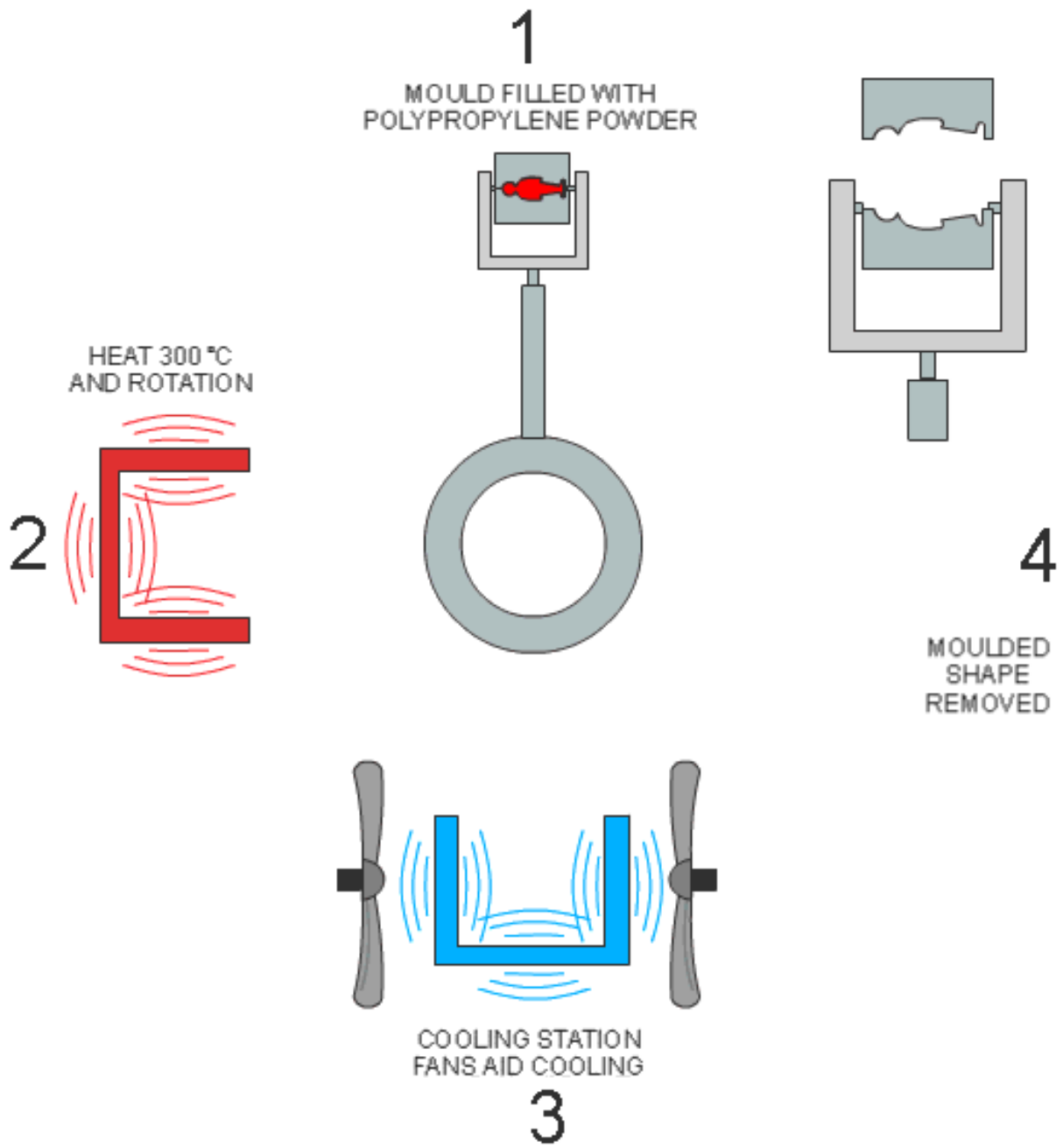
THE ELECTRIC HEATER IS TURNED ON TO WARM THE PLASTIC SHEET.

Thermoforming



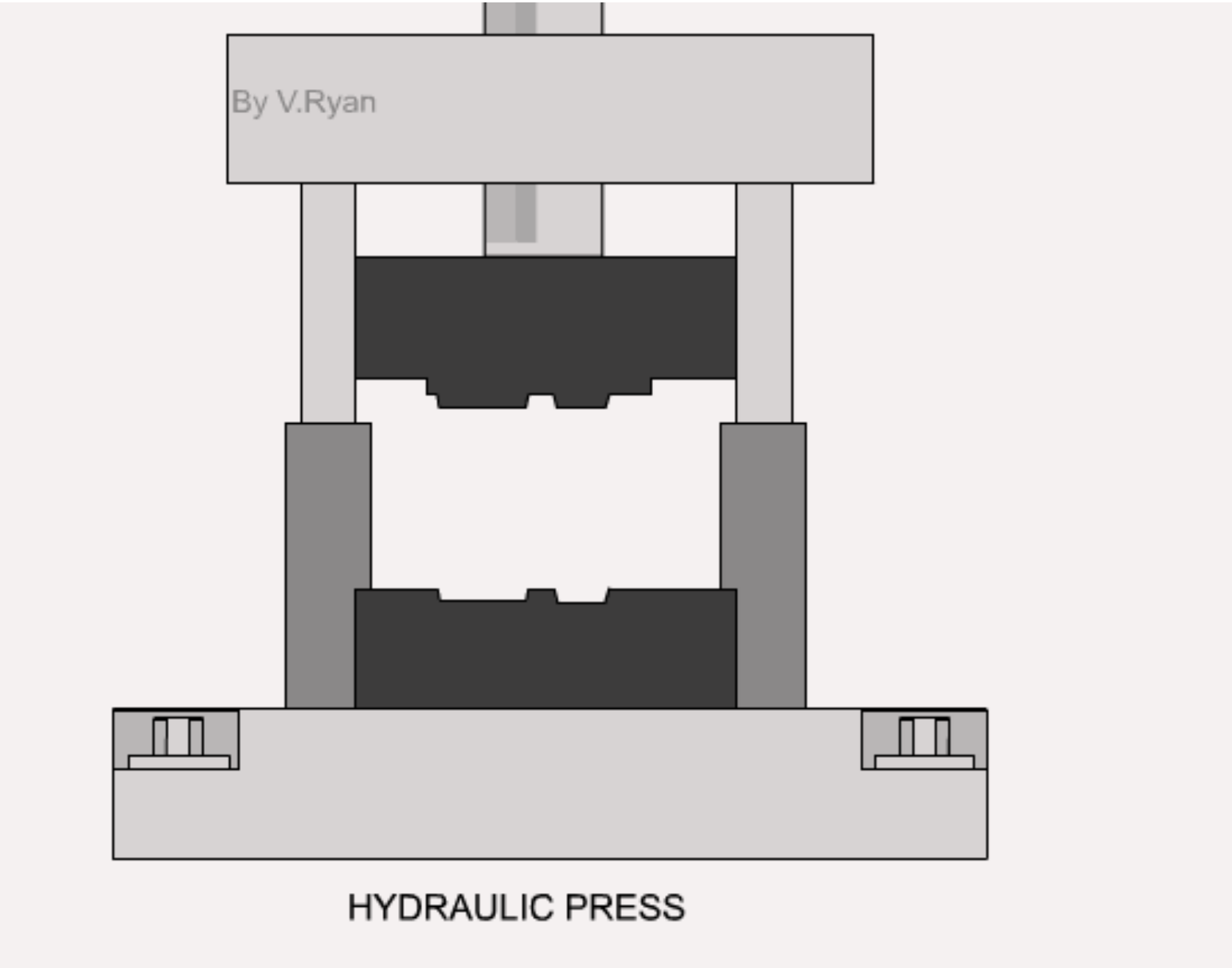


Rotational Moulding



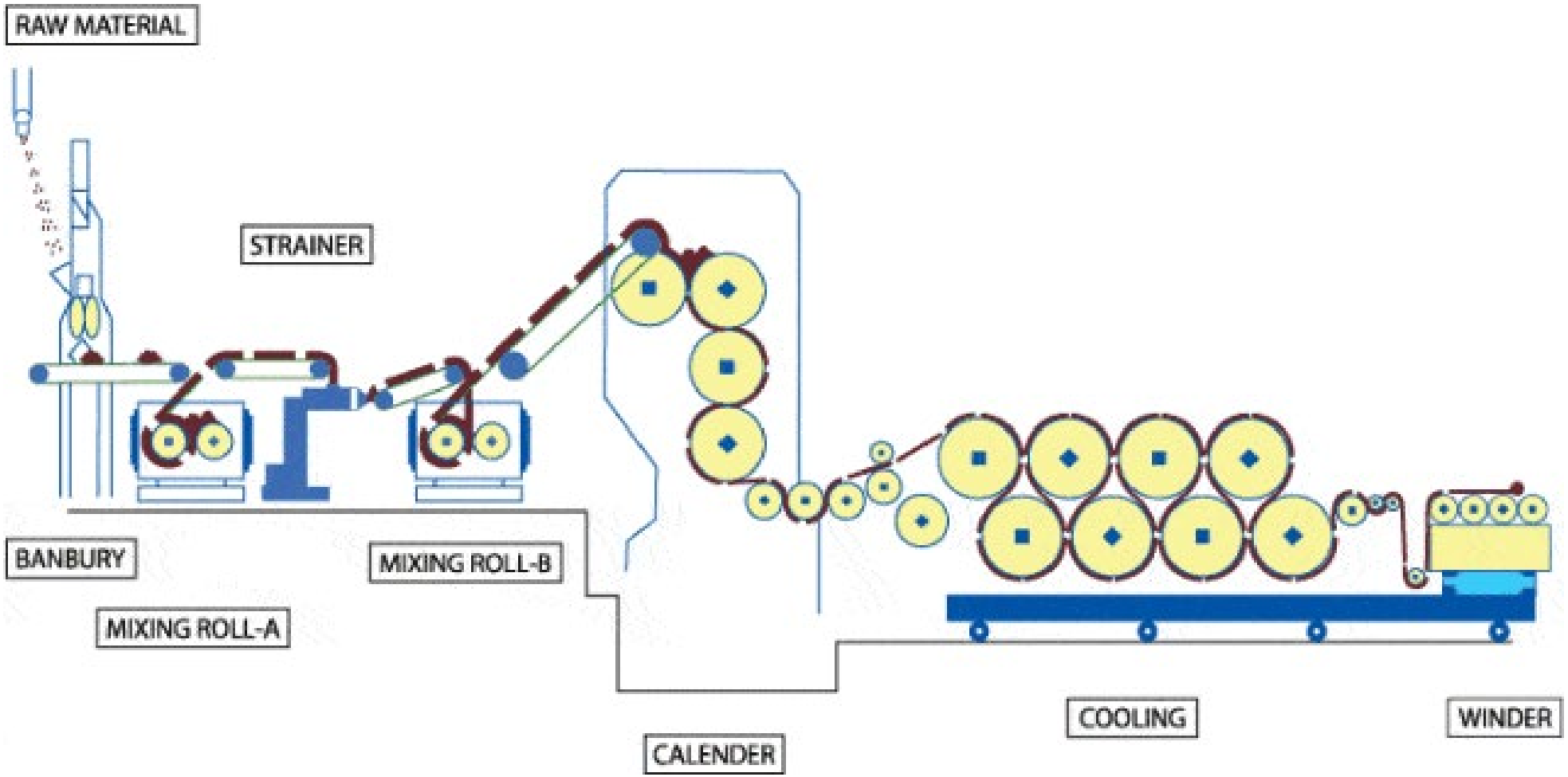
Rotational Moulding

Compression Moulding

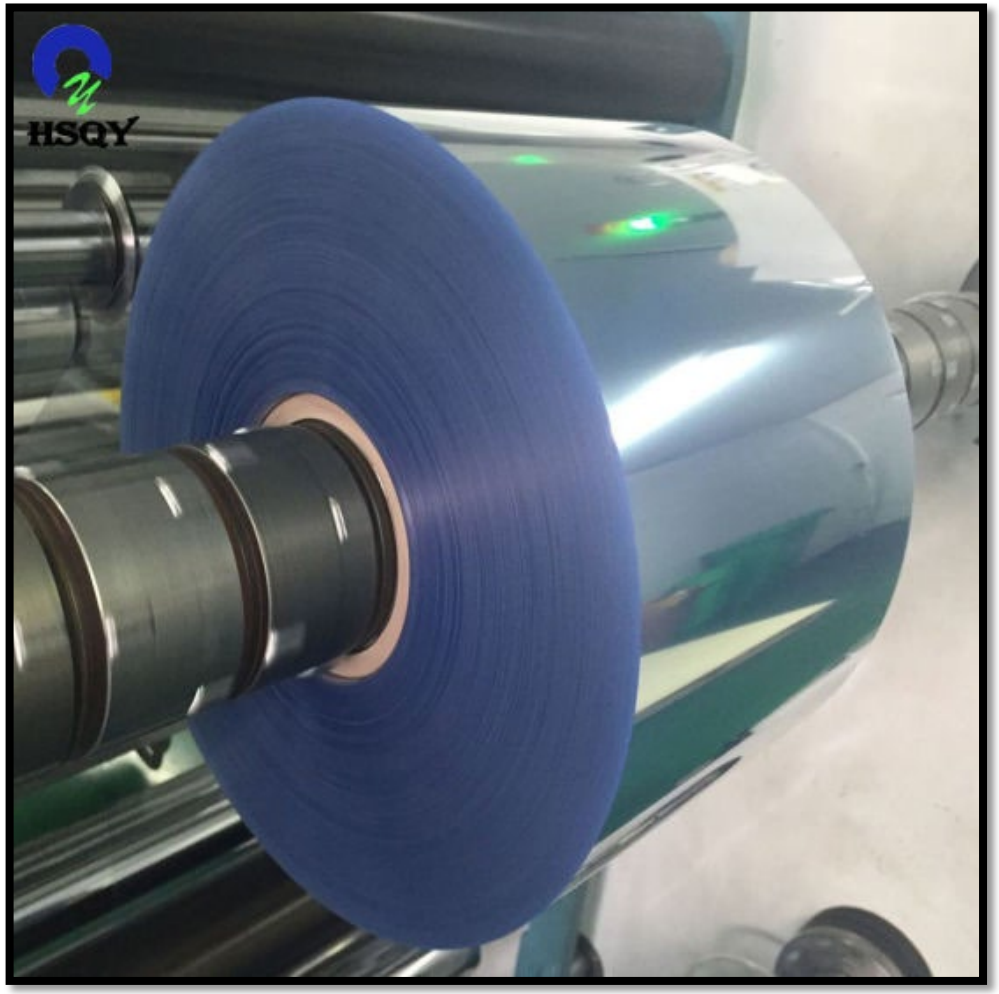


Compression Moulding

Calendaring



Calendaring



Plastics Transformation Processes

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Worksheet No. 1

Learning Unit	Polymers - Plastics and their importance
Author	Cibeli Garcia
School	FORAVE –Associação para a Educação Tecnológica do Vale do Ave
Date	

1. Name three situations where plastics are important for our society:

Answer:_____

2. Comment on the following statement:

“Plastics are materials of excellence in terms of resource efficiency, allowing people to save water, energy and CO2 emissions.”

Comment:_____

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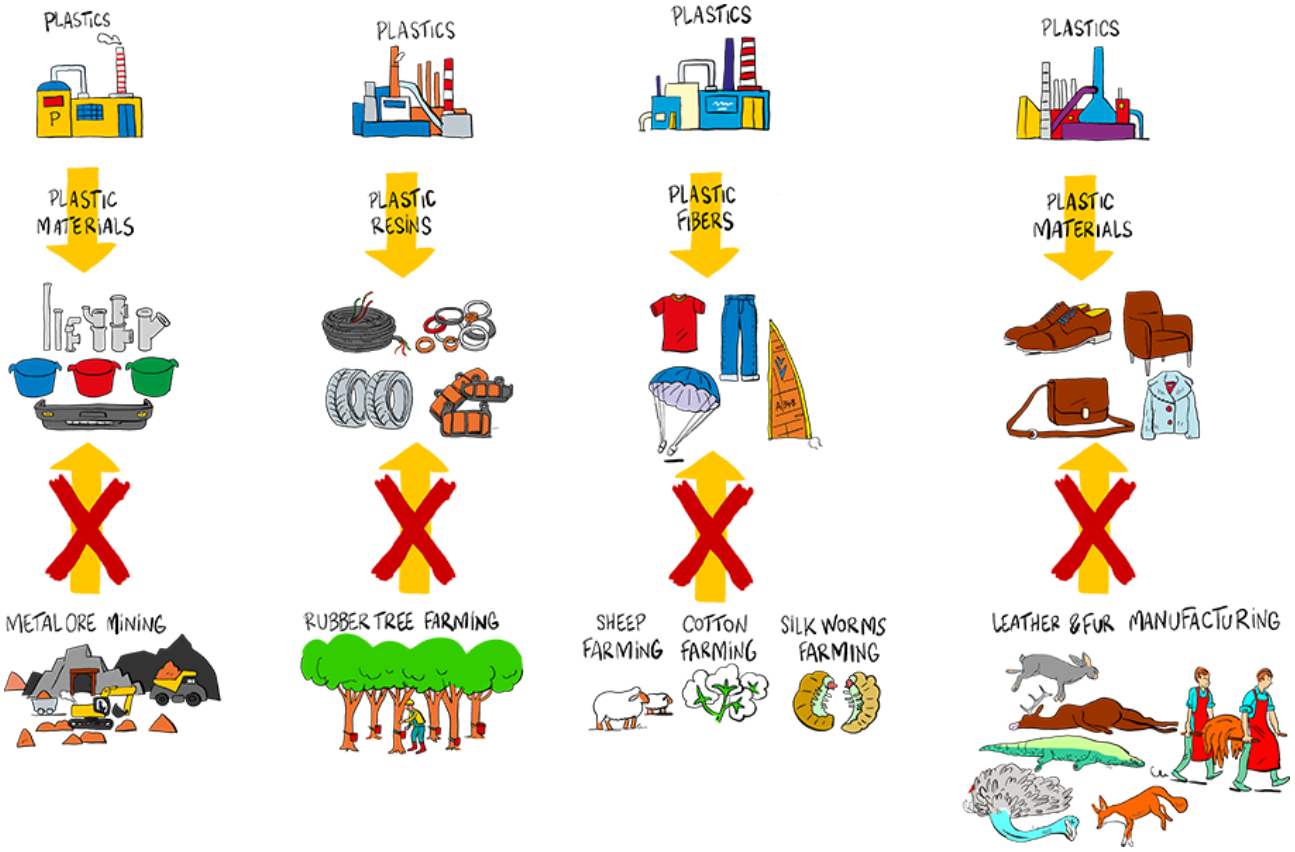
Worksheet No. 1

3. Comment on the image below:



Keep up the good work!
Teacher Cibeli Garcia

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Worksheet No. 2

Learning Unit	Polymers - Identification of polymers
Author	Cibeli Garcia e Alexandra Jales
School	FORAVE – Associação para a Educação Tecnológica do Vale do Ave
Date	

Identification of polymers

Objective:

- Identify samples of polymeric materials through the use of simple laboratory techniques.

Introduction:

Polymers can be identified using various techniques, from simpler tests such as the flame test and also visual and sensitive analysis as well as through more sophisticated techniques such as infrared spectroscopy and nuclear magnetic resonance and through X-ray diffraction. In this practice we will identify common polymers using very simple and widely accessible techniques.

Simple Preliminary Techniques for Identification:

Most of the widely used polymers can be identified using codes. Picture 1 shows the respective codes for classifying widely used commercial polymers. These codes were created with the aim of facilitating recycling. However, when we don't know the type of polymer, it is necessary to identify the material through laboratory tests or through simple tests. Examples of materials and applications are soft drink bottles made from polyethylene terephthalate or poly (ethylene terephthalate) (PET); Plastics used for containers such as milk cartons are generally high-density polyethylene (HDPE); Bottles used for shampoo or cleaning supplies are typically made from polyvinyl chloride (PVC); Plastic bags and some plastic wraps are usually low-density polyethylene (LDPE).

In this practice we will identify some materials provided through simple techniques available in any laboratory. To assist in preliminary identification and observation, some simple tests will be carried out, as shown in table 1.

After that, the main simple tests that can be used to identify polymers are presented.

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Worksheet No. 2

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Polymer	Appearance	Stiffness	Surface	Flame test	Notes	Smell	FP (ºC)
PELD	Transparent/ Translucent	flexible	waxy	blue, yellow vertex	drips like a candle	smells like a candle	105
PEHD	Transparent/ Translucent	flexible	waxy	blue, yellow vertex	drips like a candle	smells like a candle	130
PP	Transparent/ Translucent	semi rigid	waxy	yellow, crackles when burning, fuliginous smoke	drips like a candle	aggressive odour	165
ABS	Opaque	semi rigid	opaque	yellow, crackles when burning, fuliginous smoke	softens and drips	styrene monomer	230
PS	Transparent	rigid	glassy	yellow, blue based neutral smoke	softens and drips, carbonizes completely	sweet	-
POM	Opaque	semi-rigid	glassy	blue, smokeless with spark	softens and bubbles	styrene monomer	130
PET	Transparent	semi rigid	glassy	yellow, smoke with spark	-	rancid butter	180
PVC-U	Transparent	semi rigid	glassy	yellow, green vertex	self-extinguishing flame	-	127
PVC-P	Transparent	flexible	glassy	yellow, green vertex	self-extinguishing flame	chlorine odour	150
PTFE	Opaque	flexible	glassy	yellow, loses shape	self-extinguishing flame	no smell	205 327
PU	Opaque	Flexible/ semi rigid / rigid	-	yellow, blue based	drips, black smoke	spicy, sour	-
PA66	Translucent	semi rigid	glassy	blue, yellow vertex with spark, hard to burn	forms balls at the tip	burnt feather or hair	260

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Worksheet No. 2

Code for classifying polymers

Picture 1. Codes used to identify polymers, with the aim of recycling them.

Flame test: It consists of burning the polymeric material in a flame and observing the behaviour of the flame. Each type of material presents specific behaviour when burned. It's possible that burning does not occur, or combustion is difficult and is extinguished when removed from the flame, or combustion occurs in the flame, but not outside, or combustion is rapid, continuing even outside the flame. Furthermore, it is possible to check some properties of the flame, for example, its colour, presence or absence of soot and the odour emanating. Based on the characteristics observed, it is possible to identify the type of polymeric material being tested.

Practice guide:

1. Preliminary tests

(a) Select the sample to be identified;
(b) Check the appearance of the surface;
(c) Observe the level of transparency and compare it with the data in Table 1;
(d) Observe the rigidity by applying force (Table 1);
(e) Using scissors, divide the sample into smaller samples;
(f) Hold one of the samples with tweezers, inside a hood, and expose it to the flame until it ignites.
(g) Observe the characteristics of the flame, such as colour, presence of smoke, smoke colour and dripping. The results must be compared to the data in Table 1.

Discussion and presentation of the results:

The discussion should contain the relevant characteristics related to the results of each test, based on the information provided in the classes, critical analysis citing the examples of polymers from which the sample can be constituted and the arguments, according to the result of each test. If it is not possible to identify the corresponding polymer, point out possibilities and present a conclusive result.

Results:_____

_____

_____

Keep up the good work!
Teacher Cibeli Garcia

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Worksheet No. 3

Learning Unit	Polymers - Bioplastic
Author	Cibeli Garcia e Alexandra Jales
School	FORAVE – Associação para a Educação Tecnológica do Vale do Ave
Date	

Production of biodegradable plastic from potato starch

Introduction:

It is almost impossible to think about our society without the use of plastics, therefore, an alternative to help minimise the problem of waste production is the production of biodegradable plastic, that is, one that is degraded by microorganisms present in the environment, converting it into simple substances that exist naturally in our environment, fully integrating with nature. Currently, there is already industrially produced biodegradable plastic, such as corn and potato starch (natural polymer) plastics, which are generally mixed with pure synthetic plastic at the time of production. Therefore, when this material is discarded, the starch will be degraded and tiny pieces of plastic will remain, causing less harm to the environment.

How to produce a biodegradable plastic from potato starch:

Materials and reagents:

- 4 potatoes;
- 4 tablespoons of vinegar;
- 4 tablespoons of glycerin;
- Water;
- Blender;
- Glass tub
- Filter paper;
- Funnel;
- Pan;
- Hot plate or stove;
- Food colouring in the colour of your choice;
- Container with a smooth, flat surface, such as a rectangular cake pan;
- Spatula.

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Worksheet No. 3

Experimental procedure:

1- Cut 4 potatoes;

2- Blend the potatoes in a blender with a little water;

3- Filter and add a little more water;

4- Leave it to rest;

5- After a while, potato starch will form, a white precipitate at the bottom of the container;

6- Separate the brownish liquid and leave only the precipitate;

7- Take two tablespoons of this potato starch and place it in a pan;

8- Add a glass of water, four spoons of vinegar, four spoons of glycerin and drops of dye;

9- Bring to a boil, stirring constantly and stop when a kind of “slime” forms;

10- Place on a smooth, flat surface and let it dry for a few days;

11- A biodegradable plastic will be formed that can be removed with the help of a spatula.

Chemical explanation of the process:

Amylopectin, which is a type of starch-forming molecule, has many branches, which makes it more difficult for its molecules to interact to form plastic. This is why vinegar (acetic acid or ethanoic acid) is added, which reacts with the starch, reducing its branches, which, in turn, are broken and partially transformed into amylose — linear starch molecules. Glycerin works as a type of lubricant that makes the plastic more malleable and elastic, as it will stay between the starch molecules, reducing interactions between them and thus acting as a plasticizing agent.

Keep up the good work!
Teacher Cibeli Garcia

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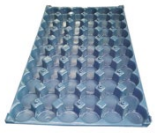
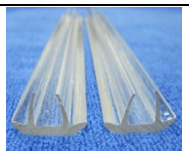
Worksheet No. 4

Learning Unit	**Polymers - Identification of polymer moulding processes**
Author	Cibeli Garcia
School	FORAVE – Associação para a Educação Tecnológica do Vale do Ave
Date	

1. State which moulding processes you would recommend for manufacturing:

Product	Process	Product	Process
			
			
			
			
			
			

Keep up the good work! ·
Teacher Cibeli Garcia

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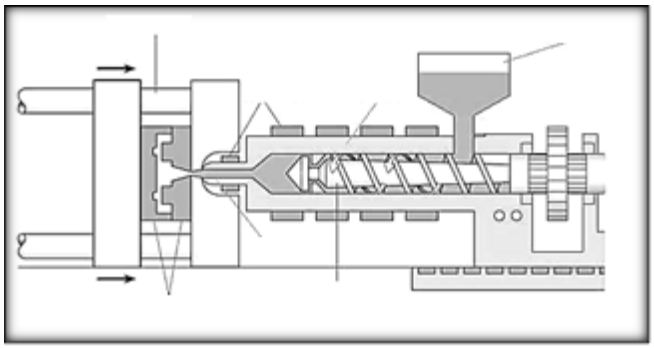
Worksheet No. 5

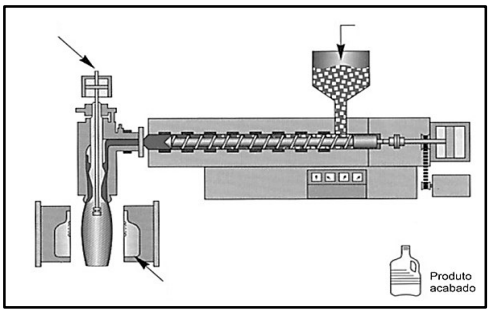
Learning Unit	Polymers - Polymer moulding processes
Author	Cibeli Garcia
School	FORAVE – Associação para a Educação Tecnológica do Vale do Ave
Date	

1. Identify the moulding processes in the diagrams below and give examples of parts produced by the moulding process:



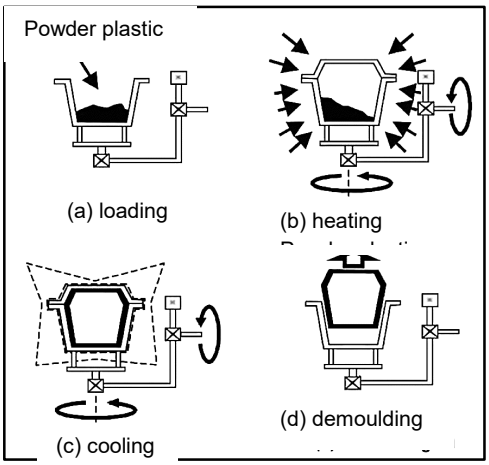
Moulding process name:
A:_____

Example(s) of part(s) produced by this moulding process:
A:_____



Moulding process name:
A:_____

Example(s) of part(s) produced by this moulding process:
A:_____



Moulding process name:
A:_____

Example(s) of part(s) produced by this moulding process:
A:_____

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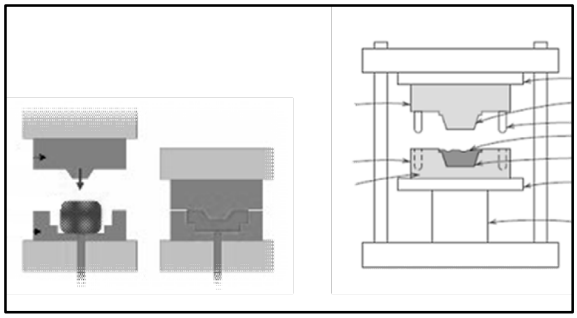
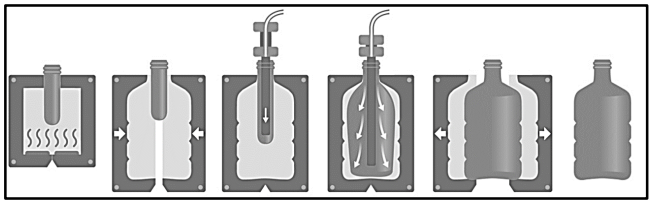
Worksheet No. 5



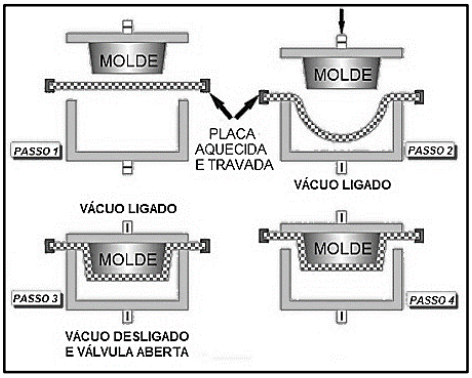
Moulding process name:
A:_____

Example(s) of part(s) produced by this moulding process:
A:_____



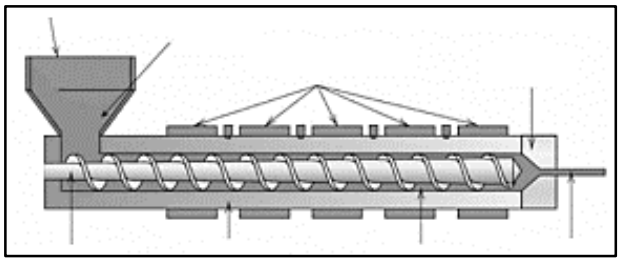
Moulding process name:
A:_____

Example(s) of part(s) produced by this moulding process:
A:_____



Moulding process name:
A:_____

Example(s) of part(s) produced by this moulding process:
A:_____



Moulding process name:
A:_____

Example(s) of part(s) produced by this moulding process:
A:_____

Keep up the good work!
Teacher Cibeli Garcia

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