TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics, Mechanics, and Engineering
Vol. 58, Issue IV, November, 2015

FAILURE MODE AND EFFECT ANALYSIS FOR MOLD DESIGN

Călin NEAMȚU, Ștefan BODI, Rareş Adrian GHINEA, Attila PAPP

Abstract: *Molds for plastic injection are complex products with many components that require careful design of the components of the subassemblies. The injection process of the plastic components is complex, with many variables that require adjustment of the process parameters in accordance with the mold and injected material. The paper proposes using Failure Mode and Effect Analysis in order to identify the situations in which a mold for plastic injection may produce scrap components.*
Key words: *Mold design, Failure mode and effect analysis, mold optimization*

1. INTRODUCTION

Today's competitive industrial environment continuously raises the expectations of customers and drives the development of highly complex products that meet end user requirements with minimum costs. The Failure Mode and Effect Analysis (FMEA) method provides a possible approach to tackle this issue because it helps to prevent defects that lead to nonconforming products, thus greater costs. By applying FMEA the defect identification is shifted from the product control phase to the product design phase, as it can be seen in the following figure:

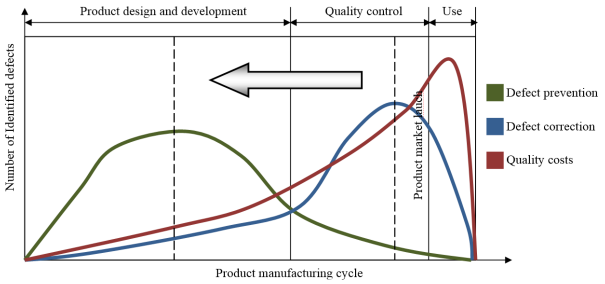

Fig. 1 Identified defects using FMEA [1]

Moreover, alongside reducing defects after manufacturing and minimizing costs, FMEA can also be used as a risk assessment tool for facilitating decision making [2].
Considering the above mentioned advantages and others that this method offers, its application ranges from the automotive industry [3],[4] , to the electronics industry [5], or even to the healthcare industry (Bonfant & et al, 2010)
The present paper aims to study the impact of applying FMEA to mold design by illustrating a case study for improving the functionality of an industrial mold used for plastic injection.

2. FMEA

The working methodology involves designing a mold for the component shown in figure 2 – polystyrene plastic anchor. After completing the design, the mold will be physically built, also a FMEA analysis will be done in parallel in order to verify whether the method can point out any problem that may arise from its use.

Fig. 2 Polystyrene plastic anchor

For the FMEA analysis were taken into account the following components of the mold:
The filling system – given that the design of the mold was made taking into account a series of simulations of the filling process, the analysis

will take into account only those unpredictable situations that cannot be simulated.

The cooling system – the correct functionality of the cooling system leads to obtaining components at the desired quality standard, its dimensioning was made analytical, the results were verified using the Moldflow solution. Same as with the filling system only those situations that cannot be verified through calculus or simulation will be taken into account.

The closing system - will consider those elements that may prevent the correct closing of the mold.

The throw system – will consider situations that could lead to system blockage and the impossibility of removing the components from the mold.

Parameter - in this category will take into account the parameters that influence the cycle time.

Design - the designing of the mold was made taking into account all the recommendations and good practices in the field; will analyze possible defects that may occur because of design elements, nests and the filling system.

Polistyrene Plastic Anchor Mold — **Design FMEA (UK)**

FMEA Reg. No: dibluri	Part No: 1582-12 v4	Model Year(s)/Vehicle(s): 2015	Rektron AB
Function: Plastic Anchor	Drawing No: 1582-12	FMEA Status: Ej Ok	
Customer: Proeli	Created by:	Created: 11/9/2015	
CoreTeam:	Rev. No./Sign:	Rev. Date	
Key Date			

Item / Function	Failure mode	Effect(s) of failure	S	Cl	Cause(s) of failure	Po	Current Control	Pd	RPN	Recom. Actions	Responsible & Completion	Action(s) taken & Completed	S	Po	Pd	RPN
(1) Mold Filling Sistem	The mold does not fill properly	Molded parts are not completely	8	FF	Incomplete closing of teh mold cavity	4	Changing the clamping force	3	96	Check the clamping force and the interval of closing force of the injection machine	Design engineering	Check the clamping force and the interval of closing force of the injection machine 11/9/2015	2	2	2	8
					Incorrect distribution of the melt plastic	5	Re-design the cavity space of the mold	5	200	Checking buckling pin, modifying them and adding extra support	Design engineering 11/15/2015	An extra support was addet on the top of the pin	3	2	2	12
(2) Cooling system	The part is deformed	The pin of the polistyrene plastci anchor can not be mounted	6	FF	Insuficient plastic was injected in the mold cavity	2	New value for injection presure	1	12							
					Insuficent colling	4	The part will be keep more time in the mold cavity	6	144	Reducing coolant temperature Increase the cycle time	Operator of the injection machine	Reducing coolant temperature 11/15/2015	6	4	6	144
	The production cycle is to long	The productivity of the mold is affected	8	FF	Undersizing colling system	7	Re design of colling system	2	112							
					High temperature of the collant	4	Reducing the temperature of collant	4	128	New injection set of parameters	Injection machine operator	New injection set of parameters	3	2	4	24
(3) Closing system	The plastic blown through the plane of separation	Mold can not be kept sealed during the filling cycle - maintain	7	D	The pneumatic cylinder is under dimensioned	7	Increse the power of pneumatic cilynder	4	196	Simulation of internal forces from mold using FEA	Design engineering	Simulation using FEA	2	2	4	16
	The part in not simetycal	Part is rejected	7	FF	Pins is deformed by injected plastic	5	Decrease the injection presure	3	105							
(4) Ejection sytem	The system can be block	The part is not ejected	8	FF	The part is block in the cavities	4	Re-design the part injected in order to incerse draft angle	3	96							
					The injected plastic block the mold moving parts	5	Revision of the filling system	3	120							
(5) Injection parameters	Presure ins not proper set	Part is incomplete or the mold cnanot be keep sealed	4	FF	Injection parameters is not proper set	4	Revision of the injection parameter	2	32							
	The cycle time is to long	The productivity of mold is reduced	4	FF	Injection system or colling system is not set properly	2	Revison of the parameters	1	8							

Fig. 3 FMEA

3. RESULTS

A mold with 8 nests was designed for the product polystyrene plastic anchor (figure 4). The design solution Moldflow was used in order to verify through simulation the following:

- correct cavities form – Design Adviser
- optimum parameters for the injection process - Molding Window,
- the position of the injection spot – Gate Location
- the filling of cavities - Fill analysis
- the quality of the cooling system : Colling
- runner - Runner Balance
- simulation of the quality of the obtained components - Warp

All results were used in the mold design process using Catia V5; after physically creating the mold, figure 5, it was tested using a molding machine type Haitian Mars 2-2500.

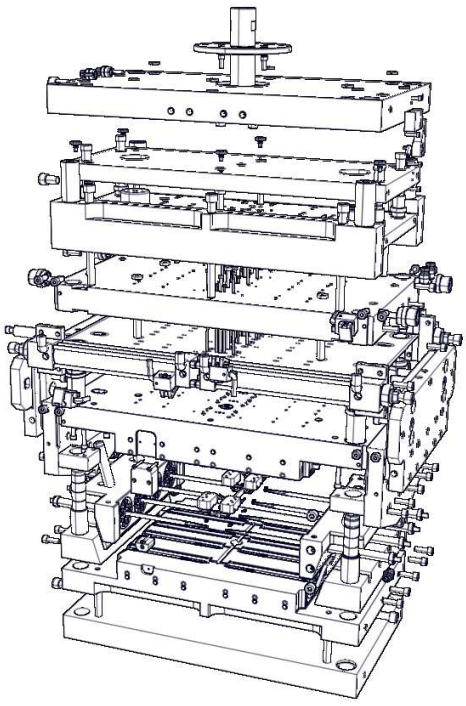

Fig. 4 Mold with 8 nests for the polystyrene plastic anchor

Fig. 5 Mold mounted on Haitian Mars 2-2500

The initial adjustment of the optimal operating cycle of the mold was carried out with the following parameters: injection pressure - 75MPA, holding pressure – 60 MPA, holding duration – 12 s, total duration – 32 s.
After several tests, at 85 MPA pressure, the apparition of a ring on the anchor's head was observed in some cases due to leaking of melted material from the nest through the boundary (fig. 5).

Fig. 6 The occurrence of a defect at the head of the anchor

This is due to insufficient pressure of the pneumatic cylinders that close the mold in the anchor head area.
Another problem detected is the incomplete injection of the anchor (fig 7), it also appears in a situation where the material ring does not show at the anchor's head.
Analyzing the material distribution (figure 7 – there can be seen a greater thickness of material on the right) it has concluded that at certain pressure and injection speed values the mold's pin that allows obtaining the opening inside the anchor buckles and thus loses its coaxial position with the walls of the cavities.

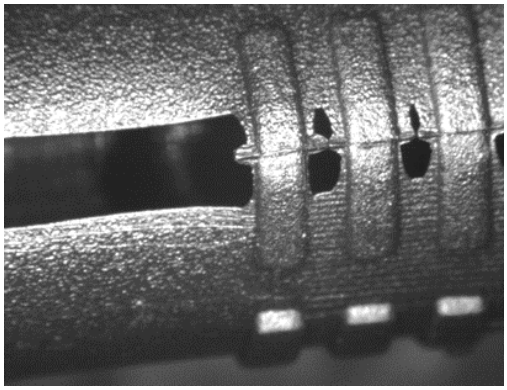

Fig. 7 Incomplete anchor

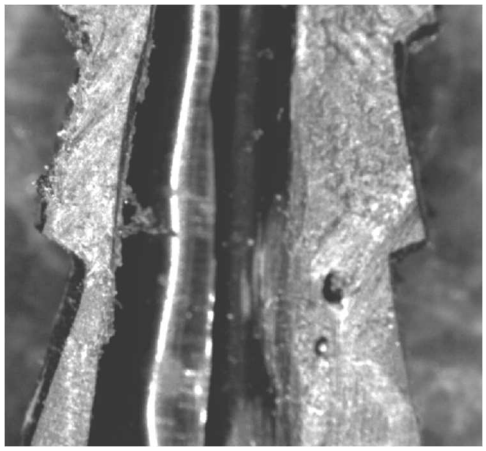

Fig. 8 Material distribution in the incomplete anchor

The effectiveness of the cooling system was investigated using a thermal imaging camera (figure 9).

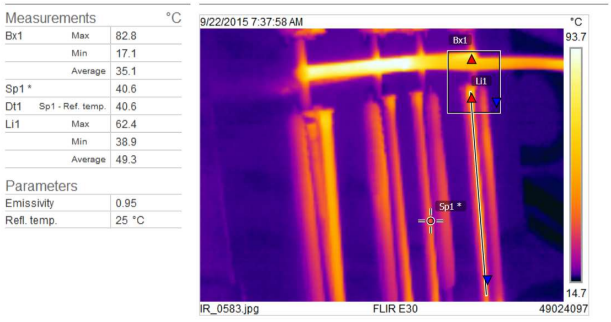

Fig. 9 Mold temperature when opening it

It was determined that temperatures obtained in the simulation and the actual injection process do not differ more than ± 3 °C.

4. CONCLUSION

Using FMEA can identify some of the possible defects that may arise when working with a

mold. Proper use of this tool can mitigate risks that arise when using the mold but will not identify all situations which can occur.
The level of specialization of the team performing the FMEA analysis in the design stage can lead to success or failure of using this method.

5. ACKNOWLEDGEMENT AND DISCLAIMER

This paper has benefited from the support of the project "Cercetare pentru proiectarea si realizarea de repere din mase plastice pentru industria mobilei", contract no. 12.P01.001 11 C1, beneficiary Proeli Concept SRL Cluj - Napoca, partner Technical University of Cluj - Napoca. The project is part of the Competitiveness Pole 12 P01 001 "Transylvanian Furniture Cluster" financed through the Sectorial Operational Program "Increase of Economic Competitiveness 2007-2013" by the European Regional Development Fund. This publication reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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Analiza modulului de detectare pentru o matrita

Rezumat: *Matriţele pentru injectat mase plastice sunt produse complexe cu foarte multe componente care necesita o proiectare atenta a subansamblurilor componente. Procesul de injecţie a pieselor de plastic este unul complex cu multe variabile care necesita o reglare a parametrilor de proces in concordantă cu matriţa si materialul injectat. Lucrarea propune utilizarea Failure Mode and Efect Analysys pentru a identifica eventualele situaţii in care o matriţa pentru injectat mase plastice poate produce piese rebut.*

Călin NEAMŢU, Associate Professor, Technical University of Cluj-Napoca, Department of Design Engineering and Robotics, calin.neamtu@muri.utcluj.ro
Ştefan BODI, PhD student, Technical University of Cluj-Napoca, Department of Design Engineering and Robotics, stefan.bodi@muri.utcluj.ro
Rareş Adrian GHINEA, PhD student, Technical University of Cluj-Napoca, Department of Design Engineering and Robotics, rares.ghinea@muri.utcluj.ro
Attila PAPP, PhD student, Technical University of Cluj-Napoca, Department of Design Engineering and Robotics, attila.papp@magic-engineering.ro