METHOD FOR OBTAINING AN EJECTION MAP IN INJECTION MOLDED PARTS

Mercado-Colmenero, Jorge Manuel; Rubio-Paramio, Miguel Angel; Martin-Doñate, Cristina

1) Department of Engineering Graphics, Design and Projects, University of Jaen, Spain

cdonate@ujaen.es

ABSTRACT

In this paper, a new methodology for automated geometrical layout localization and dimensioning of the ejection system elements of a plastic injection mold is presented. The proposed method focuses on an analysis of the discretized geometry of the plastic part. Thus, a nodal quadrature on the part surfaces belonging to core plate is generated. Then, the map of the ejector pins on the plastic part surface is obtained by means of the analysis of variations in the part thickness and the distance between nodes of the quadrature and the vertices of the original mesh. To conclude, the dimensioning of the optimal ejection system is performed through a genetic algorithm. This new method does not require heuristic techniques to achieve its goal and does not employ features as a tool for the geometrical recognition of the surface of the plastic part, avoiding the problems of dependency from the CAD modeller. The proposed methodology provides the cartesian coordinates, diameter and ejection force of each ejector pin. The results can be exported and used in others CAM/CAE applications.

KEYWORDS: Computer Aided Design, Injection Molding, Ejection System, Genetic Algorithm

1. INTRODUCTION

Injection molding is one of the most used manufacturing processes in thermoplastic parts. This process begins with the injection of molten thermoplastic into the cavities of the injection mold. The solidification and compaction of the material are the next steps in order to obtain the required geometry. Finally, when the part reaches the necessary stiffness to be ejected from the mold, the ejection mechanism extracts the part from the cavity to which it adheres. After that, the mold is closed again and the injection cycle begins again.

Currently, the layout of the ejector pins is achieved based on the experience of the mold designer. To avoid damage by the collapse of the material or excessive deformation of the plastic part, designers tend to use an oversized number of ejector rods which increases the complexity and cost of the mold, reducing the effective area for the cooling system and thus the efficiency of the energy exchange between the cooling system and the cavity.

To face these problems, authors propose the application of a new methodology for the automation of the design of the ejection system of the plastic injection mold. The automated algorithms generated during the research improve the efficiency of the designers of injection molds to achieve the system given a plastic part. Accordingly, the time of interaction between product designers and mold designers and the validation time of the manufacture of the plastic part are significantly reduced.

2. BACKGROUND AND RELATED WORKS

The ejection system design and dimensioning is a complex process in which geometric, functional and technological parameters must be taken into account. For instance, the ejection force, the shrinkage of the part after its solidification, the cooling temperature and the draft angle of the part.

Authors have focused their research to develop empirical analytical equations for estimating the force required for ejecting the plastic part from the cavity. Malloy et al. [1] established the variables related to the ejection process of the plastic part. They presented the problems associated with the analysis of the ejection force, and obtained the analytical value of the ejection forces. Bhagavatula et al. [2] focused the ejection of industrial parts molded by means of plastic injection molds. They compared the simulation of their physical model with the experimental results. O. Kazmer et al. [3] approaches theoretically the dimensioning problem of ejection system, proposing an analytical model based on the geometry of the plastic. Furthermore, location requirements of ejector pins were defined. Kwak et al. [4] proposed a method for determining the distribution and size of the ejector pins required to eject the thermoplastic molded part, minimizing the deformation of the part and the damage on its surface. The method calculates the distribution of the ejection forces required to overcome the friction between the plastic part and the mold. However, the algorithm uses heuristic methods to achieve the fine adjustment of the result. This article summarizes the research work developed focused on a new algorithm for automated design of the layout and the sizing of the ejector pins.

3. METHODOLOGY

This algorithm consists mainly of three phases. In the first phase, the geometry of the part belonging to the core plate is discretized by a nodal quadrature. Each generated node contains information about its coordinates and the thickness of the part for that location.

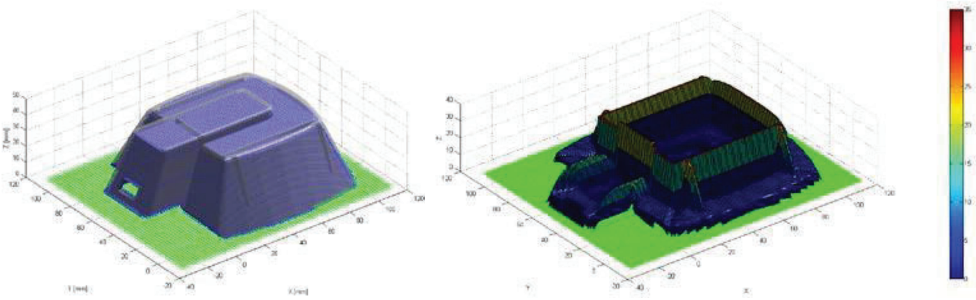

Figure 1. Discretization of geometry using a nodal quadrature and thickness map in millimeters.

During the second phase, a geometric recognition is performed to evaluate the changes of thickness that occur in the piece. These represent the final location of the ejection pins of theplastic part. Usually, plastic part regions with thickness change concentration indicate the location of turrent, corners, ribs, etc. In other words, regions with ejection resistance and adherence between the part and the mold.

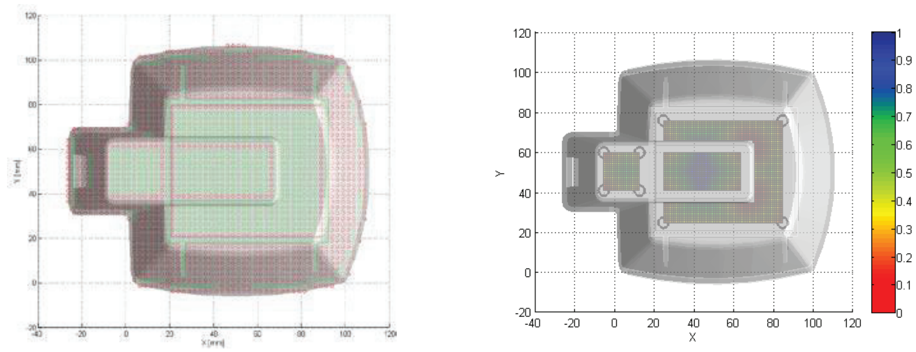

Figure 2. Nodal quadrature segmentation (Green nodes represent thickness changes) and location of ejection pins on ejection map.

Finally, a multi-objective genetic optimization algorithm that allows a balanced and uniform sizing of the ejection system, without compromising the structural safety of the plastic part is proposed to use. The developed method improves the above given that it does not use heuristic methods to obtain results, avoiding design evaluation once the physical product has been made. It does not use the procedure of features recognition, avoiding the problems of this methodology since recognized the geometry externally.

4. RESULTS OF THE RESEARCH LINE

This work has been supported by the Consejeria de Economia, Ciencia y Empleo (Junta de Andalucia—Spain) through the project titled ''A vertical design software for integrating operations of automated demoldability, tooling design and cost estimation in injection molded plastic parts. (CELERMOLD)'' (Project Code TI- 12 TIC-1623).

-Participating entities: Universidad de Jaén, Universidad Politécnica de Madrid, Centro Tecnológico del plástico ANDALTEC.- 30/1/2014 - 29/1/2016 (24 months).

-Main Researcher. Prof.Dr.Cristina Martin Doñate (University of Jaén).

-Research Team: Prof Dr. Miguel Angel Rubio Paramio (U. Jaén), Prof Cat. Antonio Vizán Idoipe (U.P. Madrid), Prof Cat. Jesús María Pérez García (U.P. Madrid), Prof Dr. Juan de Juanes Márquez Sevillano (U.P. Madrid). Predoc researcher: Ing. Jorge Manuel Mercado Colmenero.

PRODUCTS

1.- Web platform CELERMOLD(In process).

4.1. PAPERS

1.- Mercado-Colmenero, Jorge Manuel; Rubio-Paramio, Miguel Angel; Vizán-Idoipe, Antonio; Martín-Doñate, Cristina "*A new procedure for the automated design of ejection systems in injection molds"*. Robotics and Computer Integrated Manufacturing. 2017: 46: 68-85. JCR: Q1 (9/42).

2.- Mercado-Colmenero Jorge Manuel; Rubio-Paramio, Miguel Angel; Perez-Garcia, Jesus Maria; Martín-Doñate, Cristina *"A new hybrid method for demoldability analysis of discrete geometries"*. Computer Aided Design. 2016. 80: 43-60. JCR: D1. (8/106).

3.- Mercado-Colmenero Jorge Manuel; Almazan-Lazaro, Miguel Angel; Martín-Doñate, Cristina; Rubio-Paramio, Miguel Angel; Vizán-Idoipe, Antonio; Perez-Garcia, Jesus Maria; Márquez-Sevillano, Juan De Juanes; Aguilera-Puerto, Daniel "*Analytical calculation model for determining the cycle time in injection molding parts applied to design optimization algorithms"*. WITT TRANSACTIONS ON THE BUILT ENVIRONMENT. 2016. 166:427-438.

4.- Mercado-Colmenero Jorge Manuel; Rubio-Paramio, Miguel Angel; Moya -Muriana, José Angel; Martín-Doñate, Cristina. *"An automated manufacturing analysis of plastic parts using faceted surfaces"*. Lecture Notes in Mechanical Engineering.2016. 119-128.

5.- Martín-Doñate, Cristina; Rubio-Paramio, Miguel Angel *"New methodology for demoldability analysis based on volume discretization algorithms"*. Computer Aided Design. 2013. 45: 229- 240. JCR: Q1(25/105).

4.2. PATENTS

1.- Método de validación automatizada de la fabricabilidad de diseños de objetos tridimensionales en base a su geometría. Número de patente: ES2512940B2. Fecha: 06/04/2015. Martín Doñate Cristina, Paramio Rubio Miguel Angel, Mesa Villar Aurelio. Entidad titular: UNIVERSIDAD DE JAEN.
2.- Procedimiento para el diseño del sistema de varillas de expulsión para un molde. Número de publicación: ES2595099A1. Fecha: 27/12/2016. MERCADO COLMENERO, Jorge Manuel (ES); MARTÍN DOÑATE, Cristina (ES); RUBIO PARAMIO, Miguel Ángel (ES); PÉREZ GARCÍA, Jesús María (ES). Entidad: Universidad de Jaén y Universidad Politécnica de Madrid (Informe IET favorable para todas las reivindicaciones)

3.- Método y sistema de obtención de geometrías virtuales y detección de zonas no moldeables en piezas. Número de publicación: ES2594772A1. Fecha: 22/12/2016. MERCADO COLMENERO, Jorge Manuel (ES); MARTÍN DOÑATE, Cristina (ES); RUBIO PARAMIO, Miguel Ángel (ES); VIZAN IDOIPE, Antonio (ES). Entidad: Universidad de Jaén y Universidad Politécnica de Madrid (Informe IET favorable para todas las reivindicaciones)

5. RESEARCH TEAM

Name: Jorge Manuel Mercado-Colmenero-University of Jaén, Spain, Engineering Graphics, Design and Projects Department, **Category:** Predoctoral researcher.

Name: Prof. Dr. Miguel Angel Rubio-Paramio- University of Jaén, Spain**,** Engineering Graphics, Design and Projects, **Category:** University teacher

Name: Prof. Dr. Cristina Martín-Doñate- University of Jaén, Spain**,** Engineering Graphics, Design and Projects Department **Category:** University teacher

6. REFERENCES

1. Malloy R, Majeski P. Design of pin ejector systems for injection molds. ANTEC 89: 47th Annual Technical Conference-Society of Plastics Engineers. New York 1989 p 1231-1235.

2. Bhagabatula N, Michalski D, Lilly B, Glozer G. Modelling and verification of ejection forces in thermoplastic injection moulding.Modelling Simul.Mater. Sci. Eng 2004 12,234-254.

3. Kwak S., Kim T., Park S., Lee K. Layout and sizing of ejector pins for injection mould design using the wavelet transform. Proc Inst Mech Eng 2003 217(B): 463-473.

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Congreso INGEGRAF Gijón 26, 27 de junio de 2017

NUEVOS MODELOS DE INVESTIGACIÓN Y COLABORACIÓN EN INGENIERÍA GRÁFICA

Method for obtaining an ejection map in injection molded parts

Jorge Manuel Mercado-Colmenero, Miguel Ángel Rubio-Paramio, Cristina Martín-Doñate

Department of Engineering Graphics Design and Projects. University of Jaen. Spain.

Abstract

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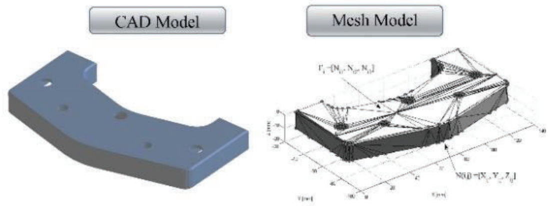
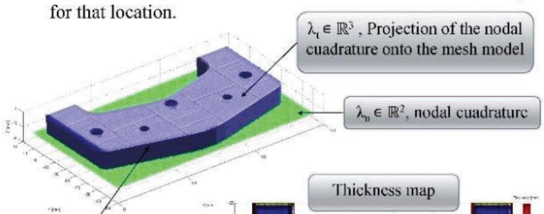
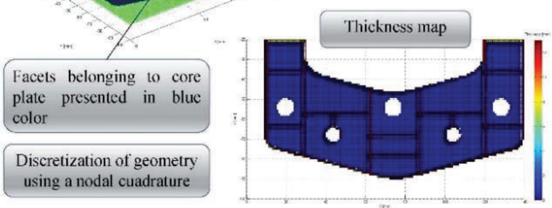
Methodology

Starting from a 3D plastic part to be manufactured, a three-dimensional mesh, formed by a set of nodes $N_{ij} \in \mathbb{R}^3$ and facets $F_i \in \mathbb{R}^3$, is generated.



This algorithm consists mainly of three phases. In the first phase, the geometry of the part belonging to the core plate is discretized by a nodal quadrature. Each generated node contains information about its coordinates and the thickness of the part for that location.





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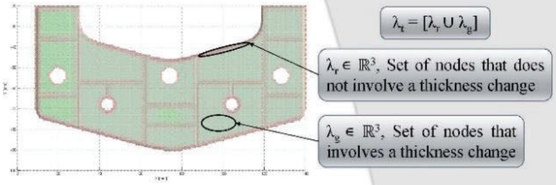
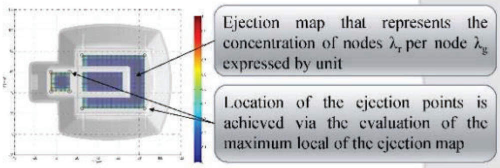
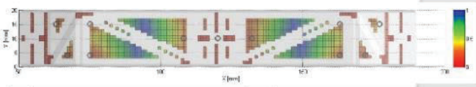


Finally, a multi-objective genetic optimization algorithm that allows a balanced and uniform sizing of the ejection system, without compromising the structural safety of the plastic part is proposed to use.

Results





	[Cx Cy] [mm]	Force [N]	$Ø_{ejec}$ [mm]		[Cx Cy] [mm]	Force [N]	$Ø_{ejec}$ [mm]
Case A	[-5,32; 40,66]	2,41	2,00	Case B	[75;4]	2,92	2,00
	[-5,32; 59,66]	2,41	2,00		[163;4]	2,18	2,00
	[12,68; 40,66]	2,41	2,00		[75;15	4,05	2,00
	[12,68; 59,66]	2,41	2,00		[163;15]	2,93	2,00
	[24,68; 24,66]	2,41	2,00		[108;10]	1,99	2,00
	[24,68; 75,66]	2,41	2,00		[132;10]	1,94	2,00
	[84,68; 24,66]	6,92	2,00		[67;4]	1,93	2,00
	[84,678; 75,66]	6,92	2,00		[63;15]	1,93	2,00
					[172;4]	1,93	2,00
					[177;15]	1,93	2,00

Conclusions

The developed method improves the above given that it does not use heuristic methods to obtain results, is valid for application to any plastic part geometry and it does not need access to internal information of the part. The geometry of the solid remains stored in arrays for later use in other CAD/CAE applications related to injection mold design, machining of plates, etc. A future work is the implementation of the proposed algorithm in an automated mold design system.

Acknowledgments

This work has been supported by Consejeria de Economía, Ciencia y Empleo (Junta de Andalucia, Spain) through the project titled " A vertical design software for integrating operations of automated demoldability, tooling design and cost estimation in injection molded plastic parts. (CELERMOLD)" (Project Code TI-12 TIC-1623)

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