

Research on Slider Stiffness for Straight Side Two-point High Speed Precision Press Based on Solidworks Simulation

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Abstract—Slider is an important power output component for high-speed precision presses, which requiring a higher stiffness (less deformation). The mold and stamping part's size were generally not considered for the traditional analysis method. In this paper, the length and thickness of the equivalent upper die and the size of the stamping parts were fully considered for the finite element analysis of the slider parts for a 3000kN straight side two-point high-speed precision press and the stiffness was much higher than the traditional one. The stiffness effects of equivalent upper die thickness, feed width, equivalent upper die length and eccentric load were studied. The results show that: the effect of equivalent upper die thickness on the stiffness was greater than that of the feed width; the equivalent upper die length's shorten will result in a decrease of the stiffness of the slider; biasing the mold will improve the stiffness of the slider when using a small mold.

Keywords—slider stiffness; high-speed precision press; die size; partial load

I. INTRODUCTION

With the characteristics of automatic, precise and high efficiency High-speed precision press is widely used in modern industrial production and it is very suitable for standardized, serialized and batch functional stamping parts(1). Compared with ordinary presses, high-speed precision presses require higher stiffness. Slider is an important power output components for the high-speed precision press and its stiffness directly affects the accuracy of stamping parts and die life. When calculating the deformation caused by the bending normal stress and the bending shear stress the slider is regarded as a stout beam, which is very different from the actual situation. And the allowable deformation is taken as $1/6000 \sim 1/8000$ slider length(2). The existing researches(3-6) mostly focus on the stress and deformation of the slider under static load and the structure optimization based on the purpose of weight loss. The impact of the mold (geometric size, partial load, etc.) is not considered in the analysis. The 3000kN straight side two-point high-speed precision press (for the stater and rotors' stamping) was researched considering the stamping parts and mold on the slider stiffness in this article. Research results for reference only.

II. SLIDER STRUCTURE

The slider structure of the 3000kN straight side two-point high-speed precision press is shown in Figure I. The slider body was cast from HT300. For precision repair after long-time using the transition plate (usually made of hard aluminum alloy or Q235A steel) was usually installed in the bottom of slider body by bolts. This additional transition plate helps to increase the rigidity of the slider and needs to be taken into account in analysis. Upper mold was fixed below the transition plate by the T-bolts and the connection stiffness was not considered in the later analysis.

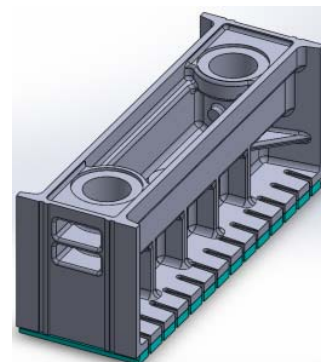


FIGURE I. SLIDER STRUCTURE

III. DIE SIZE AND FEED WIDTH

The maximum allowable die weight was designed to 2000kg for the 3000kN press. The size of the bottom surface of the slider was designed to 2300 (Left and right) x 800 (before and after) mm and the height of the die is 470~520mm. According to the provisions of the detection range in GB / T 29548-2013 high speed precision straight side press-Testing of the accuracy, the size of the mold is assumed to be 2100x640mm or less. The upper die thickness is generally less than half the die height and the thickness is about 190.8mm (Die steel density in accordance with 7800kg / m³ calculation).

Double or triple progressive die was generally installed in the 3000kN press and material width is 450mm, 400mm, 350mm and 300mm and other specifications. Therefore, the width of force zone can be divided according to the above material width in bottom of the equivalent upper mold.

IV. FINITE ELEMENT ANALYSIS

The slider components to be analyzed is composed of slider body, transition plate and equivalent upper die and the materials and properties are shown in Table I. The contact parameters in the assembly are set according to the system defaults.

TABLE I. MATERIAL PROPERTIES FOR SLIDER COMPONENTS

	material	Elastic Modulus /GPa	Poisson's ratio	Yield stress /MPa	Limit stress /MPa
Slider body	HT300	143	0.27	-	300
transition plate	Q235A	210	0.33	235	390
equivalent upper die	20Cr	210	0.3	540	640

1/4 slider part was taken for analysis due to the symmetry of the structure and a symmetrical constraint was Applied on the symmetry section(shown in Figure II).A uniform load of 750kN is applied to the divided area(material width of 400 mm) of the bottom of equivalentuppermold (shown in Figure II). And a fixing constraint was imposed on the lower guide sleeve's mounting surface in the slider body(shown in Figure II).The slider body has a very high guide stiffness due to eight guide rails used. Therefore, the guide parts of the slider body were not limited.

The system default parameters were used in grid types (solid grid, grid size 27.47mm, grid error 1.37mm). Meshed model was shown in Figure II and 138393 nodes and 91754 cells were gotten.

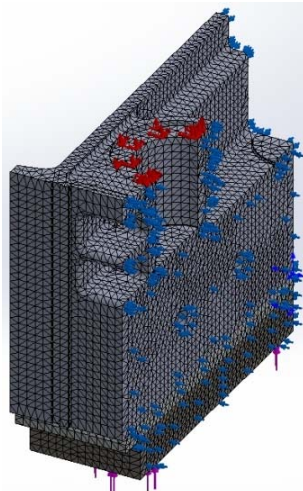


FIGURE II. MESHED SLIDER PARTS

V. CALCULATION RESULTS

As the slider body is made of brittle material(HT300), the tensile stress (P1) can be more appropriate to assess the structure's safety (7) and calculation results was shown in Figure III. The maximum stress of 29.6MPa appeared in the fillet and most of the rest of the stress were within 15MPa. The calculated safety factor is 5.12, which is greater than the minimum allowable safety factor of 1.6 to 2.5 for brittle materials (8).

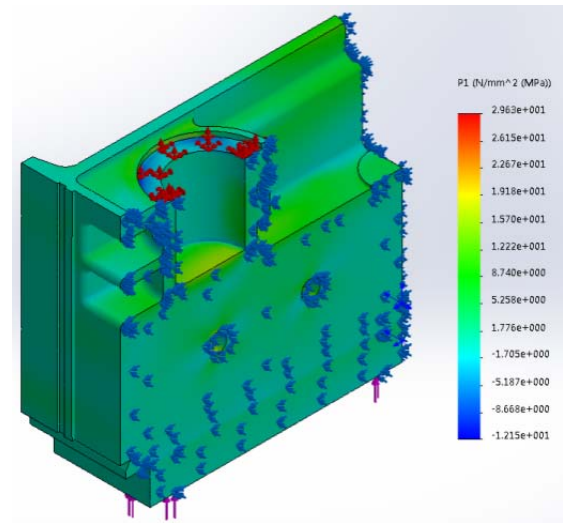


FIGURE III. STRESS DIAGRAM (TENSILE STRESS)

The Y-direction displacement diagram of the slider part was shown in Figure IV. The maximum displacement of 0.2742mm appeared in the middle of the slider. For the slider, the displacement of the middle was 0.2690mm and the outer was 0.1018mm. The deformation of the slider can be calculated as 0.1672mm (the slider's stiffness is about 1/14055). The slider body length is 2350mm. Therefore, the allowable deformation is 0.294 ~ 0.392mm.

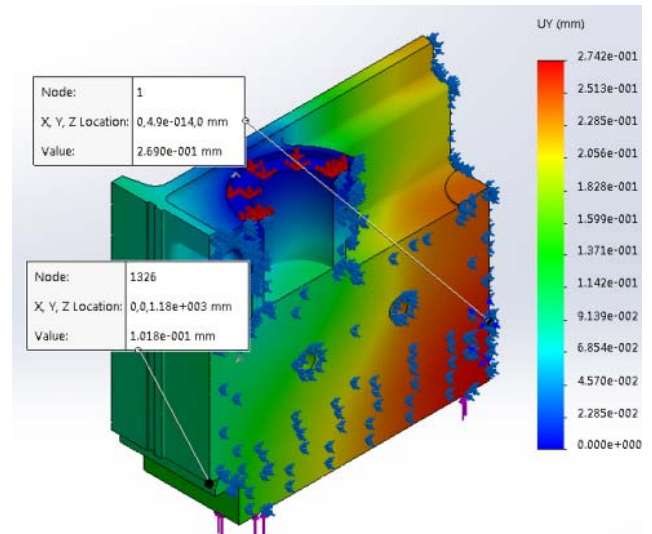


FIGURE IV. DISPLACEMENT DIAGRAM

VI. DISCUSS

A. Compare with Other Analysis Methods

Loading method reference(2) provided was shown in Figure V, where L is the left-right length of the slider and l is the distance between the two plunges' center. And the fixed constraint was imposed on the two plunges. The uniform nominal force Pg is applied at l (l = 1600mm and Pg=3000kN in this analysis).

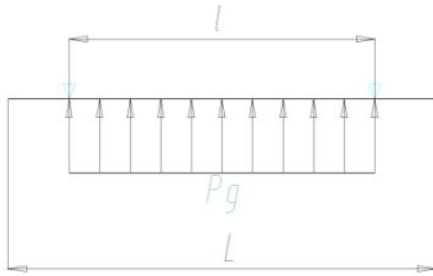


FIGURE V. SLIDER LOADING METHOD

1/4 slider parts taken to analysis according to the above loading method. Figure VI is the tensile stress diagram, the maximum stress reaches 88.9MPa and most of the stress at 45MPa. The calculation results were larger.

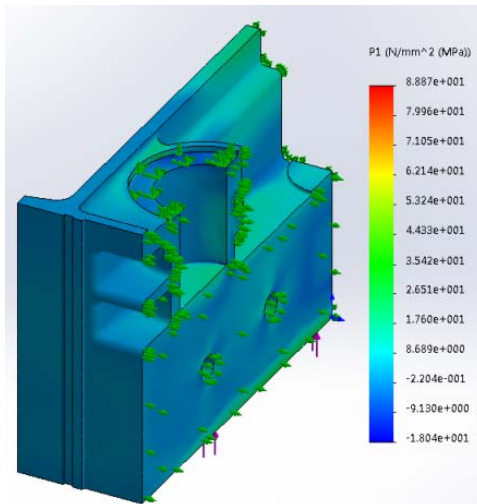


FIGURE VI. TENSILE STRESS DIAGRAM

Figure VII is the displacement diagram and the maximum displacement of 1.4mm appeared in outside of the slider parts' central area. The displacement of the slider's central area is 0.430mm, and the outside displacement of the central area (left and right direction) is 0.010mm. Therefore, the deformation amount of the slider is 0.420mm, which is lower than the maximum deformation required.

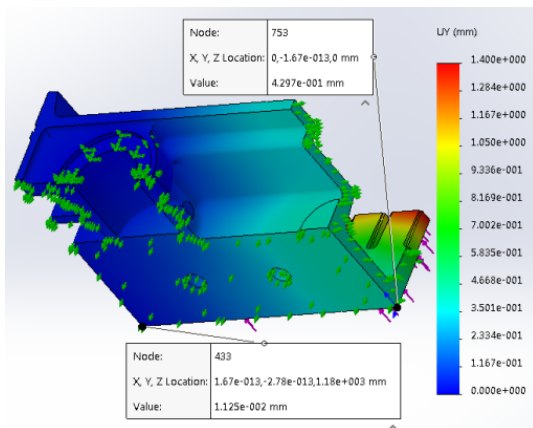


FIGURE VII. SLIDER PARTS' DISPLACEMENT DIAGRAM

B. Feeding Width and Mold Thickness

Finite element analysis refereeing to the above constraints and loading method were performed by varying the equivalent upper die thickness (i.e, changing the upper die weight) and the feed width with the same die length and width. Equivalent upper die thickness were taken 170mm, 150mm, 130mm, 110mm and 90mm. And the feed width were taken 450mm, 400mm, 350mm, 300mm and 250mm. Table II was the slider deformation data. It can be seen from the following data that the effect of the equivalent upper die thickness on the slider stiffness is greater than the feed width.

TABLE II. SLIDER DEFORMATION WITH DIFFERENT FEED WIDTH AND THICKNESS OF THE EQUIVALENT UPPER DIE/ MM

thickness of the equivalent upper die/mm	feed width/mm				
	250	300	350	400	450
90	0.1826	0.1824	0.1823	0.1822	0.1821
110	0.1787	0.1785	0.1784	0.1783	0.1783
130	0.1747	0.1746	0.1746	0.1745	0.1745
150	0.1710	0.1710	0.1709	0.1708	0.1708
170	0.1673	0.1673	0.1672	0.1672	0.1672

C. Die Length

Some small size mold (smaller punch force) also can installed on this 3000kN straight side two-point high-speed precision press. As the 2000kN and 1250kN straight side two-point high-speed precision press's standard bolster length are generally 1700mm and 1300mm, so the stamping force adjusted accordingly. The equivalent upper die thickness is 130mm and feed width is 300mm. The slider deformation with different mold length and nominal force was shown in Table III. It can be found in Table III that the smaller the mold size, the greater the deformation of the slider under the same stamping force.

TABLE III. SLIDER DEFORMATION WITH DIFFERENT DIFFERENT MOLD LENGTH AND NOMINAL FORCE/ MM

	mold length /mm				
	2000	1800	1600	1400	1200
nominal force/kN	3000	3000	2000	2000	1250
deformation/mm	0.19	0.22	0.16	0.19	0.13

D. Partial Load

For some small size mold the mold was often deviate from the press center. The following settings were made: the die size was 800 mm, the punch force was 800 kN, the feed width was 250 mm, and the die rim was 50 mm away from the center of the slider. Half slider components was taken to analysis (Figure VIII) and the relation between the mold offset and the slider deformation was shown in Table IV. It can be found in Table IV that the slider deformation decreases with the mold installation deviation from the geometric center of the slider 0 ~ 300mm and the deformation increased slightly when the deviation reaching 350mm.

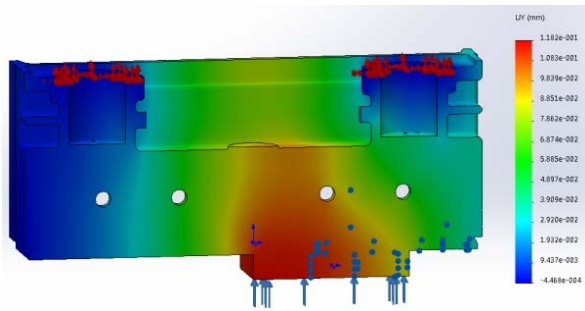


FIGURE VIII. SLIDER PARTS' DISPLACEMENT DIAGRAM(PARTIAL LOAD)

TABLE IV. SLIDER DEFORMATION WITH THE MOLD OFFSET / MM

offset	0	50	100	150	200	250	300	350
Deformation	0.11	0.10	0.10	0.10	0.09	0.09	0.09	0.09
n	31	97	60	22	88	53	34	51

VII. CONCLUSION

The deformation of the slider will be significantly reduced when the transition plate and the equivalent upper die are taken into account. Under the same pressing force, different feed widths (i.e, the divided area of the equivalent upper die) has little influence on the rigidity of the slider and the thickness of the equivalent upper mold has a greatly affects. When the punch force is same, the smaller the equivalent upper mold's length, the worse the slider rigidity. Biased use helps to reduce the amount of slider deformation when using a small mold.

ACKNOWLEDGEMENTS

The author wish to thank the Opening Project of Research Department of Intelligent Manufacturing Equipment of Nanjing Institute of Technology (project number: PTKJ201608) and The introduction of talent research fund project of Nanjing Institute of Technology (project number: YKJ201503).

REFERENCES

- [1] Yuzhi Yan. Simulation and Optimization of Operating Mechanism and Frame of the LTH450T High-speed Press[D] (Master Thesis). Jinan: Shandong University, 2014.(in Chinese)
- [2] Deyu He. Crank Press[M]. Beijing: China Machine Press, 1981.(in Chinese)
- [3] Yunxiao Fan, Congcong Guan, Qisheng Chen and Bo Mou.Optimum Design for Slider of JA39-1200E Press[J]. Coal Mine Machinery, 2012, 33(12):32-34.(in Chinese)
- [4] Qisheng Chen. Optimized design of Slider for L4-1200M3 Press[J]. China Metalforming Equipment & Manufacturing Technology, 2013, 48(5):24-26.(in Chinese)
- [5] Junyong Zhan, Jianming Huang and Jinyi Zhang.The Finite Element Analysis and Optimization of Slider in Double-point Press[J]. China Metalforming Equipment & Manufacturing Technology, 2010, 45(6):43-44.(in Chinese)
- [6] Huawei Ye and Jianhua Mo. Research on Lightweight Design of Servo Press Slider[J]. Forging & Stamping Technology, 2016, 41 (2):103-108. (in Chinese)
- [7] Chaoliang Chen and Xiuzi Ye. SolidWorks Simulation Fundamentals (2010 Edition)[M]. Beijing:China Machine Press, 2010.(in Chinese)
- [8] Xuanhui Qun editor. Mechanical Design (Fourth Edition) [M]. Beijing: Higher Education Press, 1997.(in Chinese)