Analysis of resistant-bias loading of 12,000KN fine-blanking press frame

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Keywords: fine-blanking press frame, resistant-bias loading, variable-control method

Abstract. For the 12,000KN fine-blanking machine's complexity, instantaneous, heavy stress conditions and fine-blanking die's high-precision, which puts forward a high stiffness requirement of the equipment, the structure of fine-blanking press frame was designed, and its finite element analysis model was established. Combined with variable-control method, research was done by Hyper works software about the frame's tilt amount affected by the thickness of side standing plate, main vertical board and under the ribs when the eccentric load is imposed. It can lay the foundation for the design of fine-blanking press frame.

Introduction

Fine blanking is an advanced precision forming of plastic processing technology [1]. Fine-blanking press is the basis for the application of fine blanking technology. It's crucial to get a fine-blanking press with good rigidity, large bearing capacity, load deflection resistance ability and light weight [2]. To get fine-blanking parts of high quality, it is necessary to ensure that all parts of the fine blanking press have small work deformation, stress distribution and high guiding precision. As a more complex critical component, the structure of fine-blanking press frame is the key factor to ensure the reliable work and must be researched firstly [3,4]. This paper used the 12,000KN fine blanking press frame's tilt amount under the eccentric load as the test index, then the laws of plates' thickness(side standing plate, main vertical board and under the ribs) effect on the frame's tilt amount were studied combined with variable-control method.

Modeling and analysis of the fine-blanking press frame

12,000KN fine blanking press frame is welded by thick steel plate with closed [5] cuboids frame. The frame use Q235-A as the main material with elasticity's modulus of 200GPa, Poisson's ratio of 0.3, and density of 7850kg/m3. Here the mesh of machine frame was generated by Hypermesh using volume tetra, the element size is 30mm, and the element type is solid 95. The structural model of the frame is shown in Figure 1 and Figure 2.

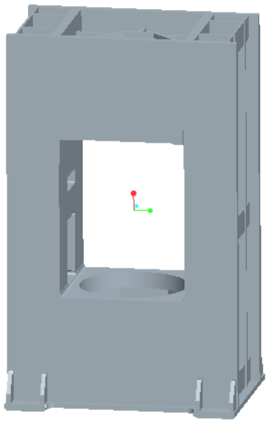

Figure 1. 3D model

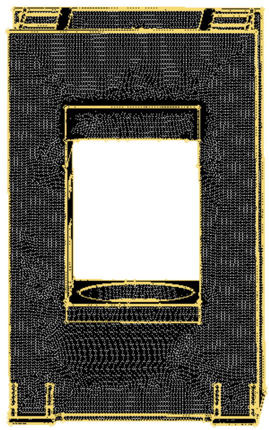

Figure 2. Finite element model of the frame

Considering resistant-bias loading of 12,000KN fine blanking press frame, the eccentric load was applied according to the test diagram as shown in Figure 3. The eccentric load P were 1000, 2000, 3000, 4000, 5000, 6000KN, respectively. When eccentric load is applied to the fine blanking press, the up and down working table will bear to the P load. The distribution of down working table load is a rectangle regional with the load direction being vertically downward. The rectangle area includes 74 nodes, so (P/74) KN is applied to each node. The distribution of up working table load is a rectangle regional with the load direction being vertically upward. There are 150 nodes in the square area, so (P/150) KN is applied to each node. As the frame is fixed on the ground using the anchor bolt, no displacement of the frame bottom produces in the vertical direction. Therefore, the constraint is equivalent to zero displacement in each direction of all nodes as shown in Figure 4. Using δ as the frame's tilt amount.

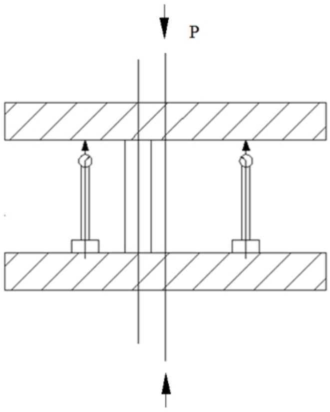

Figure 3. Test diagram

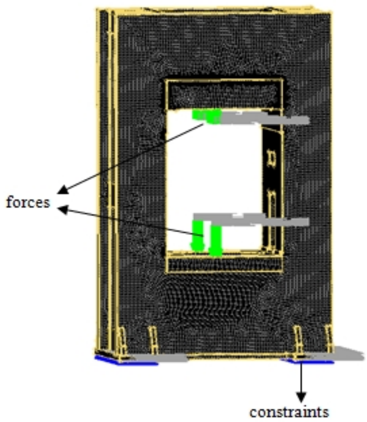

Figure 4. Model after applying constraints and loads

Here are the static analysis results of the static analysis when P = 1000KN. The strain distribution of the 12,000KN fine blanking press frame is shown in Figure 5. The tilt amount of the frame is reflected by the displacement difference between the given point in X direction. The law of eccentric load effect on δ is shown in Figure 6. Test standard values are shown in Table 1. Test results are shown in Table 2. (Test results have been rounded off according to the maximum precision that the dial indicator can measure)

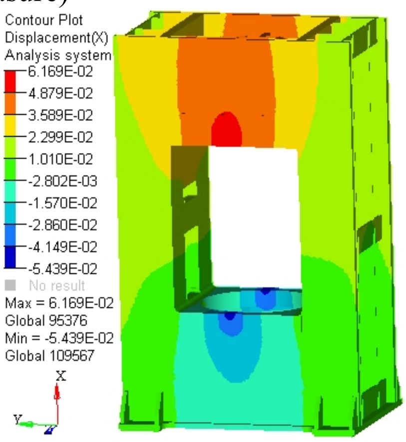

Figure 5. The strain contours of the frame

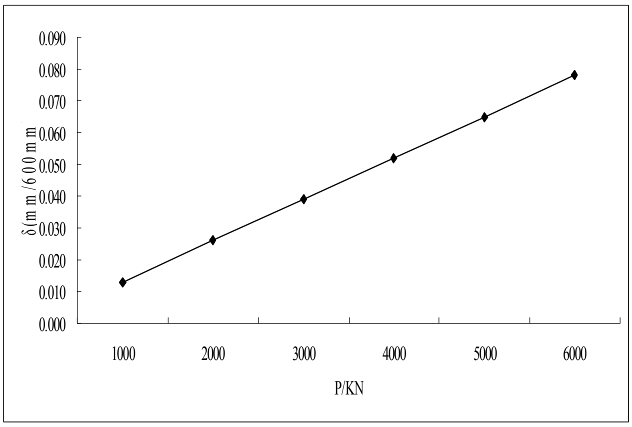

Figure 6. Law of eccentric load effect on δ

Table 1. The tilt of the standard reference value

No.	Load [KN]	Dial indicator value on the right [mm]	Dial indicator value on the left [mm]	Tilt [mm /600mm]
1	1000	0.280	0.240	0.040
2	2000	0.378	0.292	0.086
3	3000	0.476	0.344	0.132
4	4000	0.575	0.396	0.179
5	5000	0.674	0.448	0.226
6	6000	0.772	0.500	0.272

Table 2. The tilt of the test results

No.	Eccentric load P [KN]	δ [mm/600mm]
1	1000	0.013
2	2000	0.026
3	3000	0.039
4	4000	0.052
5	5000	0.065
6	6000	0.078

Analysis of the frame's resistant-bias loading

The frame's tilt amount is effected by plates thickenss at each position. The main influencing parameters are, main vertical board thickness, side standing plate thickness and under the ribs thickness. Keeping other parameters constant, the effect of each parameter on the frame's resistant-bias loading was studied in turn. Using A as main vertical board thickness. Using B as side standing plate thickness. Using C as under the ribs thickness.

The effect of main vertical board thickness

Static analysis was made in a series of main vertical board with different thickness in same material, and the load P = 1000KN. The results are listed in Table 3.The effect law is shown in Figure 7.

The data in Table 3 and Figure 7 shows, the frame's tilt amount decrease with the increase of main vertical board thickness.

Table 3. tilt amount under various thickness

A [mm]	δ [mm/600mm]	B [mm]	δ [mm/600mm]	C [mm]	δ [mm/600mm]
80	0.015	80	0.013	30	0.013
85	0.015	85	0.013	35	0.013
90	0.014	90	0.013	40	0.013
95	0.014	95	0.012	45	0.012
100	0.013	100	0.012	50	0.012
105	0.013	105	0.012	55	0.012
110	0.012	110	0.012	60	0.012
115	0.012	115	0.012	65	0.012
120	0.012	120	0.012	70	0.012
125	0.012	125	0.012	75	0.012
130	0.011	130	0.012	80	0.012

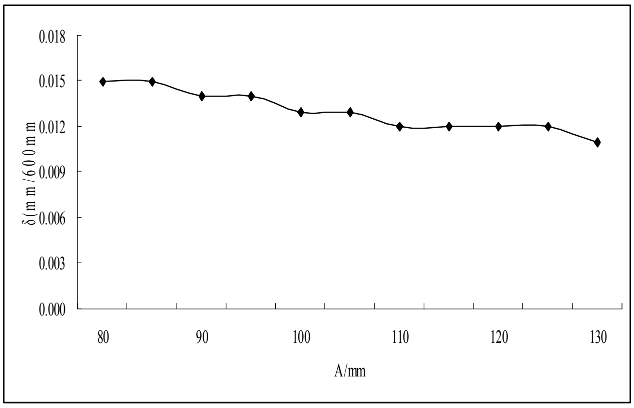

Figure 7. Law of main vertical board thickness effect on δ

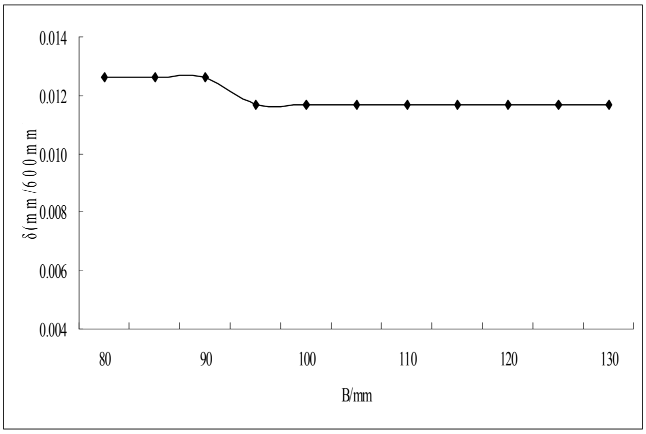

Figure 8. Law of side standing plate thickness effect on δ

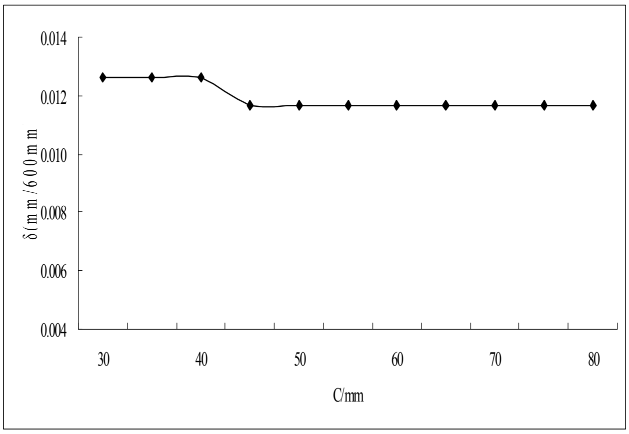

Figure 9. Law of under the ribs thickness effect on δ

The effect of side standing plate thickness

Static analysis was made in a series of side standing plate with different thickness in same material. The results are listed in Table 3.The effect law is shown in Figure 8.

The data in Table 3 and Figure 8 shows, the frame's tilt amount shows a decreasing trend overall with the increase of side standing plate thickness. The tilt remained basically unchanged when the thickness is in 80-90mm and greater than 95mm; and the tilt decreased when the thickness changed from 90mm to 95mm.

The effect of under the ribs thickness

Static analysis was made in a series of under the ribs with different thickness in same material. The results are listed in Table 3.The effect law is shown in Figure 9.

The data in Table 3 and Figure 9 shows, the frame's tilt amount shows a decreasing trend overall with the increase of under the ribs thickness. The tilt remained basically unchanged when the thickness is in 30-40mm and greater than 45mm; and the tilt decreased when the thickness changed from 40mm to 45mm.

Conclusions

In this paper, static analysis of the 12,000KN fine- blanking press frame was done using FEM. Laws of different plate thickness effect on the frame's tilt amount are studied combined with variable-control method, the main conclusions are as follows,

(1) The frame's tilt amount is obtained through the static analysis, which is far less than the allowable value in Table 1, resistant-bias loading of the frame can meet the requirements fully. And a linear relationship between the frame's tilt amount and the applied load is found.

(2) Laws of different plates thickness(side standing plate, main vertical board and under the ribs) effect on the frame's tilt amount are obtained through variable-control method. Considering the frame's resistant-bias loading only, the main vertical board thickness can take the value greater than 100mm, the side standing plate thickness can choose 95mm and the under the ribs thickness can choose 45mm preferentially. It can lay the foundation for the design of fine-blanking press frame in next step.

Acknowledgements

The authors would like to thank the Independent Innovative Foundation of WuHan University of Technology (Undergraduate class) (NO. 2014-CL-B1-21) and Cooperation of production, study and research in HuBei for"The12000KN numerical control fine blanking press" (NO. 2013BAA012) for the support given to this research.

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