# WARPAGE OPTIMIZATION OF A NAME CARD HOLDER USING NEURAL NETWORK MODEL

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Thesis submitted in fulfilment of the requirements
for the award of the degree of
Bachelor of Mechanical Engineering with Manufacturing Engineering

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

NOVEMBER 2009

# UNIVERSITI MALAYSIA PAHANG

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## LIST OF SYMBOLS

| | |
|---|---|
| $^0$C | Degree Celsius |
| % | Percent |
| MPa | Mega Pascal |

## LIST OF ABBREVIATIONS

| | |
|---|---|
| DOE | Design of experiment |
| ABS | Acrylonitrile-butadiene-styrene |
| CAD | Computer aided drawing |
| CAE | Computer aided engineering |
| FYP | Final year project |
| MPI | *Moldflow plastics insight* |
| PC | Polycarbonate |
| PE | Polyethylene |
| PS | Polystyrene |
| ANN | Artificial neural network |
| MoT | Mold temperature |
| MeT | Melt temperature |
| PP | Packing pressure |
| PPT | Packing pressure time |
| CT | Cooling time |

## ABSTRACT

Injection molding has become widely process that used in plastic manufacturing. To produce high quality product, it has to consider the process condition. In this study, optimum parameters for injection molding of a name card holder are determined. Finite element software MoldFlow, statistical design of experiment and artificial neural network are used in finding optimum value. The process parameter influencing warpage is determined using finite element software based on data using full factorial design. By exploiting finite element analysis result, a predictive model using artificial neural network is created. Optimum value is determined by comparing result by using finite element analysis and optimization using artificial neural network and choose the smallest percentage of error.

## ABSTRAK

Injection molding telah menjadi proses yang digunakan secara meluas dalam pembuatan plastik. Untuk menghasilkan produk berkualiti tinggi, ia harus mempertimbangkan keadaan proses. Dalam kajian ini, parameter optimum untuk ‘injection molding’ dari pemegang kad nama ditentukan. Perisian MoldFlow, statistical design of experiment dan rangkaian saraf buatan digunakan dalam mencari nilai optimum. Proses parameter yang mempengaruhi ‘warpage’ ditentukan menggunakan perisian MoldFlow berdasarkan data menggunakan ‘full factorial design’. Dengan memanfaatkan keputusan analisis ‘finite element’, suatu model ramalan menggunakan rangkaian saraf buatan dicipta. Nilai optimum adalah ditentukan dengan membandingkan hasilnya dengan menggunakan analisis elemen hingga dan pengoptimuman menggunakan rangkaian neural buatan dan memilih peratusan kesalahan terkecil.

# CHAPTER 1

# INTRODUCTION

## 1.1 INTRODUCTION

One of the most common methods of converting plastics from the raw material form to an article of use is the process of injection molding. This process is most typically used for thermoplastic materials which may be successively melted, reshaped and cooled. Injection molded components are a feature of almost every functional manufactured article in the modern world, from automotive products through to food packaging. This versatile process allows us to produce high quality, simple or complex components on a fully automated basis at high speed with materials that have changed the face of manufacturing technology over the last 50 years or so.

## 1.2 OBJECTIVE

The objectives are:

(i) To investigate best process injection molding parameter values for a name card holder minimizing warpage

(ii) Analysis and optimize warpage using neural network method

## 1.3 PROJECT SCOPE

This project is confined to the following scopes of study:

(i) To develop Finite Element (FE) model using MoldFlow to get predicted warpage value

(ii) Using data from MoldFlow to optimize warpage using Artificial Neural Network

## 1.4 PROBLEM STATEMENT

Injection molding is the most widely used process in manufacturing plastic products. It is an important issue in plastic injection molding to predict the warpage problem before manufacturing takes place. Below is example that faced by the plastic industry regarding warpage that occur in injection molding process:

Medical device companies are always under pressure in two key areas: time and cost. Time delays in the production cycle can substantially affect product introduction timetables, and consequently, revenue. One area where medical device companies often lose valuable time, experience cost overruns, and face production delays is in poor design of injection molded components related to the mechanical functioning of the mold.

Injection mold fabrication is widely used in medical device manufacturing because of its versatility. Many different types of plastics can be used for injection molding, and once a mold is made, an extremely large number of pieces can be manufactured with it. Because of this, injection molding manufacturing is extremely cost effective in high volume production. But the properties of injection molding (plastic resin is fed into the injection machine, heated, and forced at high pressure into the mold by a screw and cures on cooling), and the mechanics of molding, dictate that designers pay particular attention to certain principals to ensure successful manufacture. Often medical device designers know basic injection mold design rules but this may not be enough to ensure smooth manufacture of parts and guarantee that the mechanical functioning of the mold does not cause problems.

Much of the specifics of mold design have to do with the particular characteristics of thermoplastics. Thermoplastics are heated, melted, and then injected at high pressure into the mold. They cure upon cooling and parts shrink during this cooling time. The variation in shrinkage that can occur must be a major consideration for a

designer in order to achieve dimension control, hold tolerances, and avoid warpage. This shrinkage is due to a number of variables:

(i) The type of plastic used
(ii) The rate of cooling in the mold
(iii) The wall section dimensions
(iv) The gate location and the related flow characteristics in the mold
(v) The molding machine process parameters (such as temperature and pressure)

Article from: http://www.manufacturing.net/article.aspx?id=7818&menuid=280

One of the problems is injection molding process parameter that affects the parts quality. Since the quality of injection molded plastic parts are mostly influenced by process conditions, how to determine the optimum process conditions becomes the key to improving the part quality.

## 1.5 PROBLEM SOLVING

From this study, warpage that occur in plastic injection molding industry can be minimized. Then the losses caused by rejected part due to warpage can be solved. This study is one of the solutions that can minimize problem that face in plastic industry. The optimization methodology in this study can be employed to improve part design and determine appropriate material properties in injection molding of other plastic parts as well.

# REFERENCES

[1] H.T. Paro, C.P. Bosnyak, K. Sehanobish, Machine Design, 1986.

[2] U.S. patent #133229, dated 19 November 1872.

[3] Douglas M. Bryce. Plastic Injection Molding: Manufacturing Process Fundamentals. SME, 1996. pg.1-2

[4] http://www.scudc.scu.edu/cmdoc/dg_doc/develop/process/physics/b3500001.htm

[5] http://www.imtechdesign.com/mouldflow_shrinkage_warpage_analysis.php

[6] http://www.scudc.scu.edu/cmdoc/dg_doc/develop/process/physics/b3500001.htm

[7] http://www.custompartnet.com/calculator/injection-molding-cooling-time

[8] Michael Negnevitsky, Artificial Intelligence, A Guide to Intelligent System, 2002

[9] A.M.S. Zalzala and P.J. Fleming, Genetic algorithms in engineering systems, 1997

[10] M.L. Huang, Y.H. Hung, Combining radial basis function neural network and genetic algorithm to improve HDD driver IC chip scale package assembly yield, Expert Systems with Applications 34 (2008) 588–595

[11] Hasan Kurtaran*, Babur Ozcelik, Tuncay Erzurumlu , Warpage optimization of a bus ceiling lamp base using neural network model and genetic algorithm, Journal of Materials Processing Technology 169 (2005) 314–319GA

[12] Chiaming Yen, J.C. Lin*, Wujeng Li, M.F. Huang, An abductive neural network approach to the design of runner dimensions for the minimization of warpage in injection mouldings, Journal of Materials Processing Technology 174 (2006) 22–28

[13] Douglas M. Bryce, Plastic injection molding, 1997

[14] Shen Changyu, Wang Lixia*, Li Qian, Optimization of injection molding process parameters using combination of artificial neural network and genetic algorithm method, Journal of Materials Processing Technology 183 (2007) 412–418

[15] Chris Rauwendaal, Statistical Process Control in Injection Molding and Extrusion, 2000

[16] http://www.moldflow.com/stp/

[17] Wen-Chin Chen a, Pei-Hao Tai a, Min-Wen Wang b, Wei-Jaw Deng c, Chen-Tai Chen d,*, A neural network-based approach for dynamic quality prediction in a plastic injection molding process, Expert Systems with Applications 35 (2008) 843–849

[18] Yuehua Gao, Xicheng Wang*,Surrogate-based process optimization for reducing warpage in injection molding, Journal of Materials Processing Technology 209 ( 2009 ) 1302–1309

[19] B. Ozcelik*, T. Erzurumlu, Comparison of the warpage optimization in the plastic injection molding using ANOVA, neural network model and genetic algorithm, Journal of Materials Processing Technology 171(2006) 437-445

[20] F. Marini[a], Neural Networks, Comprehensive Chemometrics Chemical and Biochemical Data Analysis Volume 3, Pages 477-505, 2009

[21] J.A. Conesa*, J.A. Caballero, J.A. Reyes-Labarta, Artificial neural network for modeling thermal decompositions, Journal of Analytical and Applied Pyrolysis 71 (2004) 343-352

[22] Biron,M.,Thermoplastics and Thermoplastic Composites, 2009