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Reduction of Stress Concentration in a Frame Type "C" for Punch Press by Experimental and Numerical Methods

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Abstract: *Presses work is important in industrial activities for development of products, thus requiring optimal performance at competitive costs. The effective use of materials manufactured machinery is directly related to an appropriate stress analysis, especially if the geometry of the components are not prismatic bars, such as the frame of a stamping press which has a stress distribution very irregular and is convenient to optimize its shape, which we do by analyzing photoelasticity efforts through numerical methods and what is presented in this paper.*
Keywords: *gap-frame, numeric analysis,photoelasticity, stress analysis.*

I. Introduction

Presses have been used since ancient times, one type still used by primitive cultures is the simple, uncomplicated lever press, shown in figure 1 [1].The material used in these presses were wood and rock.

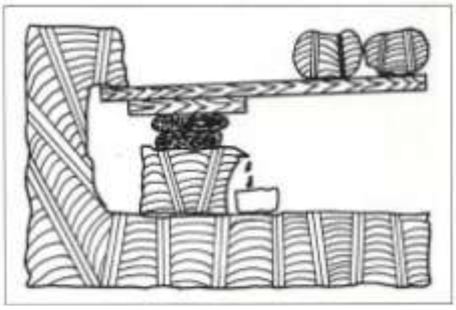


Fig 1: A simple lever press used to extract or press substances from vegetable matter [1].

Now there are many types of presses, for small parts of metal, is used a typical gap-frame open back mechanical press, like shown in figure 2. This machine has a frame made of AISI 1018 plate, which is the heaviest component. In 2013 we presented a work [2] whereanalysisthe stresses in the frame by photoelasticity and numerical methods. We observed areas of high stress concentration and areas where virtually no have stress, this means that material is wasted which increases the manufacture of the press, and this is prohibitive at this time of high industrial competitiveness, the fight for global markets requires investigate optimal ways of the geometries of machine components, that reduces cost.

Fig 2: Press type gap-frame [2].

A simple analysis according to the theory of mechanics of materials leads to a typical axial combined with bending problem stresses, the stress distribution would be linear as shown in Figure 3

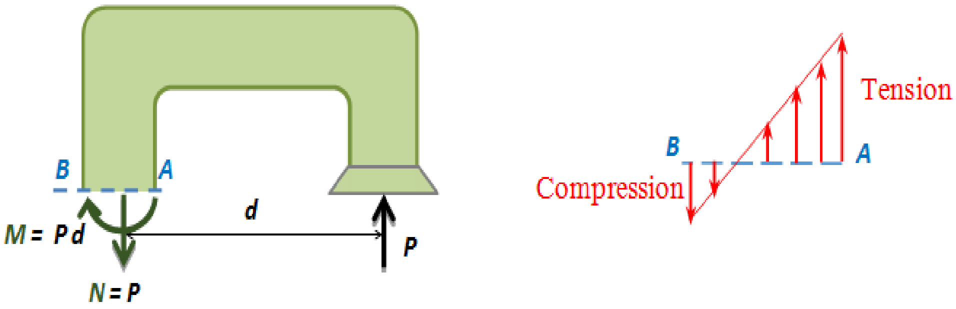
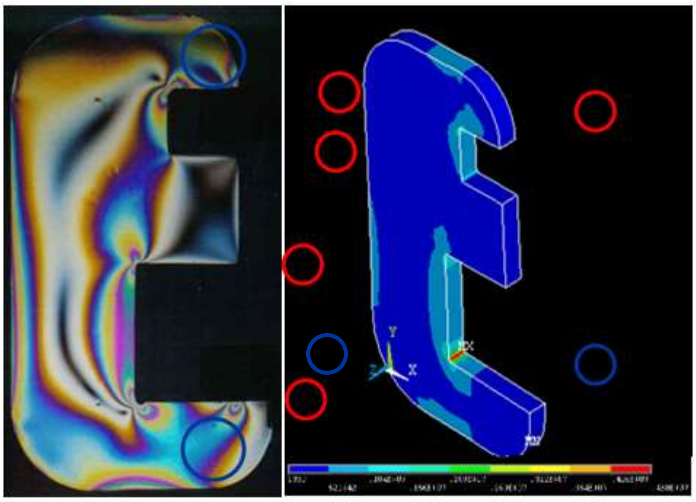


Fig 3: Variation of stress in a simple press by theory of mechanics of materials.

But nevertheless, the assumptions made in mechanics of materials are not applicable to the case of framework is intended to optimize. First by the shape of the cross section and then by stress concentrators. For these reasons we had to perform experimental and numerical analysis methods whose results are shown in Figure 4the photoelastic analysis showed four points of high stress and areas whit low stress. To achieve efficient distribution of stresses, we propose to increase material in areas of high stress concentration and removing material in low stress values.In figure 3 [2], shows the stress distribution in the frame, we can see four points of high stress (concentration of isochromatic fringes fig. 3a) concentration and some parts virtually without stresses (**blue color**in fig 4b)



a b

Fig 4: Results of stress analysis by a) photoelasticity b) numeric [2].

We decide increasing material in the vicinity of the four points of stress concentration shown with red circles and in the top low stress we reduced material.

II. Photoelasticity

The models for photelasticity was made by birefringent material in order to view fringe patterns produced in it when load is applied. The material is a polycarbonate with excellent optical properties whose trade name is PSM-1,also it allows manufacturing off model without changing its properties by the heat produced during machining.The reinforcing material is adhered with a special adhesive that does not change the optical properties of birefringence is a resin called a transparent PL-1which must be applied carefully to avoid remaining trapped air bubbles that distorting the formation of the fringe pattern.We propose to analyze four models for analysis of efforts. First a reduction of material in the upper radius, as shown in Figure 5b. For the two models shown in figure 5 is added material considerate two types of reinforcements; In the first case, separate reinforcements are added in the upper and lower zones of the spherical concentration, by means of "C" shaped figures, figure 6a, and another with a rebound covering the two zones by adding the "E" Figure 6b.

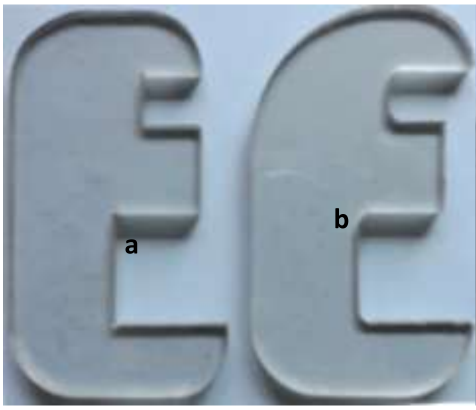


Fig 5: a) Original model, b) Model with reduction of material in the upper radius

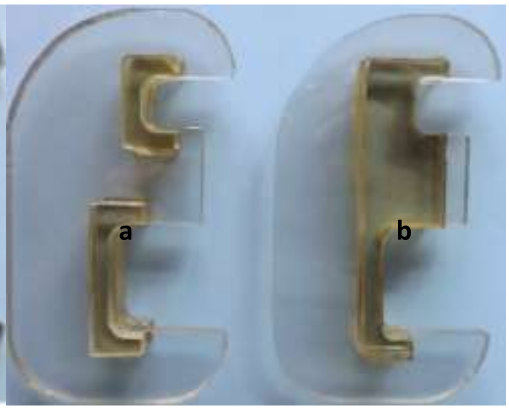


Fig 6: a) Model with reinforcements type "C", b) Model with reinforcements type "E"

It will be taken as reference the effort developed by the original model, which with a load of 50 N, develops a value of unitary effort of 4.17 MPa (figure 7).

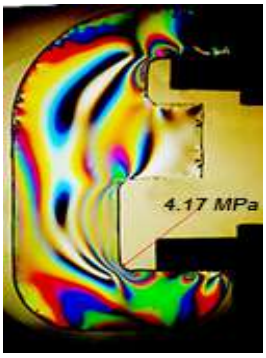


Fig 7: Original Model O.

The other four models are loaded with the same force of 50 N, obtaining the fringe patterns shown in Figures 8 and the results in table 1.

Fig 8: a) Model "OC" **Fig 8**: b) Model "OE" **Fig 8**: c) Model "RC" **Fig 8**: d) Model "RE"

In order to determine the stress developed in the model we will consider the method developed by Professor Henri Favre of the Polytechnic of Zurich [3], applied whit boundary condition shown in equation (1).

$$\sigma = \frac{N f_\sigma}{h} \qquad (1)$$

Where: N is the number of fringe,
f_σ is the photoelastic constant of material,
h is the thickness of model.

The results to applies to the four models the equation (1), are shown in table 1.
A numerical analysis was also performed using the ANSYS software (figure 9), where stress values are similar to those obtained by photoelasticity, which are shown in Table 1.

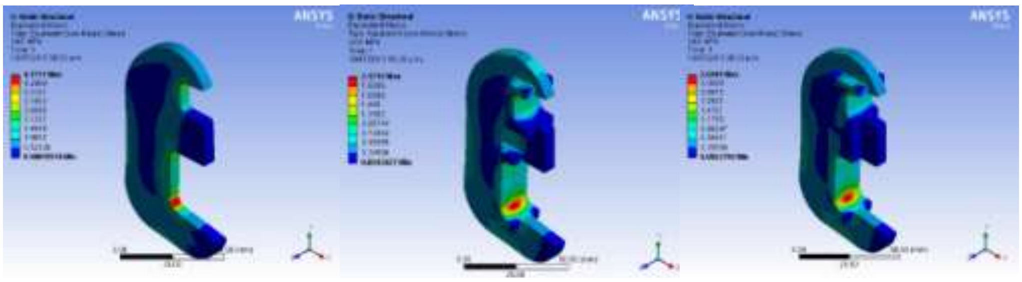


Fig 9: Numerical analysis.

Table 1. Stresses developed in the models.

Comparison of experimental and numerical results of stress concentration.			
Model	**Load**	**Stress (MPa) Photoelastic**	**Stress (MPa) ANSYS**
Original	50	4.17	4.77
OC	50	1.94	2.17
OE	50	2.33	2.65
RC	50	1.94	2.15
RE	50	2.33	2.64

Experimental analysis show that the reduction of stress in the case of reinforcement "E" is 44.1% and in the case of reinforcements "C" is 53.5%; and numerical analysis show that the reduction of stress is similar, 44.7 % and 54.5% respectively.The reinforcements increase the weight of the press, in the graph of figure 1.0 the increase of the volume of the model is presented, which is directly proportional to the weight of the frame. For the case of the OC model the weight increase is 22%.

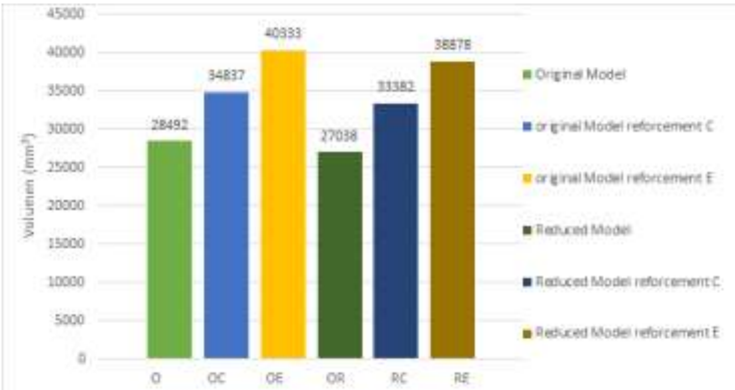


Fig 10: Comparative graph between the volumes of the models used.

III. Conclusion

The "C" reinforced model reduces stress concentrations by 54% with a volume increase of only 22 22%, because it is the best option to increase the strength of the press frame without a significant increase in its weight.When comparing experimental and numerical results, stress concentration reductions are consistent.The "E" reinforced model reduces stress concentration but increases its weight considerably, i.e. even increasing material in that area does not lead to an efficient reduction of stress concentration.

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