**International Journal of Innovative Research in Engineering & Management (IJIREM)**
**ISSN: 2350-0557, Volume-2, Issue-3, May-2015**

# RESEARCH ON FORMING TECHNOLOGY OF AUTOMOBILE FRONT FENDER

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## ABSTRACT

In this paper, according to the orthogonal experiment principle and making use of Pamstamp2G software, the numerical simulation was made on different blank-holding force, the rubbing factor between die and sheet bar. Through an analysis and comparison between the thickness of sheet bar got from numerical simulation and from practical forming part, the effects of the factors mentioned above on the forming results of front fender was arrived at, and the optimized technological condition for the forming was pre-estimated.

## Keywords

orthogonal experiment; numerical simulation; front fender

## 1. INTRODUCTION

Automotive panel forming process is the mechanical process involving large deformation materials, geometric nonlinearity and complexity of contact friction conditions, with many factors influencing the forming process. Bao xiangjun and others studied of the three material mechanics parameters (yield strength, strain hardening exponent, thick anisotropy coefficient) which affected the results of automotive panel forming process. C-W Hsu, ZQ Sheng and others studied the changed blank-holding force in the forming process and described the problem of optimal blank-holding force. In the automotive panel forming process, the flow resistance of the sheet has a decisive influence on the outcome stamping. If binding force is too small, the sheet would be led to wrinkling. If binding force is too large, the sheet would result in pulled crack. There are many common means which control blank-holding force, such as type , location and quantity of drawbead, shape and size of sheet metal blank, the size of blank-holding force, friction factor. During the actual stretch forming, the binding force was generally offered, then the binding force gradually reduced to the appropriate range according to actual situation.

## 2. ORTHOGONAL EXPERIMENT

Orthogonal experiment is a scientific method and a kind of arrangement method of Multivariate factors. By selecting a representative part of the experiment program and according to experiment data acquired, the relationship was analyzed between primary and secondary factors, between influencing factors and test indicators. Better experiment conditions and experiment direction were obtained. According to the sheet forming theory and preliminary analysis of the actual situation through simulation, the test program of the five factors and four levels was choosed($L16,4^5$). Specific programs were shown in Table 1. And a corresponding level table was shown in Table 2.In table 2 C factor (column) is BHF coefficient, which BHF is calculated as follows, BHF = 150 * blank circle area * BHF coefficient. T of D factors for sheet is initial thickness. The initial size of the sheet refers to minimum distance from the outermost edge to the center of the sheet. When the front fender molding, sheet initial shape is pentagon sheet.

Table 1 Test Program

| NO. | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| fctor | A | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 |
| | B | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| | C | 1 | 2 | 3 | 4 | 2 | 1 | 4 | 3 | 3 | 4 | 1 | 2 | 4 | 3 | 2 | 1 |
| | D | 1 | 2 | 3 | 4 | 3 | 4 | 1 | 2 | 4 | 3 | 2 | 1 | 2 | 1 | 4 | 3 |
| | E | 1 | 2 | 3 | 4 | 4 | 3 | 2 | 1 | 2 | 1 | 4 | 3 | 3 | 4 | 1 | 2 |

## 3. DATA MEASUREMENT PROCESSING

### 3.1 Related parameters of front fender molding parts

In the actual forming ,BHF is 600KN, forming force 1050KN. Sheet Baosteel ST14. The thickness of 0.8mm, the Young's modulus of 210GPa, Poisson's ratio of 0.3, a thick anisotropic coefficient 2.105, strain hardening coefficient of 0.5436, 0.243 strain hardening exponent.

### 3.2 Data Measurement

According to the front fender molding characteristics and analysis of the actual forming parts, Different thickness area of measurement was selected, such as large deformation angle section, rounded top part and small deformation plane. Combining CAD model to determine the three-dimensional coordinates of the measuring point, in different regions of the actual molded article total 44 points were measured, and to determine a reference point.

In numerical simulation with Pamstamp2G software, final forming position calculation of different model has some offset, based on the reference point on the Z-axis coordinates conversion, conversion of the coordinate values acted as the position coordinate points of the thickness measurement. When measuring the thickness of the local interpolation was carried out if necessary. Figure 1 is a factor test No. 1-8 numerical simulation measured thickness curve.

Table 2: Level Table

| No. | friction coefficient between Punch, blank holder and sheet (A) | friction coefficient between die and sheet(B) | Coefficient of BHF(C) | Gap of punch and die(D)/mm | Initial sheet size(E)/mm |
|---|---|---|---|---|---|
| 1 | 0.09 | 0.09 | 0.90 | 0%*t | 40 |
| 2 | 0.09 | 0.10 | 0.95 | 5%*t | 60 |
| 3 | 0.09 | 0.11 | 1.00 | 10%*t | 80 |
| 4 | 0.09 | 0.12 | 1.05 | 15%*t | 50 |
| 5 | 0.10 | 0.09 | 0.90 | 0%*t | 50 |
| 6 | 0.10 | 0.10 | 0.95 | 5%*t | 80 |
| 7 | 0.10 | 0.11 | 1.00 | 10%*t | 60 |
| 8 | 0.10 | 0.12 | 1.05 | 15%*t | 40 |
| 9 | 0.11 | 0.09 | 0.90 | 0%*t | 60 |
| 10 | 0.11 | 0.10 | 0.95 | 5%*t | 40 |
| 11 | 0.11 | 0.11 | 1.00 | 10%*t | 50 |
| 12 | 0.11 | 0.12 | 1.05 | 15%*t | 80 |
| 13 | 0.12 | 0.09 | 0.90 | 0%*t | 80 |
| 14 | 0.12 | 0.10 | 0.95 | 5%*t | 50 |
| 15 | 0.12 | 0.11 | 1.00 | 10%*t | 40 |
| 16 | 0.12 | 0.12 | 1.05 | 15%*t | 60 |

## 3.3 Analysis of the results of data processing

The corresponding factor test thickness measurements are compared with measurements values of the actual number of formed parts, relative error was calculated according to the numerical simulation and the actual molding part thickness. Error for each point was represented by △ij,in which i was the factor test number(i=1-16), j was the number of measurement points(2,4,6,…….). $\triangle ij=[(P_j-p_{ij})/P_j]^2$,in which,$P_j$ was the actual formed parts thickness, $p_{ij}$ was the numerical thickness of j in test expermiment j. In table 3, the orthogonal experiment results of data processing were given.R- maximum difference, That is the difference between maximum and minimum values for each column.

R's size reflects impact on the index size due to select different levels of same column factors. Table 3 shows: R of the third column and fifth column is 1.2791 and 1.4374. R of the first column is only 0.2868. R of the second and fourth is 0.6470 and 0.4287, whose impact is far less than the third and the fifth column, close to the first column.

Test results can be seen from the orthogonal experiment. Initial Sheet size and BHF have much influence on thickness of formed parts. While punch and the friction factor between blank holder and the sheet metal have small influence on thickness of formed parts(as shown in Figure 2). BHF affected the thickness of the formed and intial sheet sizes from 40mm to 50mm affected the thickness largerly, the total error is from 5.4487 to 6.6016. Punch and die gap have much impact thickness of formed parts largely, when the punch and die gap is reached 5% of sheet thickness, the total error of thickness is 6.2669 .The influence of die and the friction coefficient between the die and the sheet metal on the thickness is not significant, but the actual impact on the friction is very critical.

# 4. CONCLUSION

1. Five factors influencing the forming results were as follows: initial sheet size, BHF, punch and die gap ,friction factor between the die and the sheet metal, and friction factor of punch and blank holder and the sheet metal.

2. The initial size of the sheet and BHF have greater impact on the results, molds and sheet metal friction factor, the gap of the punch and die have less impact on the results.

3. Fender of car was not too complex exterior parts in the automotive parts, if complex automotive parts for analysis, then, the obtained results should be made the necessary corrections.

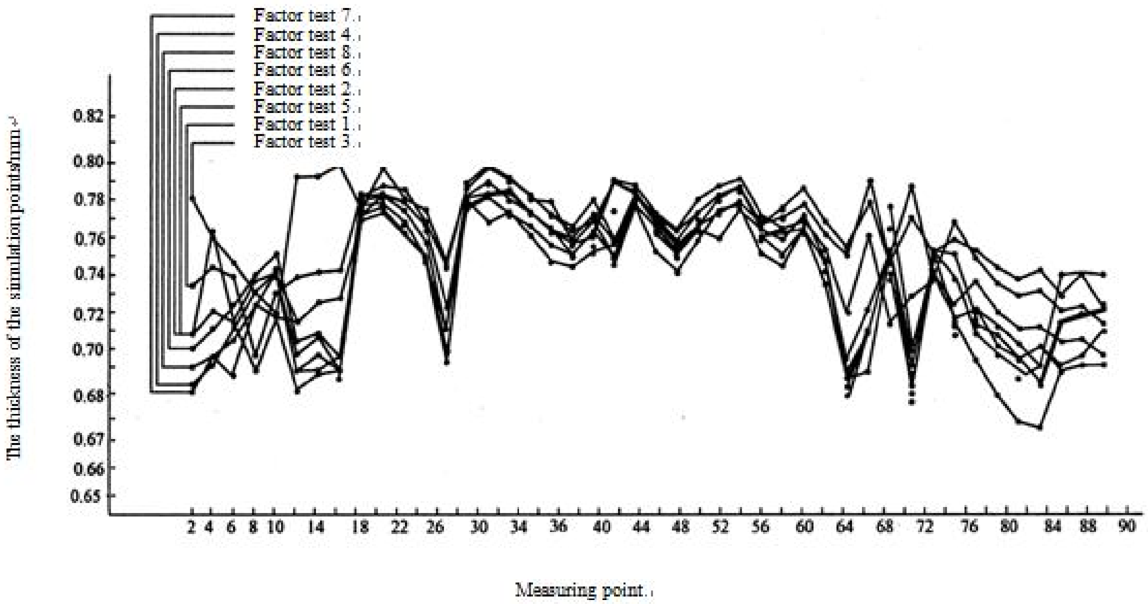


Figure 1 Thickness curve of factors 1-8

Table 3 Orthogonal test results

| NO. | Column No. | | | | | |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | Total error |
| 1 | 1 | 1 | 1 | 1 | 1 | 1.3158 |
| 2 | 1 | 2 | 2 | 2 | 2 | 1.6213 |
| 3 | 1 | 3 | 3 | 3 | 3 | 1.7019 |
| 4 | 1 | 4 | 4 | 4 | 4 | 1.9047 |
| 5 | 2 | 1 | 2 | 3 | 4 | 1.4920 |
| 6 | 2 | 2 | 1 | 4 | 3 | 1.4876 |
| 7 | 2 | 3 | 4 | 1 | 2 | 1.8944 |
| 8 | 2 | 4 | 3 | 2 | 1 | 1.3829 |
| 9 | 3 | 1 | 3 | 4 | 2 | 1.7650 |
| 10 | 3 | 2 | 4 | 3 | 1 | 1.5198 |
| 11 | 3 | 3 | 1 | 2 | 4 | 1.4469 |
| 12 | 3 | 4 | 2 | 1 | 3 | 1.7274 |
| 13 | 4 | 1 | 4 | 2 | 3 | 1.8158 |
| 14 | 4 | 2 | 3 | 1 | 4 | 1.7580 |
| 15 | 4 | 3 | 2 | 4 | 1 | 1.2301 |
| 16 | 4 | 4 | 1 | 3 | 2 | 1.6054 |
| □ | 6.5437 | 6.3886 | 5.8557 | 6.6956 | 5.4487 | T=∑△i =25.6691 |
| □ | 6.2569 | 6.3867 | 6.0709 | 6.2669 | 6.8861 | |
| □ | 6.4591 | 6.2734 | 6.6078 | 6.3191 | 6.7327 | |
| □ | 6.4094 | 6.6204 | 7.1438 | 6.3875 | 6.6016 | |
| R | 0.2868 | 0.3470 | 1.2791 | 0.4287 | 1.4374 | |

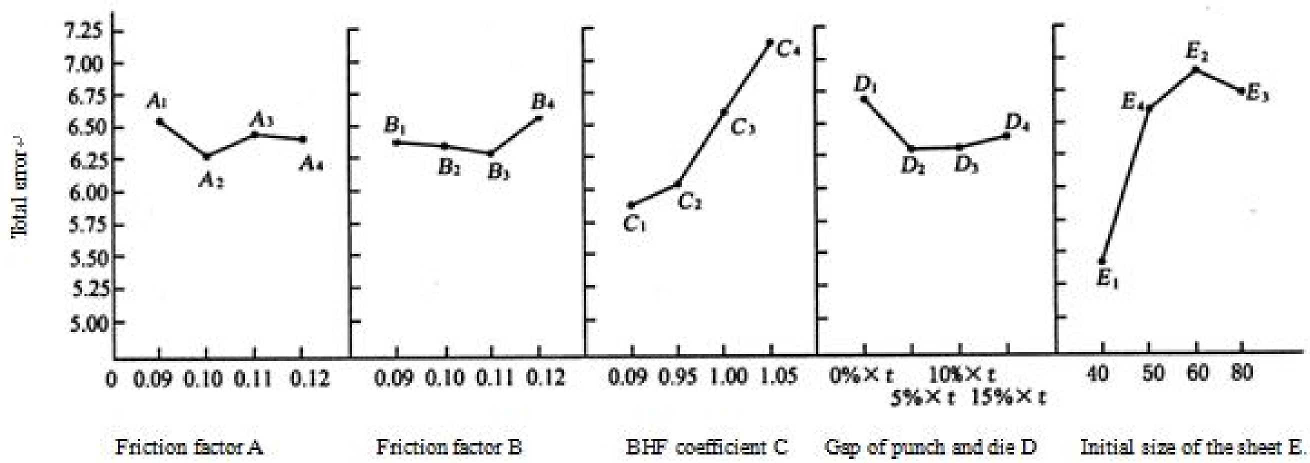


Figure 2 The impact of various factors on the thickness of the forming

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