AVOIDING THE NONCONFORMITIES IN THE PLASTICS INJECTION PROCESS

Ana-Maria OLTEANU [1],
Dana TILINĂ [2],

Rezumat. *În cadrul acestei lucrări este prezentat procesul de injecție a maselor plastice din punct de vedere teoretic, de la injectarea materiei prime, până la obținerea produsului finit, precum și identificarea factorilor care influențează modul de desfașurarea a procesului, ducând la apariția neconformităților. Dacă organizațiile doresc să aibă succes, acestea trebuie să se adapteze rapid la condițiile de schimbare într-un mediu competitiv. Organizația trebuie să fie flexibilă și să poată rezolva rapid problemele care apar. Pentru a rezolva aceste probleme se folosesc diverse instrumente și metode. Una dintre aceste metode este 8D, care în esență este un proces standardizat, cu accent pe fapte, ce contribuie la îmbunătațirea produselor și proceselor. Această metodă permite rezolvarea problemei la timp si corect.*

Abstract. *Within this paper is presented the process of plastic injection from a theoretical point of view, from the injection of the raw material, to the obtaining of the finite product, as well as the identification of the factors that influence the process, leading to the appearance of nonconformities. If the organizations want to be successful they must quickly adapt to changing conditions in a competitive environment. The organization must be flexible and be able to quickly solve occurring problems. To solve these problems are used various tools and methods. One of these methods is 8D, which is essentially a standardized process, with an emphasis on facts, it also serves to improve the products and processes. This method allows solving the problem on time and correctly.*

Keywords: moulding process, injection moulding machine, nonconformities, 8D method

1. Introduction

If we look closely at the surrounding things, it is hard to find an object that is not related to the plastics industry, whether it is toothbrushes, photo lenses, contact lenses, medical equipment or even cars.

The plastics industry has grown considerably over the last 50 years [1, 2] due to the diversity of production, becoming one of the most important industries in the world. The volume of parts manufactured is large, of good quality, at the lowest

[1]Master CMP student, University POLITEHNICA of Bucharest, Spl. Independentei 313, zipcode 060042, Bucharest, Romania, e-mail: anamaria.staicu95@yahoo.com
[2]PhD, Eng., Lecturer, POLITEHNICA of Bucharest, Robots and Production Systems Department, Spl. Independentei 313, zipcode 060042, Bucharest, Romania, e-mail: dana.tilina@upb.ro

prices and with the lowest production time. One of the most used processes for the production of plastics is the injection process.

At the moment, plastics production plants operate in principle with hydraulic injection machines, but this situation is changing with the development and introduction of full-electric (total electric) injection machines. Full-electric injection machines present new opportunities in the plastics industry, not only because of their repeatability and precision but also for their special functions. These technological improvements target the two key factors of profitability: the quality of the product and the duration of the production cycle, the reduction of the cycle time leads directly to the increase of profitability and return on investment.

The quality is a set of characteristics of a product or service, which gives it the ability to satisfy, expressed or implied needs. [3] According to this definition, quality is not expressed by a single characteristic, but through a set of characteristics, which varies continuously in relation to customer needs. Measurements, analysis and monitoring are permanent actions related to the supervision and improvement of the entire activity of the company, among other things, purchases, product manufacturing, delivery to the customer, after-sales service.

The characteristics that define quality are affected by many factors, which act especially during the injection process, causing deviations that affect the quality. The 8D method is an effective method for identifying problems, analyzing causes, developing creativity, decision-making and planning actions that generate performance and productivity.

2. Injection process

The injection process consists of bringing the thermoplastic polymer mixture into plastic, followed by placing it under pressure into a mould relatively cold in which it passes into a solid state.

Almost all macromolecular compounds, both thermoplastics and thermosets, can be processed by injection. Thermoplastics such as polyethylene, polypropylene, polystyrene, vinyl chloride, polyamide, ABS, etc. are commonly used.

2.1. The description of the optimal injection flow

The production process of plastic parts is a continuous flow process, built from a series of operations:

- Operation 1 - supply of raw material: the raw material consists of plastic granules; it is purchased from producers or distributors and stored in the raw material storage, from which it is transferred to the supply zone for the injection process;

- Operation 2 - supply of material: from the supply area, the raw material is directed using an automatic installation of transport at the injection machines.

- Operation 3 - plastic injection: this is the basic operation of the technological flow. The granules of plastic material is melted in the injection machine, and then injected under pressure into a cooled mould, resulting the finished parts. Mould cooling is done with cold water from the central cooling system. The defects resulting from the injection process are granulated again in mills and are reintroduced into the injection process;

- Operation 4 - quality control of injected parts: the injected parts are qualitatively checked in the CTC production area, after which they are transferred to the assembly area or directly to the finished parts storage;

- Operation 5 - assembly/packaging: the operator assembles finished part according to customer's requirements in the area of the assembly. The packaging operation for the assembled parts is followed, which is performed custom in the packaging room/area;

- Operation 6 - quality control assembled parts: the parts assembled and packaged in the packaging area are checked qualitatively and quantitatively in the assembly quality control area, after which the parts are transferred to the finished parts store;

- Operation 7 - storage: Finished parts are stored in the finished parts storage area for delivery;

- Operation 8 – delivery: Finished parts are delivered to customers, depending on the order entered/ recorded. Delivery is made by means of rented transport or by means of customer transport.

3. Appearance of the nonconformities in the injection process

The injection process depends on a large number of factors, which can lead to a wide range of nonconformities (flashes/excess material, points of different colors - contaminated material, traces of burns, holes, bubbles, deformation, etc.). Defects are caused by errors that occur during two important processes: the injection process and the part design process. Different tools and methods of analysis are used to resolve and eliminate any nonconformity that occurs in the injection process. One of these methods is 8D, which is essentially a standardized process, with an emphasis on facts, it also serves to improve products and processes. The method focuses on the origin of the problem and determines its root cause.

The main benefits of the 8D process problem solving are given by:

- quickly identifying the root causes and development of actions to eliminate the main causes and implementation of permanent corrective measures;
- improvement the ability to detect the source elements of the problems;
- establishing a system of good practice to prevent recurrence of problems [8].

Method 8D consists of 8 steps. These steps are:

D1 –establishment of the multidisciplinary team. The purpose of this step is to establish a team with adequate knowledge about the product or process and experience in the technical areas necessary to solve the problem and remedial action.

D2 – problem description. This step identifies the problem that needs to be solved and specifies the quantifiable parameters in detail.

D3 - the implementation of a temporary solution. The application of this step depends on the nature of the problem. Its purpose is to establish and verify a rescue measure that would prevent the problem from affecting the customer.

D4 - identification of the root cause. The purpose of this step is to identify the root cause. There are a number of methods that make it possible to determine the root cause.

D5 - Permanent corrective actions. The essence of this step is to select the best permanent corrective action to eliminate root cause.

D6 - Implementation of permanent corrective actions. The purpose of this step is to plan, implement and validate the selected permanent corrective actions. If they have been implemented, interim protective measures are usually required before the implementation of permanent corrective actions to remove these temporary measures.

D7 - Prevention of reoccurrence. This step lists the changes, operations, and procedures necessary to prevent the problem from reoccurring.

D8 - Appreciation of the team!

The analysis presented in this article was performed for a disposable knife product. The material used to make it is polystyrene.

During the injection process, the operator has noted the presence of a flash (as shown in fig. 1 a.), this excess material was present at the injection point of 3 cavities, the mould having 18 cavities (according to fig. 1 b.). The visual defect found is shown in the check sheet (according to table 1), which is in the documentation for this marking. After detecting the fault, the operator applied the reactivity rule when defects occurred (according to table 2). He identified the defect, isolated the non-compliant parts, recorded them in the production record table and announced the shift leader. The shift supervisor first announced the adjuster, which attempted to eliminate this defect by changing the injection parameters, but failed, an 8D analysis will be carried out to detect the cause of the fault.

Fig. 1 a. Flash

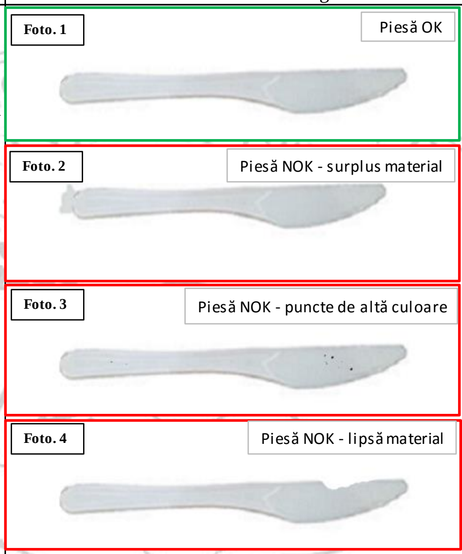
Fig. 1 b. Mould

Table 1) Reactivity rule

REACTIVITY RULE									
QUALITY - FAULTY TYPE	STEP 1: FAULT IDENTIFICATION - OPERATOR-	STEP 2: PRODUCT INSULATION NOT CORRECT - OPERATOR-	STEP 3: FAULT RECORDING - OPERATOR-	STEP 4: FAULT REPORTING - OPERATOR-	STEP 5: STOP PRODUCTION DECISION - LEADER-	REACTIVITY SCHEME INFORMATION FLOW - REPORT NON-CONFORMANCE			Reactions to the product and/or process
Lack of material	Individual marking with red marker on the parts with the type of nonconformity	Insulation of defect parts in the red box	Production register table	Leader notification	Production record target overflow	OPERATOR →	LEADER →	ADJUSTER LEADER PRODUCTION QUALITY RMP	**QRQC** (quick response quality control)
Flash									
Deformations									
Cracks									
Pipe (holes from uneven solidification)									
Points									
Stains									
Dropped parts									
New defects									

Table 2) The verification sheet

Logo	The verification sheet			Card No. / date:	001/06.01.2020	Service index/ date:	Frequency of verification/responsible	
	Name	PS knife - White	Part number	1007-100	Customer	100%	1 inj. / 4 hours	1 inj. / 2 hours
						Operator	Leader	CTC

Side	Operation name:	Diagrams / Photo	
	Injected Part: Check the entire surface of the part photo 1 Not supported: burrs and/or material missing traces of water, reshinings (deformation on the part surface), stains and/or scratches, burn marks, pigments of other color on the part, Non-conforming NOK packaging (crease, loose, workpiece placement), material overruns and/or injection point breaks; impurities in material;		Parts OK (correct quality parameters) NOK parts (shows nonconformities)
Done:		Approved:	

VS. 0	THE INSTRUCTIONS CONCERNING WORK ON PLASTIC INJECTION MACHINES MUST BE OBSERVED	THE FAULT REACTIVITY RULE APPLIES
Symbols	Visual	Manually

A team of five people (D1) with technical experience was formed to perform this analyse Quality Manager (the team leader), Production Manager, Maintenance Manager, Quality Analyst and Technologist.

D2 - during the injection process the operator has noticed a flash at the injection point. The product has followed the manufacturing process steps properly, the cause of the defect being the injection mould - not following the maintenance plan.

D3 - due to the maximum urgency for this order, the first solution was to remove the flash by the operator, only for this batch.

D4 - the main cause of this nonconformity is the wear of active part of the mould.

5 Whys was used to identify it, as shown in the following table:

Table 3. 5 Whys

5 WHYS - ANALYSIS				
PROBLEM DESCRIPTION: **Flash**		**Root cause:** Injection moulding machine [ ]; Mold [X]; Environment [ ]; Method [ ]; Operator [ ]; *Logistics (Packing) [ ]; Material [ ]; *Supplier [ ]; N/A (Suspendat) [ ]		
Why 1 - Why the burr appeared	**Why 2 - Why the wear was not been spotted**	**Why 3 - Why level 2 maintenance was not performed**	**Why 4 - Why was it decided that injection should continue**	**Why 5 - Why the delivery deadline has not been postponed**
Wear of active plaque (plate)	Because level 2 maintenance was not performed	The maximum number of injections allowed has been reached during the order	To comply with the delivery deadline	After completing the command, the injection machine would produce another part mark.

Five whys (or 5 whys) is an iterative interrogative technique used to explore the cause-and-effect relationships underlying a particular problem. The primary goal of the technique is to determine the root cause of a defect or problem by repeating the question "Why?". Each answer forms the basis of the next question [10].

D5 - The permanent corrective actions for eliminating the nonconformity are:

- welding to reduce the injection point,
- sanding of the welding of the supply area;
- final polishing in the welded area;
- mould fitting, mould close check, and remove any flashes.

After the order for this part is completed, 09.04.2020, the mould was transferred to maintenance to correct the cause of the defect. The rectifying mould was received on 11.05.2020, the product is scheduled for tests. No flash was found after the tests, thus the mould is ready for the next order.

D6 - For level 2 maintenance monitoring, the production manager must establish a maintenance record that allows him to warn of 5000 injections before the maximum number of injections allowed until the next order (30000).

D7 - In order to prevent reoccurrence, the production manager shall be required to check the maintenance record after completion of each production batch.

Thank the team for the results they achieved (D8)!

The completed 8D report form is shown in the table below:

Table 4 8D Report

Logo	**8D - REPORT**			8D Nr. 1	
Supplier	-	Data Notified	07.04.2020		
Location	-	Initial Response	07.04.2020		
Part No.	1007	Target Close Date	18.04.2020		
Product Name	Knife	Actual Close Date	18.04.2020		
D1 - SUPPLIER TEAM MEMBER NAMES		**D2 - PROBLEM DESCRIPTION**			
Team Leader	Quality Manager	What happened	Flash		
Team Members	Production Manager	Who detected	Operator		
	Maintenance Manager	Where	During the production process		
	Quality analyst	When	In the current batch		
	Technologist	Why	The maintenance plan was not followed		
		How Much	9		
D3 - IMPLEMENTING CONTAINMENT ACTIONS				Target Date:	Actual Date:
ICA	Continue the injection process and the operator must remove the flash			09.04.2020	09.04.2020
D4 - IDENTIFY PROBLEM ROOT CAUSE					
Why 1	Why the flash occure				
Why 2	Why the wear of the active part was not detected				
Why 3	Why level 2 maintenance has not been achieved				
Why 4	Why it wasn't done in time				
Why 5	Why the injection continued				
Root Cause	General maintenance failure to achieve				
D5 - PERMANENT CORRECTIVE ACTIONS					
Corrective Action Plan			Resp. by		
Mold interventions: - welding to reduce the injection point - sanding of the welding of the supply area - final polishing in the welded area - mold fitting, check mold closure and remove any flash			Maintenance Manager		
D6 - IMPLEMENT PERMANENT CORRECTIVE ACTIONS					
Corrective Action Plan		Resp. by	Target date	Actual date of Completion	
A maintenance record that monitors the number of injections of each mold. Warning of 5000 injections before maximum number of injections allowed until next maintenance (30000).		Production Manager	08.04.2020	08.04.2020	
D7 - PREVENT RECURRENCE					
Preventive Action Plan		Resp. by	Target Date	Actual date of Completion	
Checking the maintenace record after completion of each production batch.		Production Manager	After completion of each production batch	Permanent	
Dic. Review: [x]	Control Plan [ ]	Flowchart [ ]	Work Instr. [ ]	Add to Internal Audit	
D8 - TEAM AND INDIVIDUAL RECOGNITION					
Congratulations to the team!					

Conclusions

The plastics industry has developed considerably over the last 50 years [1, 2] due to the diversity of production, it is considered one of the world's most important industries. The volume of parts produced is high, of good quality, at the lowest prices and with the lowest production time. One of the most used processes for the production of plastics is the injection process.

The injection process is a cyclical phenomenon consisting of bringing the thermoplastic polymer mixture into the plastic state, followed by placing it under pressure in a relatively cold mould in which it passes into a solid state. This process depends on a large number of factors, which can lead to a wide range of non-conformities. A problem occurred during the injection process that has the mould as root cause was highlighted in this Article. The 8D method was used to eliminate this defect, which is essentially a standardized process with an emphasis on facts, which helps improve the products and processes.

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