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Optimal Design of Plasticizing Screw Using Artificial Intelligent Approach

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Abstract. This study integrated plasticizing screw analysis software with neural-network in the design of a screw for injection molding application. The qualities of the plasticizing screw selected in this study are output rate, melt temperature variation at the end of metering zone, the specific mechanical energy (SME), and the melting distance. The Taguchi orthogonal array is implemented to carry out the experiment and to obtain the test data for training the neural network. The Back-propagation Neural Network (BPNN) was then used for screw quality predictor, and optimal design was solved with Genetic Algorithm (GA). The optimal screw design for a diameter of 25 mm screw for molding PC resin in this study is 5.37D in solid conveying zone, 9D in compression zone, metering zone depth of 2.44 mm, and flight width of 3 mm. The performance of this screw with the preset processing condition can have the temperature difference at the end of metering (ΔT) of 5.67°C, the output rate Q of 20.12 kg/h, the SME of 520.80 (kJ/kg), and the plastics completely melted at 17.39D.

1. Introduction

A plasticizing screw is an important part of an injection molding machine as it is responsible for melting, mixing, metering, and conveying the plastic material inside the barrel. Thus, plasticizing screw should be the heart of an injection molding machine. The standard three-zone plasticizing screw, as shown in Figure 1, is the most common screw in the injection molding machine. Four different objectives should be considered in the design of a plasticizing screw and they are dispersive mixing, distributive mixing, plasticizing capacity, and the consistency of melting temperature of plastic material [1]. Energy is one of the most concerned issues in the molding industry, and the design of the plasticizing should as well consider the energy consumption [2].

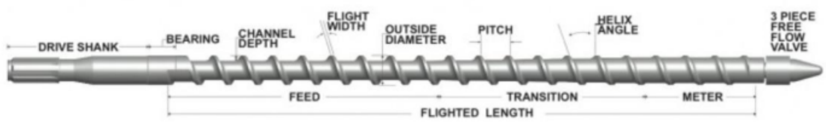

Figure 1. General Scheme of an Injection Molding Screw [3]

Since there is no standardized and integrated theory in designing plasticizing screw, the screw design was done by experienced engineers through trial and error process in the past. In recent years, with the advancement of computing technology and the development of plasticizing screw analysis software, computer-aided screw design becomes realistic. Altmann et al. [4] used a simulation software to study the standard three-zone plasticizing screw. Wagner et.al [5] used FLOW 2000 simulation software and experimental design to study extrusion screw performance and to search for the response of extruder system. Instead of trial and error method, Wang and Lin [6] have demonstrated an optimal screw design process with Taguchi method using Moldex3D ScrewPlus injection molding screw analysis software. The use of Taguchi Method can reduce the practice of experiments compared to the conventional trial and error method, because it's more efficient and time and cost saving [7-9]. Zhang et al. [10] and Wang and Lin [6] have applied Taguchi method to design injection screws for molding PMMA and PC materials. A design with preferable quality within the preset range of parameters can be obtained but the Taguchi Method cannot obtain continuous and global optimum design. Unlike the Taguchi Method, the neural network optimization method can reach continuous and global optimum design in problem analysis, and it is used to resolve the problem in optical design and parameter analysis in injection molding [11]. A back propagation neural network (BPNN), shown in Figure 2, was first built and trained as a quality predictor, then Genetic Algorithms (GA) was successfully applied in developing an LED lens and also finding the optimal molding parameters [12][13].

This study proposes an optimal design process integrating BPNN, GA, and screw analysis software for injection screw design. To demonstrate this optimal design process, an injection screw design for compact disk (CD) molding application will be carried out in this study.

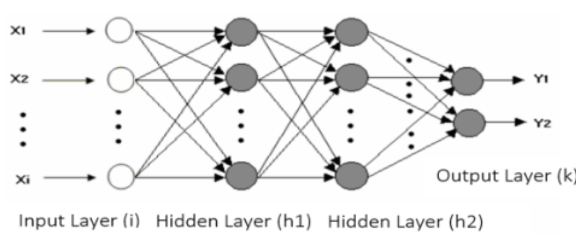

Figure 2. Architecture Diagram of Back Propagation Neural Network

2. Method and Procedure

Moldex3D ScrewPlus is a plasticizing screw simulation software that can provide the plastics properties during plasticizing process with given screw design and the processing parameters, and the user can estimate the performance of the screw with the simulation results. In this study, the ScrewPlus simulation will be used to observe the performance of the screw for molding compact disks (CD). The material for this study is a PC resin (GE plastics). The design parameters of a standard three-zone screw generally are its diameter, pitch, length of the three zones, flight width, feed depth, and compression ratio (the ratio of feed depth to metering depth) [6]. Though all the parameters have effects on the screw performance, four different parameters (feeding zone length, compression zone length, metering zone depth, and flight width) are chosen in this experiment. For a CD molding machine, the tonnage is around 50 tons and with a screw of ϕ25 mm and 20 in L/D. To train the BPNN, 27 sets of simulations will be prepared first, L27 orthogonal array is chosen to devise the experimental plan, each of the four selected design parameters with 3 different levels as shown in Table 1. Four quality characteristics selected to measure the overall performance of the screw in this study are melt temperature difference(ΔT) at the end of the metering zone, output rate of the screw (Q), specific mechanical energy (SME), and the distance that plastics melted completely (MD). Some of the screw design parameters and the molding parameters are kept the same as previous research done by Wang and Lin [6]. The pitch of the screw is 26.5 mm, compression ratio is 3. The processing parameters are 140 rpm, feeding zone temperature 300°C, back pressure 0.45 MPa, injection volume 18.379 cc, and injection stroke 37.443 mm. The parameter combinations of the 27 experiments are listed in Table 2.

Table 1. Design Parameters and Values at Different Levels

Standard / Parameter	1	2	3
Feed zone length W (D)*	4	5	6
Compression zone length X (D)*	9	10	11
Metering zone depth Y (mm)	1.69	2.03	2.54
Flight width Z (mm)	3	3.5	4

*: the length is presented is D, diameter of the screw

Table 2. L27 Orthogonal Array Combination

Number	W	X	Y	Z	Number	W	X	Y	Z	Number	W	X	Y	Z
1	1	1	1	1	10	2	1	1	1	19	3	1	1	1
2	1	1	2	2	11	2	1	2	2	20	3	1	2	2
3	1	1	3	3	12	2	1	3	3	21	3	1	3	3
4	1	2	1	2	13	2	2	1	2	22	3	2	1	2
5	1	2	2	3	14	2	2	2	3	23	3	2	2	3
6	1	2	3	1	15	2	2	3	1	24	3	2	3	1
7	1	3	1	3	16	2	3	1	3	25	3	3	1	3
8	1	3	2	1	17	2	3	2	1	26	3	3	2	1

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9	1	3	3	2	18	2	3	3	2	27	3	3	3	2

3. Result and Discussion

The parameters setting of the BPNN and the GA for this experiment is listed in Table 3 and Table 4. The four selected screw design parameters and the four quality characteristics obtained from ScrewPlus simulation are fed into the BPNN to train the neural network. Figure 3 shows the BPNN training convergent map. After BPNN training is completed, the GA is applied to obtain the optimal parameters with the following objective function:

$$Obj = (\Delta T - \Delta T_{min})^2 + (Q - Q_{max})^2 + (SME - SME_{min})^2 + (MD - MD_{min})^2$$

where ΔT is the melt temperature difference at the end of metering zone, ΔT_{min} is the minimum melt temperature of the 27 sets training data, Q is the output rate, Q_{max} is the maximum output rate of the 27 sets, SME is the specific mechanical energy, SME_{min} is the minimum specific mechanical energy of the 27 sets, MD is the complete melted distance and MD_{min} is the minimum complete melted distance of the 27 sets. Through BPNN and GA search, the values of the design parameters as well as the quality characteristics are listed in Table 5. The quality characteristics of the 27 training sets and those of the optimal design are shown in Figure 4.

Table 3. Arrangement of the Neural Network Parameters

The input layer	4 Neurons
Hidden layer	1 Layer, 10 Neurons
Output layer	4 Neurons
The transfer function	Double bend function
Learning rate	0.7 Decreasing by batch
Normalized range	0.1~0.9
Stop condition	Iteration 15000 Times or error threshold
Training materials	27 Pieces
Test data	5 Times

Table 4. Search Parameters for Genetic Algorithm

	Feeding zone length (D)	Compression zone length (D)	Metering zone depth (mm)	Flight width (mm)
Upper bound	6	11	2.54	4
Lower bound	4	9	1.69	3

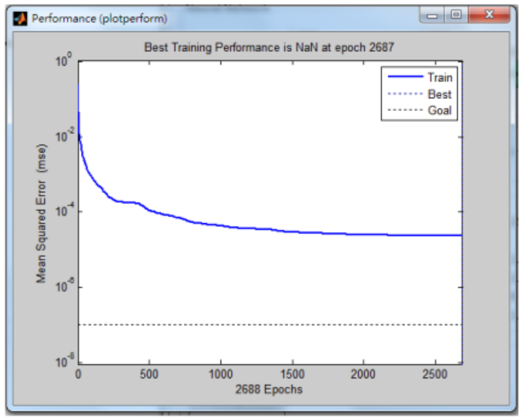
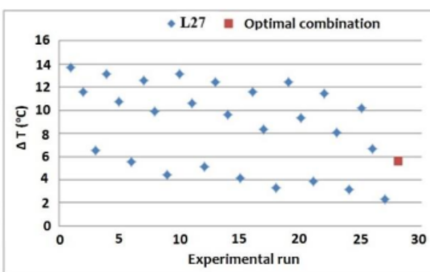


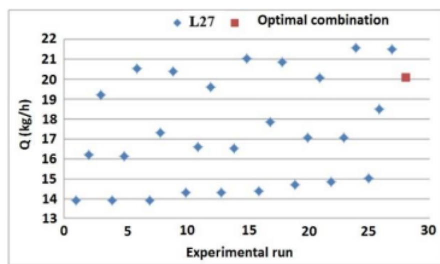
Figure 3. Back Propagation Neural Network Training Convergence Map

Table 5. Best Combination of Design Parameters

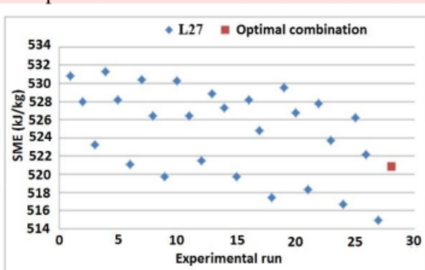
Design parameters				Quality characteristics			
A	B	C	D	ΔT	Q	SME	Melted distance
5.37	9.00	2.44	3	5.67	20.12	520.80	17.39



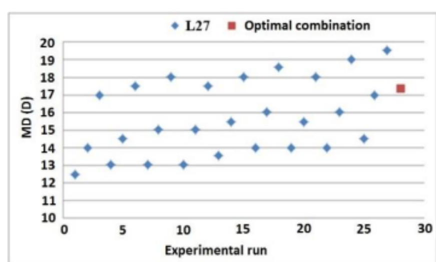
a. Temperature Difference at the End of Metering



b. The Output Rate



c. Specific Mechanical Energy



d. Complete Melted Distance

Figure 4. Screw Performance

The optimal performance of the screw considered all the four quality characteristics, each of the quality characteristic is not the maximum or the minimum compared to the other 27 runs shown in

Figure 4. The best design parameter values of this PC screw design for CD molding example are as follows: feeding zone length of 5.37D, compression zone length of 9D, metering zone depth of 2.44 mm, and flight width of 3 mm.

4. Conclusion

This study has proposed and demonstrated technology integration in computer-aided plasticizing screw design. The ScrewPlus can provide meaningful details of the plastics properties inside the barrel during plasticizing process, that will help engineers to estimate the performance of the screw before actually making it. Besides, design plasticizing screws with simulation software together with Taguchi experimental method or neural network optimization methods can save a lot of time and cost. Unlike experimental method with real screws, no screws have to be made before the best performance screw is designed using computer-aided simulation.

Unlike the Taguchi Method, the optimal design values of the four parameters studied in this experiment are not limited in the combination of the preset levels, it shows again that the neural network optimization method can create continuous and global optimum design in problem analysis.

This study considers four screw quality characteristics in the optimal design process as a demonstration and any quality characteristics combination can be selected to modify the objective function to come up with the best performance screw design for the specific applications.

Acknowledgment

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Reference.

[1] Verbraak C P J M and Meijer H E H 1989 *Polymer Engineering and Science* 29 pp 479-487

[2] Energy- Efficient Melting, https://inmex.de › inmex-KU-2019-02-EN, Accessed, May 2, 2019

[3] L/D Ratio, http://reiloyusa.com/processing-tips/screw-design/ld-ratio/, Accessed, April 20, 2019

[4] Altmann D, Kopplmayr T and Steinbichler, 2019 Analytical and Numerical Method for Optimizing Screw Geometries of an Injection Molding Plasticizing Unit with Focus on Standard Three-Section Screws *AIP Conference Proceeding 2065* https://doi.org/10.1063/1.5088298

[5] Wagner J and Perdikoulias J 2005 Extrusion Process and Screw Design Investigation Via Experimental Design and Computer Simulation Antec 1 pp 296-307

[6] Wang M-W, and Lin W-C 2009 Computer-Aided Optimal CD Molding Plasticizing Screw Design Using Taguchi Method *Asia Pacific Conference on Manufacture (APCOM) 11th to 14th February 2009*

[7] Wang M-W, Arifin F, Huang J-Y 2019 Optimization of the Micro Molding of a Biconcave Structure *International Journal of Technology* 10 (2) pp 269-279

[8] Wang M-W, Arifin F, Huynh T T-N 2019 Optimization of Molding Parameters for Gear with Taguchi Method 2nd *Forum in Research, Scince and Technology IOP Conference Series: Journal of Physic:*

Conf.Series 1167(2019)0212001 doi:10.1088/1742-6596/1167/1/012001

[9] Arifin F, Iskandar, and Azharuddin 2012 Taguchi Method Approach to Optimize Manufacturing Process Parameters of Aluminum-5% Fly Ash Allay Using Powder Metallurgy *Advanced Materials Research* 576 pp 284-288

[10] Zhang L-K, Liu Y-C, Xu, and Wang M-W and Ming W 1998 The Study of PMMA Dedicated Injection Screw the Taguchi Method Is Applied *The 21th Polymer Study Symposium Papers album* pp 33-36

[11] Chen W-C and Hsu S-W 2007 A Neural-Network Approach for an Automatic LED Inspection System *Expert Systems with Applications* 33(2) pp 531 – 537

[12] Chen W-C, Wang M-W, Chen C-T, and Fu G-L 2009 An Integrated Parameter Optimization System for MISO Plastic Injection Molding *International Journal of Advanced Manufacturing Technology* 44 pp 501 - 511.

[13] Chen W-C, Tai P-H, Wang M-W, Deng W-J and Chen C-T 2008 A Neural Network-Based Approach for a Dynamic Quality Predictor in Plastic Injection Molding Process, *Expert Systems with Application* 35(3) pp 843-849

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