

InjePro-Interactive Training in Plastics Injection Molding -

CONTENTS

Module 1 – “The Material”

1. Plastics and Polymers

2. Structure

- Concept of Molecules
- Polymer Molecules
- Monomers and Polymers
- The polymerization reaction
- The molecular weight of Polymers
- Distribution of Molecular Weight
- Branching

3. The Origin of Plastics

- Sources of Raw Material
- Production steps – from oil to finished products
- The production of the main types of plastics: Polyethylene, Polypropylene, P.V.C., Polystyrene.

4. Classifications of Polymers

- Thermoplastics, Thermosets, Elastomers.
- Amorphous and Crystalline Polymers.
- Homopolymers, Copolymers and Blends.
- Commodity Resins and Engineering Resins

5. Plastics and the Injection Molding Process

- Mains characteristics of plastics related to the injection molding process
- Melt flow index / Viscosity
- Mold shrinkage
- Temperature processing range
- Hygroscopicity

6. Rheology

- The flow of fluids / viscosity
- Influence of temperature on the viscosity of fluids
- The flow of plastics
- Newtonian and non-Newtonian Fluids
- Influence of melt flow rate (shear rate) in the viscosity of plastics
- Alignment of plastics molecules at high flow rates / viscosity reduction.

- Diagrams “viscosity x flow rate” for some resins.
- Viscosity reduction / mold filling
- Polycarbonate’s behavior
- Molecular alignment vs. Average Molecular Weight
- Molecular alignment vs. Molecular Weight Distribution
- Methods for measurement of rheological parameters
- Melt flow index vs. molding conditions: clarification.

7. Properties of Plastics

- Relation between the properties and types of plastics
- Choosing a resin for a certain application
- Influence of additives on the properties of plastics
- Main types of additives: antioxidants, flame retardants, impact modifiers, stabilizers, plastifiers, fillers, reinforcements, colors.
- Density
- Mechanical properties
 - Tensile strength
 - Compression strength
 - Flexural strength
 - Hardness
 - Impact resistance
 - Toughness
 - Rigidity
 - Abrasion resistance
 - Tear resistance
- Thermal properties
 - Melt temperature
 - HDT-Heat Deflexion Temperature
 - VICAT-Softening Point
 - Thermal conductivity
 - Specific heat
 - Thermal Expansion / Shrinkage
 - Thermal stability
- Electrical properties
- Optical properties
 - Transparent, translucent and opaque materials
 - Influence of material crystallinity on the transparency of plastics
 - Gloss, Haze, Clarity , Color
- Weatherability
- Chemical resistance
- Other properties
 - Combustion behavior
 - Permeability
 - Flexibility

8. Main types of Plastics:

- Outline of the main kinds of polymers. The following resins are described, along with their main characteristics, production processes, raw materials, properties and applications.
 - Polyethylene
 - Polypropylene
 - P.V.C.
 - Polystyrene
 - S.A.N.
 - A.B.S.
 - Polycarbonate
 - Poliurethanes
 - Polyamides
 - Acrylics
 - P.E.T.
 - E.V.A.
 - Acetal resins

Module 2: "The Injection Molding Machine"

1. Introduction

- History of injection molding machines
- Main sections: injection unit and clamping unit
- Main machine manufacturers
- Other sections of the machine: hydraulic system, electric/electronic system
- Auxiliary equipment: feeding systems, cooling, part removal equipment, etc.

2. The single screw injection molding machine:

- Function of the machine
- Location of the components of the injection section: hopper, barrel, screw, heating bands, valve, nozzle, drive motor, hydraulic cylinder
- Function of each component.
- Demonstration of machine operation

3. The injection section:

- Feed / hopper: manual feed, automatic feed, blenders, magnets, dryers, dehumidifying systems.
- Barrel: function, thermowells, barrel wall temperature, feed area temperature, barrel wall surfaces
- Heater bands: supply of heat to the material, location of heater bands, temperature zones, temperature control (microprocessors).
- Screw

- Functions
- Construction characteristics: flight, root, screw pitch, screw channel, flight land, flight depth.
- Screw Parameters: L/D ratio, compression ratio
- Processing zones: feed zone, compression zone, metering zone
- Mixers
- General purpose screw: characteristics
- Resin dedicated screws
- Screw's material of construction / finish
- Screw tip / non-return valve
 - Function of the screw tip
 - Types of tips: plain tip , tip with non-return valve
 - Plain tip: description and application
 - Tips with non-return valves: description and application
 - Non-return valves: function and positioning during the molding process.
 - Problems with the non-return valve related to the molding process.
- Nozzle
 - Function and location
 - Contact nozzle / sprue bushing
 - Nozzle temperature control
 - Types of nozzle: open nozzle, shut-off nozzle
 - Open Nozzle – types, description and applications: conventional nozzle, extended nozzle, reverse tapered nozzle.
 - Shut-off nozzle – types, description and applications: Spring loaded, Hydraulic nozzle.
- Screw drive motor
 - Function and types : hydraulic, electric drives
 - Coupling: direct, indirect
 - RPM and Torque
 - Electrical drive: features
 - Hydraulic drive: characteristics
- Hydraulic Injection cylinder
 - Functions
 - Injection of the material
 - Back-pressure

4. The clamping section

- Functions
- The clamping force
- Range of clamping force values
- Mold projected area, cavity pressure
- Parts of the clamping section: location and functions: platens, tie-bars, ejection system and clamping mechanism
- Platens

• Plas

- The stationary platen: function, locating ring, mold alignment with the nozzle.
- The moving platen: function, holes for ejector bars
- Mold mounting on the platens
- Tie-bars:
 - Functions
 - Tie-bar stretching
- Ejection system
 - Parts within the mold: knock-out plate, knock-out elements
 - Components in the molding machine: hydraulic cylinder, ejection plate and ejection bars
 - Function and location of each component of the ejection system
 - Demonstration: how the ejection system works.
 - Central ejector pin / Ejector bars
 - Types of ejection mechanisms: hydraulic / mechanical
- Clamping system
 - Types and description of clamping mechanisms: hydraulic, toggle.
 - Hydraulic system: demonstration on how it works.
 - Location of the various parts of a hydraulic system with central cylinder
 - Toggle system: location of parts, description and demonstration on how it works.
 - Comparison between the two systems.

Module 3: "Injection Molds"

1. Introduction

- Functions of the mold.

2. Mold Parts: function and location

- Description of a generic two-plate mold
- Mold halves: stationary and moving plates
- Mold parting line
- Sprue
- Runners
- Cavities and cores
- How the mold works
- Components of the mold stationary half: function and location
 - Locating ring, top clamp plate, sprue bushing, leader pins, cavity retainer plate, cavity inserts
- Components of the mold moving half: function and location
 - core inserts, core retainer plate, support plate, spacer blocks, ejector plate, ejector retainer plate, ejector pins, return pins, sprue puller, bottom clamp plate

- Mold cooling channels
 - Mold shutheight
- 3. Types of Molds:**
- Factors that influence the choice of a mold for a certain process
 - Two plate molds:
 - Description
 - Features
 - How it works
 - Advantages / disadvantages
 - Three-plate molds:
 - Features
 - Function and location of parts
 - How it works
 - Applications
 - Advantages/disadvantages
 - Hot runner molds
 - Features
 - The heated plate, manifold and nozzles
 - Heat supply and temperature control
 - How it works
 - Applications
 - Advantages / disadvantages
 - Insulated runner molds
 - Features
 - Parts of the mold
 - Large diameter runners, the insulating layer of material
 - Use of torpedos
 - How it works
 - Applications
 - Advantages / disadvantages
 - Stack molds
 - Description and function
 - Clamp tonnage required / projected area / productivity
 - Injection capacity
 - How it works
 - Rotating cores molds
 - Applications: threaded parts
 - Description of the rack and pinion mechanism
 - How it works
 - Molding with metallic inserts
 - Description of the process
 - Insertion of the metallic part
 - Vertical machines

- Crystallinity of resins / insert molding
- Recommendations for a good processing

4. Number of Cavities

- Multicavity molds: applications and advantages
- Mold filling variables in multicavity molds
- Single cavity molds: applications and advantages

5. Sprue and Runners

- Direct feed / indirect feed
- Sprue and runners: regrinding the material
- Sprue: taper, length and diameter
- Cold runner systems: characteristics
 - Length
 - Diameter
 - Shape
 - Balancing
 - Finish
 - Cold Slug / Sprue Puller
- Comparison between hot runner and cold runner systems

6. Gates

- Description and location
- Functions
- Gate location in thick sections of the part
- Gate location and weld lines
- Gate location and sink marks
- Gate location and jetting
- Multiple gates
- Types of gates: description, geometry and applications
 - Capillary Gate
 - Fan Gate
 - Film Gate
 - Disc Gate
 - Ring Gate
 - Submarine Gate
 - Tab Gate
 - Sprue Gate
- Advantages and applications of restricted gates

7. Ejection Systems

- Types of ejection mechanisms available
- Choice of a type for a certain application
- Knock-out plate based systems:

- Description
- How they work
- Ejection with pins: features, applications
- Ejection with blades: features, applications
- Ejection sleeves: features: location, applications
- Mold stripper plate:
 - Description
 - Application
 - How it works
- Air ejection
 - Description, application
- Rotating cores
 - Applications
 - Description
 - How it works
- Robots
 - Use of robots
 - Related costs
 - How it works

8. Cooling Circuits

- Introduction: function of the cooling circuitry, mold temperature, coolant
- Construction of cooling channels: cylindrical holes, copper tubes
- Location of the cooling channels: recommendations
- Spirals
- Baffles
- Bubblers
- Mold temperature and the type of material
- Effect of mold temperature on the molded parts
- Design parameters for the cooling circuitry
- Air cooling

9. Mold Venting

- The need for mold venting
- Defects resulting from bad mold venting
 - Short shots, burn marks, weak weld lines
- Mold venting methods
 - Vents on the mold parting line
 - Porous metal plate
 - Venting through ejectors

Module 4 - Processing

1. Interaction Material / Machine / Mold

- 1.1. Feed of material into the hopper
- 1.2. Melt flow along the barrel
 - 1.2.1. Feed zone
 - 1.2.2. Compression zone
 - 1.2.3. Metering zone
- 1.3. Injection of the Material
- 1.4. Packing
- 1.5. Part ejection
- 1.6. Part inspection

2. Main Operational Parameters: Times, temperatures and pressures

- 2.1. Times: Mold closing time, Injection time, Packing time, Cooling time, Mold opening time.
- 2.2. Temperatures: Temperature of the material fed into the barrel, Barrel zone temperatures, Nozzle temperature, Mold temperature, Room temperature.
- 2.3. Pressures: Injection pressure, packing pressure, ejection pressure, back-pressure.

3. The molding cycle:

- 3.1. Phases of the injection molding cycle: mold closing, injection of the material, packing, part cooling, mold opening, part ejection.
- 3.2. Cycle time: how it relates with productivity
- 3.3. Variables that interfere in cycle time.

4. Mains steps of the injection process

- 4.1. Mold closing: Displacement of the platens, mold clamp-up, mold safety.
- 4.2. Carriage travel forward: Applications. Nozzle forward time, nozzle forward speed, nozzle pressure on the sprue bushing
- 4.3. Injection of the material. Parameters: time, speed, pressure.
- 4.4. Packing of the material. Parameters: time, pressure. Importance of the packing stage. Cushion.
- 4.5. Material Plastication. Back pressure, RPM, shot size. Importance of these parameters.
- 4.6. Decompression. Applications. Description.
- 4.7. Carriage travel backwards: Applications. Parameters.
- 4.8. Part cooling: importance of the cooling stage. Defects that may result from a poor cooling.
- 4.9. Mold opening: Parameters. Opening speed. Mold open position.
- 4.10. Part ejection: Parameters: speed, time and ejection pressure.

Module 5: "Machine and Mold Setup / Start-up"

1. Mold Installation

- Shutheight adjustment
- Measurement of mold width
- Ejector bar setup
- Procedures for lowering the mold safely
- Attachment of the mold to machine platens
- Procedures for levelling the mold
- Mold faces alignment
- Attaching ejector bars to the ejector plate

2. Machine Setup

- Setup sheet: main characteristics. Part information. Raw material data. Machine Specifications. Mold construction characteristics. Mold temperatures and pressures.
- Connecting cooling water hoses to the mold. Cooling water temperature, flow rate and pressure.
- Warming up the hydraulic oil
- Setting up barrel temperatures
- Setting up mold closing speeds and positions. Mold protection.
- Clamping force adjustment
- Cooling time setup
- Mold opening speed and position.
- Part ejection: ejector's stroke, speed and pressure. Repetitive ejection.
- Injection of the material. Setting up shot size, injection speed, pressure and time.
- Material packing: Setting up pressure and time
- Material plastication: Adjustment of Screw back position, back pressure and screw RPM
- Setting up parameters for Decompression and Carriage travel backwards / forward.

3. Machine Start-up

- Purging the barrel
- Inspecting mold cavities
- Starting the hydraulic motor
- Adjusting shot size
- Starting the cycle
- Inspecting the mold and parts
- Switching to "auto-cycle"
- Part quality control

4. Machine Shut-down: General procedures

Module 6: "Molding Defects"

- Troubleshooting approach.
- Main types of molding defects: outline, examples, possible causes and possible solutions.
 - Short shots
 - Flash
 - Delamination
 - Burn Marks
 - Sinks
 - Voids
 - Warpage
 - Parts sticking to the mold
 - Sprue sticking
 - Flow marks / record grooves
 - Black specks
 - Brittle parts

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