Journal of Theoretical and Applied Information Technology
20th January 2013. Vol. 47 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

CAR B-PILLAR SKID PLATE MOLDING PARAMETER OPTIMIZATION

[1]WANG YOUMIN, [2]YU CHUN, [3]CHEN MINGXIN, [4]ZHOU GE，[5]DOU ZONGYING, [6]YANG XAOLI, [7]DU XIAOYANG

[1,2]School of Mechanical and Automotive Engineering, Anhui Polytechnic University, Anhui Wuhu,241000
[3]Anhui Key Laboratory of Advanced Numerical Control ＆ Servo Technology, Anhui Wuhu,241000
[4]National Center of Supervision and Inspection on Auto Parts Products Quality(Wuhu), Anhui Wuhu, 241007
[5,6,7]Chery Automobile Co., Ltd, Anhui Wuhu 241002
E-mail: [1]wymtlf@126.com, [2]yuchun@anpu.edu.cn

ABSTRACT

To obtain the best injection molding process parameters and mold design for the car B-pillar skid plate， the process parameters of injection molding CAE needs to be optimized. After determining the parts quality standards, we complete the range and analyze the results. But this method can only identify the influence trend of parameters on the test results; it can’t get the best process parameters. This paper uses the modified simplex method as optimization method. We transform the function optimization into the injection molding CAE process optimization. The injection molding process parameters are optimized. We get the best parts injection molding process parameters: the Mold temperature is 33.24℃, the melt temperature is 213.98 ℃, injection pressure is 80.12MPa, parts of the program sink mark index is 0.5221%, volume shrinkage is 1.0143% , maximum warping deformation is 1.426mm, the cavity residual stress is 4.8333MPa. Car B-pillar skid plate is injected according to the best process parameters, the obtained parts have met our quality requirements.

Keywords：*Injection Molding(IM), Process Parameters(PP), Optimization(O)*

1. INTRODUCTION

Car interior plastic as the car decorative material has advantages, because it has a certain strength and toughness, stain resistance, and the price is low. The quality of car interior plastic parts is one of the important quality evaluation indicators. High-quality car interior parts can enhance the value and market competitiveness. The B-pillar skid plate which installed in the car at the B-pillar is the interior parts of a car. B-pillar skid plate of a car factory in domestic has problems in the actual injection molding process, less injection, flow imbalance , flow channel imbalance, and so on. The article adopted the molding process simulation and orthogonal of B-pillar skid plate, developed a comprehensive quality evaluation of parts, used the modified simplex method as optimization methods and transformed the function optimization into the injection molding CAE process optimization. The injection molding process parameters were optimized. Modified simplex optimization method is a function optimization method, the programs can be optimization comparison through the objective function, and the optimization of injection molding process parameter is the optimization of process. The pros and cons of each programs can not be calculated by comparing the objective function, we can’t read the injection molding test results automatically and evaluate the pros and cons by the objective function. We used an integrated weighted score for evaluating injection molding; transform the function optimization into the process optimization. Each step of optimization iteration is necessary to carry out a simulation of injection molding. At last, we got the best parts injection molding process parameters, and used the injection solution to produce qualified products quickly.

2. CAR B-PILLAR SKID PLATE MOLDING PROCESS PARAMETER OPTIMIZATION

2.1. Test Target Weight and Integrated Weighted Score Value

Use Wj for test indicators weights, where j represents the j-species test indicators. Set the sum

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

of each test indicators weights equal to 1. When set the weights, we should analyze the influence degree of experimental index on plastic parts quality, production efficiency, manufacturing cost and so on correctly. The more important the test index is, the greater value should be given.

Residual stress is one of the factors that can cause plastic deformation, therefore, consideration from the quality of plastic parts; we set its weight 0.4. Take quality, materials, performance, control costs and cycle times and other factors into account, the importance of sink mark index, volume shrinkage rate and maximum warping deformation is nearly. So set the weight of each index 0.2.

First, we compared score for each test index value of each test numbers, Y (i) represents the scores, where i represents the i-th test number. Calculated by 100-point scale, the maximum test target the Aimax is 60 points, the minimum value Aimin is 100 points. Arranged by the size of each value, there is a difference of 5 points between two adjacent values. According to the requirements of plastic molding quality, production efficiency and manufacturing cost, the test indicator values should be as small as possible.

$$Y_i^* = \sum_{i=1}^{4}\left[Y(i)\times W_j\right] \quad (1)$$

Orthogonal test results and integrated weighted score are shown in Table 1, No. 3 has the highest integrated weighted score values in 9 groups experiments. Its score is 85, the combination of process parameters is A1B3C2, this group test except volume shrinkage rate, the observed value of the other test indicators in nine groups are closer to the lowest test value. To obtain the best parameter combination under the multi-index, we need a statistical analysis for each tests of the integrated weighted score values.

*Table.1 **9**group Orthogonal Experiments Results And Score Of Comprehensive Weighted*

No.	sink mark index (%)		volume shrinkage rate (%)		maximum warping deformation (mm)		cavity residual stress（MPa）		integrated weighted score Y*
	value	evaluation	value	evaluation	value	evaluation	value	evaluation	
1	1.100	85	0.975	95	1.41	90	5.44	65	80
2	2.386	70	1.0994	75	1.396	100	5.11	80	81
3	0.7291	90	1.1638	70	1.473	75	4.9733	95	85
4	1.168	80	0.9763	90	1.407	95	5.4783	60	77
5	2.422	65	1.0982	85	1.425	85	5.0517	90	83
6	3.417	60	1.1763	65	1.427	80	4.9567	100	81
7	0.000	100	0.9738	100	1.536	60	5.3633	70	80
8	0.4371	95	1.0988	80	1.527	65	5.1017	85	82
9	72.72	10	0.9993	90	58.17	10	5.155	75	71

2.2. Modified Simplex Optimization Method

The simplex is a geometric consisted of m +1 points in m-dimensional. The concrete implementation method of simplex first formed a matrix P based on a dimensionless variable:

$$P = \begin{bmatrix} P_1 & P_2 & \cdots & P_j & \cdots & P_m \\ -P_1 & P_2 & \cdots & P_j & & P_m \\ 0 & -2P_2 & & P_j & & P_m \\ 0 & 0 & & \vdots & & \vdots \\ \vdots & 0 & & -jP_j & & \vdots \\ \vdots & \vdots & & 0 & & \vdots \\ \vdots & \vdots & & \vdots & & \vdots \\ 0 & 0 & \cdots & 0 & \cdots & -mP_m \end{bmatrix} \quad (2)$$

$$P_j = \sqrt{\frac{1}{2j(j+1)}} \quad (3)$$

Form an m-dimensional positive simplex, which is made up of m columns, m +1 lines, and the experimental design of m-factor is indicated by dimensionless. First, based on experience or preliminary experiments, to determine the initial simplex, and to do test based on the parameters of the initial simplex. Then analyze the results to identify the worst point and use its symmetrical point as a new point, re-composition simplex, do

Journal of Theoretical and Applied Information Technology
20th January 2013. Vol. 47 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

further experiments until the optimal has been achieved. New point should meet the following conditions:

The worst response point is Pw in the current simplex, calculate the Pr which is mirror launch point of Pc, the Pc is the centroid of Pw relative residual m points. Use Pr instead of Pw, constitute a new adjacent simplex, thus to achieve the advancement of the simplex. For an arbitrary-dimensional simplex, if the peak is represented by the coordinates vector, P1, P 2, ..., Pw, ..., Pm, Pm +1, give up Pw, the centroid Pc of residual points P1, P, 2, ..., Pw-1, Pw +1, ..., Pm, Pm +1 can be calculated as follow:

$$P_c = \frac{1}{m}(P_1 + P_2 + \cdots + P_{w-1} + P_{w+1} + \cdots P_m + P_{m+1}) \quad (4)$$

So the launch point Pr which Pw on Pc can be calculated:

$$P_r = P_c + (P_c - P_w) \quad (5)$$

When Pr beyond the scope of its set value, take $P_r = P_c$, or else $P_r = P_c + (P_c - P_w)$.

2.3. Optimization Results of Process Parameters

The optimal error was 0.01 based on this paper, the optimization test can meet the requirements require 24 steps. Table 2 is orthogonal test and the optimized of the step 10 and step 24. The front nine test numbers are basic orthogonal.

*Tab.2 **9**group Orthogonal Experiments And Process Parameter Optimization Results*

No.	sink mark index (%)		volume shrinkage rate (%)		maximum warping deformation (mm)		cavity residual stress （MPa）		integrated weighted score Y*
	value	evaluation	value	evaluation	value	evaluation	value	evaluation	
1	1.100	85	0.975	95	1.41	90	5.44	65	80
2	2.386	70	1.099	75	1.396	100	5.11	80	81
3	0.729	90	1.164	70	1.473	75	4.9733	95	85
4	1.168	80	0.976	90	1.407	95	5.4783	60	77
5	2.422	65	1.098	85	1.425	85	5.0517	90	83
6	3.417	60	1.176	65	1.427	80	4.9567	100	81
7	0.000	100	0.974	100	1.536	60	5.3633	70	80
8	0.437	95	1.099	80	1.527	65	5.1017	85	82
9	72.72	10	0.999	90	58.17	10	5.155	75	71
10	1.50	75	1.077	82	1.42	92	5.3083	78	81
24*	0.522	92	1.014	82	1.426	83	4.971	94	89

The process parameters corresponding to the steps of 24 is the optimal, the optimal process parameters: the mold temperature is 33.24℃, the melt temperature is 213.98℃, injection pressure is 80.12MPa, the injection molding quality: Sink marks index is 0.5221%, volume shrinkage is 1.0143%, maximum warping deformation is 1.426mm, and the cavity residual stress is 4.8333MPa.

2.4 Simulation Results of Other Process Parameters

Through simulation, program comparison, to obtain the other process parameters as follows: programmable process parameters: injection pressure is 81.2MPa, holding pressure is 59.01MPa, holding time is 8.3s. Parameters which are produced by the molding process: cavity pressure is 61.31Mpa, filling time is 3.213s, clamping force is 2812.9t, injection molding machine parameters: the largest injection molding machine clamping force is 7.0002E +03t, the maximum injection pressure is 1.8000E +02MPa, injection molding machine hydraulic response time is 1.0000E-02s.

3. PRODUCTION APPLICAYION

Through simulation and optimization of the process parameters, the best injection molding process parameters and mold design program are obtained. Then apply it directly to the actual

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

production of a car factory to produce a car B-pillar skid plate mold, the final test mode uses the best process parameters to produce the products, thus to meet the accuracy requirements. The part material is PP + T20, which are linear olefin polymers. Casting system used the program d in Figure 2. The main channel entrance diameter is 15mm, length is 170mm, draft angle is 3°, across runner diameter is 11mm, the side gate entrance diameter is 4mm, draft angle is 15°, the length is 14mm. Injection molding process parameters: the mold temperature is 33.24℃, the melt temperature is 213.98 ℃, injection pressure is 80.12MPa, filling time is 3.213s, clamping force is 2812.9t. The injection mold and parts are shown in Figure 7.

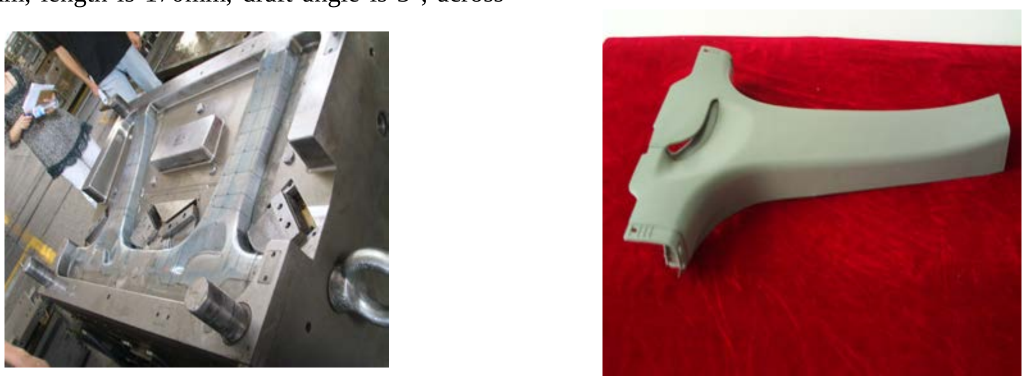

Figure7 Figure Of Parts Mold And Product

4. CONCLUSIONS

（1）This paper uses the modified simplex method as optimization method, transforms the function optimization into the CAE process optimization, optimizes for the injection molding process parameters. We get the best parts injection molding process parameters: the Mold temperature is 33.24℃, the melt temperature is 213.98℃, injection pressure is 80.12MPa, parts of the program sink mark index is 0.5221%, volume shrinkage is 1.0143%, maximum warping deformation is 1.426mm, the cavity residual stress is 4.8333MPa. Car B-pillar skid plate is injected according to the best process parameters, the obtained parts meet our quality requirements.

（2）Apply the mold design program to the actual manufacturing, process out the B-pillar skid plate. According to the best process parameters injected the B-pillar skid plate, the parts meet quality requirements.

REFERENCES

[1] Feng Xiaojun ,LI Aiping. technical parameter optimization of rapid tooling filling process[J]. *Journal of Mechanical Engineering*，2009,45（11）：363～368

[2] Wu Zhigang Shi Yusheng Wei Qinsong, Simulation and Optimization of Injection Molding for Precise Drip Emitters[J]. *Transactions of the Chinese Society for Agricultural Machinery*，2007,38（4）：42～46

[3] SUN Guangyong ，LI Guangyao ，CHEN Tao，SheetMetal Forming Based Six Sigma Robust Optimization Design[J]. *Chinese Journal of Mechanical Engineering*，2008

[4] OKTEM H, ERZURUMLU T, UZMAN I. Application of Taguchi optimization technique in determining plastic injection molding process parameters for a thin-shell part[J]. *Materials and Design*, 2007, 28：1271-1278.

[5] CHENG Jin， TAN Jianrong， YU Jiahong. Multi-objective Robust Optimization of Injection Molding Process Parameters Based on TOPSIS[J]. *Chinese Journal of Mechanical Engineering*，2011,47（6）：27～32

[6] Zhao Tao, Zhang Haiou, Wang Guilan.Melting-Joint Defect CAE Analysis and Optimized Design of Injecting System on Vehicle Inside Decorative art[J].*Processing and mould*，2007（5）：38~41

[7] Shen Liqin，Gui Tao.The Applications of Taguchi in Parameter Optimization of Injection Molding[J].*Electro- Mechanical Engineering* ,2010,26(4) :38~45