STUDIES REGARDING THE DIE FITTING AND RIGGING ON THE PRESS

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Rezumat: *Scopul acestui articol este de a prezenta rezultatele unui studiu cu privire la procesul de fixare şi reglare a unei matriţe nou proiectate pe presă. Subiectul poate fi baza unor studii viitoare cu scopul de a reduce numărul de paşi până la obţinerea unei piese corespunzătoare fără dificultate şi cu reducerea timpului. Într-o companie trebuie avută în vedere o strânsă colaborare între departamentele de simulare, laboratorul 3D şi atelierul de încercări pentru a descoperi zonele critice în piese şi măsurile ce sunt necesare.*

Abstract: *The purpose of this article is to present the results of a study regarding the process of fixing and rigging for a new designed die on a press. The subject can be a basis for further studies with the aim of reducing the number of steps until a proper part is obtained without difficulties and with time reducing. In a company a tight collaboration between the engineering and simulating departments, the 3D laboratory and the tryout tool shop must be considered in order to discover the critical areas in the parts and the measures that are required.*

Keywords: die, parallelism block gauges, rigging block gauges, compensators.

1. Introduction

Stamping has a history of over 150 years and it is largely applied to a great variety of materials based on their metal working from common metals to rare alloys. Cold stamping represents one of the most modern branches in technology offering great economic and technical advantages in making a large scale of works [14].

At global level nowadays there is a strong competition in reducing time and costs for the entire process of production, from the step of realising the part to die tryout, mounting on press and series production.

The correct execution of dies represents one of the main items in fabrication, because their quality determines industrial products and that is why active parts must be properly executed because they are the most important for a die [1]. The main part of devices for stamping and cutting are subjected to a continuous process of wearing and to compression dynamic efforts [8].

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It is known that tool wear is determined by the quality of the material, the constituents of the raw material, improper punch and die clearance, poor selection of tool steel, improper heat treatment of tool steels, dirt or debris in die, poor lubricant or lack of lubricant.

To obtain good quality dies are required advanced technological procedures, technical control during work, periodically checking and verifying. Also, if die design CAD is correctly applied it can avoid many design errors that often result in extensive die reworking during a die tryout program [11].

But beside designing, material quality, chemical composition, greasing, fabrication process, tolerances, wear and thermo treatment, an important item is represented by a correct rigging and fitting of the die for which are required specialized workers highly qualified. On all these the quality and the precision of production, the durability of stamping dies, equipment defects and damages avoiding depend [4].

After the die is designed, simulations and 3D measures are made. The simulations create a model for the process for studying behaviour (output data) in different experimental conditions (input data), as is a real model and the way in which the real system responds to the entering data changing [7].

The successful application of simulation depends on reliable input material properties and a good understanding of the problem [13].

Mounting, fixing and trying a new designed die on the press are actions that are continuously improved but there are numerous steps for making a good quality part and still require a lot of repetitive work.

In order to obtain a good fitting parallelism block gauges, rigging block gauges and compensators are necessary. For verifying the construction height are also required four reference block gauges and four block gauges for final of blank holder course.

2. Definitions of Block Gauges and Utilizations

According to specialised literature parallelism block gauges are mounted between the die and the blank holder in the four corners (usually they are of Φ100mm).

The fixture is made on the parallelism block gauges so as to ensure the parallelism. They have also the role of avoiding the swing/flip of blank holder during its tightening process. If parallelism block gauges are not used defect risks during the starting off due to the changing of the pressure points of the cushions will appear. In stamping operation cushions bring the required contra-pressure during the semi finished tightening and are also used for extracting parts. If there are used hydraulic die cushions these have the advantage of taking up less space than air cushions while offering controllable programmable resistance throughout their travel [10]. Using parallelism block gauges the tightening of the blank holder

can be done repeatedly no matter the number or the position of the pressure points. In conclusion a good equilibrium for efforts is assured.
Rigging block gauges are used to control the dimensions.
The Compensator is a block-gauge mounted on the blank holder, near the contour of semi finished to allow the tool to control the sheet displacement in series production. The compensator (usually of Φ50mm) compensates the variations of the material, the variations of weight, the variations of pressure supported by the semi finished during the downward displacement and also the wear of the tightening contact. On narrow parts they must be placed in front of ribs on die and on the blank holder and/or in front of application forces. After the blank holder is touched the compensator block gauges must be put in place with a clearance of 0.5 mm in relation to the studied one in order to avoid rectifying, and then the compensators must be adjusted. When a stamped part is obtained with the quality required a final adjustment of the compensators will be done with the help of a lead piece.

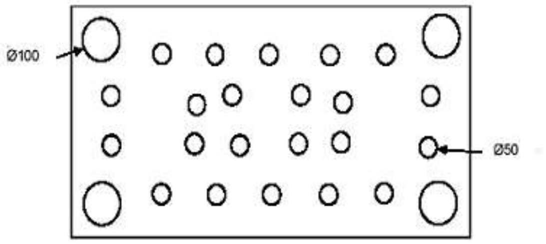

Fig. 1. Parallelism block gauges and compensators.

3. The Fitting Process

In order to obtain a good geometry and a high quality part it is necessary to obtain a perfect izostatism of the part and almost a perfect positioning of the part. To reach the final stage we make a tightening of the attack edge between the blank holder and the die. The semi finished can be 10mm greater than the tool tightening. The blank holder is pressed in parallel with the semi finished with the help of block gauges. After that the parallelism block gauges are painted in blue and the ram is moved down and again the parallelism is properly checked. Then rigging block gauges must be put under the parallelism gauges. The 4 parallelism block gauges are of course always of the same thickness. Now the sheet is painted in blue and the ram is got down. The blue areas left on the surface of the blank holder are polished with a Biax and the operation is repeated until all the surface of the blank holder is tightened. With Indian stone through a manual procedure the surface of the blank holder is grinded and in this way the plies and undulations can be seen very well. Then must be checked the radius for the stamping part. A first stamping is done at about 50% from the BDC after which the results are analyzed in order to see if there are cracks, undulations, plies on the metal sheet or if there is a certain clearance, the problems detected being solved. The operation is repeated with another semi finished at the same value. If everything is ok the operation will be done at 70, 80, 90% from BDC. If it is not ok the step is repeated until there will be no more problems. When 90% from BDC is reached the operation must be continued until the first contact with the die and when this is reached a lot of stamped parts will be made to this depth. Then the tool is dismounted and twisted so as to tighten the bottom of the die, the reference being the punch not the blank holder. When is reached 100% tightening of the bottom of the die, the surface is painted in blue and checked if the block gauges between the bed frame and the blank holder are not in contact when the tool is in beating because usually on the pillar of the plunger-pins there is a protection of 1mm.

Blue painting is frequently used in the stamping process. Anyway in order to establish the quality of the processed elements these are painted in blue paint in the interior of the model with a thin and uniform layer of Prussia blue, the punch being mounted on the upper part. The ram is got down or the inferior part is got up (depending on the type of the press) until the surface of the model touches the surface of the punch. In the higher points on the surface of the punch points will be painted that must be remediated. Inking is finalized the moment when the paint is uniformly distributed on the surface of the punch. Usually are accepted 80% $/cm^2$. Inking permits the checking of assuring the contact between the blank holder and the semi finished

Going back to die fitting, the main items are noticed and validated: the rigging parameters, high for closed tool usually of 1100-1600 mm (+/-1mm) (for a certain press this height must be constant in order to avoid other riggings), the pressure in boosters, the characteristics of the sheet, the degree of lubrication, greasing. The dimension for parallelism block gauges cannot be known from the first time.

Firstly we must estimate the A dimension. In order to do so we make a stamped part and the A dimension is estimated in the “closed tool” position. The block gauges are then made at a dimension of “A- 0.5mm”.

Further is added a piece of lead, and we measure the exact “A” dimension to be able to make the block gauges. Then we shall make a stamped part at 1/3 from BDC. The contact surface of the superior holster will be painted in blue. If the contact is equal to or greater than 30% it is considered correct. If not the procedure under compensators is repeated. When each compensator reached a 30% contact the reference called “zero compensator” is reached.

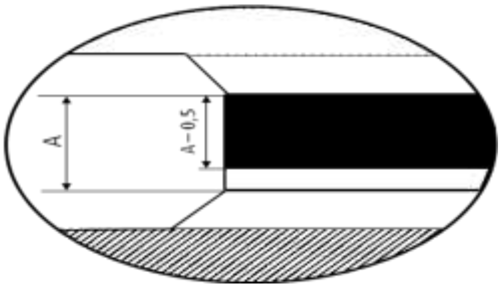

Fig. 2. Dimensioning the block gauges.

In the case in which the heights for pins reduction are not in the $\pm$ 0.05 tolerance, we must measure the “A” dimension and adopt it to $\pm$ 0.1 mm tolerance.
Then we must twist the blank holder and put it on the block gauges and work the pins in order to reach the $\pm$ 0.05 tolerance. These parallelism block gauges are situated in the four corners of the blank holder to permit the defining of a parallel distance irrespective of the “hard points” positions. A hard point induces the risk of getting out from the parallelism equilibrium. Industrial sheet metal is never entirely homogeneous, nor free of local defects. Defects may be due to variations in composition, texture or thickness, or exist as point defects such as inclusions. These are difficult to characterize precisely [6].

4. Establishing the High of the Assemble

The most important elements that have an impact on the tools are:
- Placing the press at BDC at idle and controlling the four corners of the ram by means of a micrometric gage. The maximum difference on length and width is of 0.1 mm per meter. If when misalignment is confirmed we can pass to the next step:
- Placing the press at BDC with representative adapter reductions for a cubic volume of a die, auctioning the press and controlling the four corners of the ram by means of a micrometer gage. The maximum tolerance on diagonal is of 0.2 mm. Misalignment produces the die displacement and punch displacement and consequently a non uniform clearance between them [3].
- Getting up the rods at the specified height and marking them. The difference for each rod is of 0.1 mm.

In order to establish the height of the construction, the four parallelism block gauges must be worked to obtain a +1 mm clearance between the two surfaces of the sheet. After that we lay them down on the marble and check the total height for the four superior corners with the help of a /marking gauge with vernier. The deviation must be 0.1 mm per meter.
If the measures show a 0.2 mm parallel misalignment on the diagonal then we shall measure and check the height of the blank holder and the height of the blank holder plus the height of the parallelism block gauge plus the height of reference

block gauges plus the height of the block gauge for the final of the blank holder course. When the correct tolerance for the height of the ensemble is obtained this must be confirmed, and we pass to the next step.

The four block gauges must be painted in blue and the tightening is verified for that minimum 30%. At the final of the course of the blank holder there we shall remove 2 mm + plus the sheet thickness from the height of the final course block gauges, then 1 mm from the height of parallelism block gauges and then mount the reference block gauges and paint in blue the die on the surface of the blank holder. After a cycle the contact of blank holder points is released and 0.1mm is removed from the four parallelism block gauges. After another cycle the contact points are released and again we remove 0.1 mm from the four parallelism block gauges, and again and again until the complete tightening to “iron on iron” is realised. The four block gauges are painted in blue and the tightening is checked for 30% at least.

In order to start the “iron on iron’ tightening 2 mm from the height of the block gauges at the final course of the blank holder must be removed. After reducing the block gauges the height must be checked so that the reductions of the rods do not surpass the inferior bed frame shoe (2 mm minimum). When the objective of “iron on iron” is reached under the parallelism block gauges must be added a block gauge equivalent to the thickness of the sheet for stamping. This is the reference the die is at the “zero” point.

The new idea given by this work compared to what exists in other specialised literature is the use of effort cells in order to measure the efforts for the same reason of checking parallelism. In this way it can support and complete the fitting and the parallelism of the entire press can be verified because the parallelism in effort will be balanced. In this experiment at least 16 consequent courses will be made with the press having the rigging of 606 mm, at a developed force of 400 Tf, when the surface of the ram is of 2500 x 1500, and the total admissible clearance between two opposed guide casings is 1.15-0.25 mm.

Table 1) Pressure measures on the eccentric rods.

PRESS : **SIMPLE EFFECT**			
PRELOADED PRESSURE: 63 BARI, MEASURES REALIZED AT A MEDIUM HEIGHT OF 610 mm			
Final Height position (mm)	Press on rod eccentric 1 (Tons)	Press on rod eccentric 2 (Tons)	Pressure (Bar)
610			63
609,5	2.9	1.1	67
609	21.3	18.2	69.3

608,8	31.2	28.7	72.8
608,6	43.6	41.8	75
608,4	57.1	56.2	78.8
608,2	65.6	64.8	80.9
608	82.1	82.5	84.1
607,8	91.4	91.7	84.6
607,4	119.1	120.4	91.4
607,2	129.6	132.1	94.4
606,8	156.1	158.3	103.8
606,6	172	172.7	110.6
606,4	183.4	183	116.6
606,3	195.9	195.4	125
606,2	196.2	195.5	125.2
606,1	202.4	201.5	127.5
606	212.4	212	135.5

Parallelism measured is:
- for 90° - 0.15 mm/m
- for 180° - 0.10 mm/m
- for 270° - 0.15 mm/m

The conclusion was that the fitting and parallelism of the press were properly made in the above-mentioned conditions.

5. Contribution for Further Researches

The new idea given by this work is to use effort cells on the area of parallelism block gauges in order to measure the efforts on each of them. In this way it can support and complete the fitting and it can verify the parallelism of the entire press because the parallelism in effort will be balanced. A sensing system can also be used for process diagnosis, process optimization and/or process control to increase the efficiency of material utilization in sheet metal forming [5].

Another important item to which must be paid special attention is the use of sets of sensors (3 sensors) that do not allow the authorization of press functioning if the part is not correctly mounted on the die. Other kind of sensors could be used for the security of equipments through innovative solutions. The researches on die mounting, fitting and trying must be continued in order to reduce the number of the steps until the first proper part is obtained.

The electrical apparatus for measuring and checking geometrical dimensions and differences appeared when modern technology asked for precision increase, distance transmission of the measured value and reducing the influence on the measured process [9].

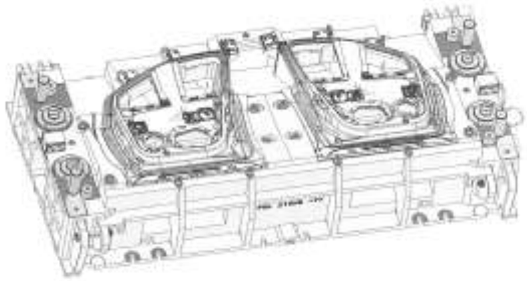

Fig. 3. Die for caisson of front door (Inferior part – for restamping and cutting operation).

Tryouts are important steps in engineering and also in the manufacturing process of a die especially in the case of mounting the die for the first time on a press. Tryouts are costly and time consuming steps but imperative. The idea is to try to reduce the number of correction loops, any improvement in the effectiveness of tryouts being a progress in the activity of the company and without simulation it is very difficult to obtain. So it must be considered a systematic procedure with a tight collaboration between the departments in the frame of a factory where engineering office, simulating office, 3D laboratory and tryout tool shop must collaborate in order to discover the critical areas in the parts, the measures for solving quickly and effectively the problems, what other areas of the part will suffer after applying the modifications. Thus several correction loops on the tool are made until a proper tool is obtained so as to produce the part of the required quality. With this aim in view we applied simulations in which all the theoretically possible correction measures are performed in a simulation model and calculus are made before altering the tool. The causes of problems likely to appear can be identified on the computer and can be stated quickly the best measures that can be applied. For example in the figure below is represented a front fender part before modifying and after modifying it.

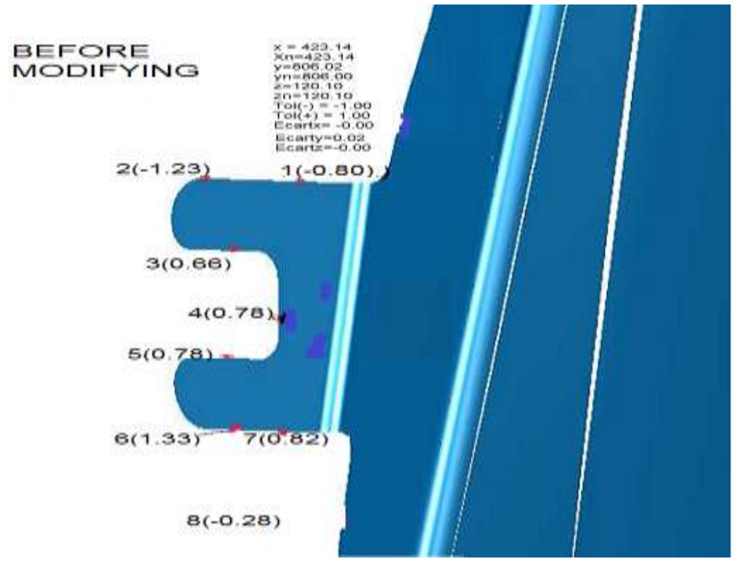

Fig. 4. Section of Fender part before modifying.

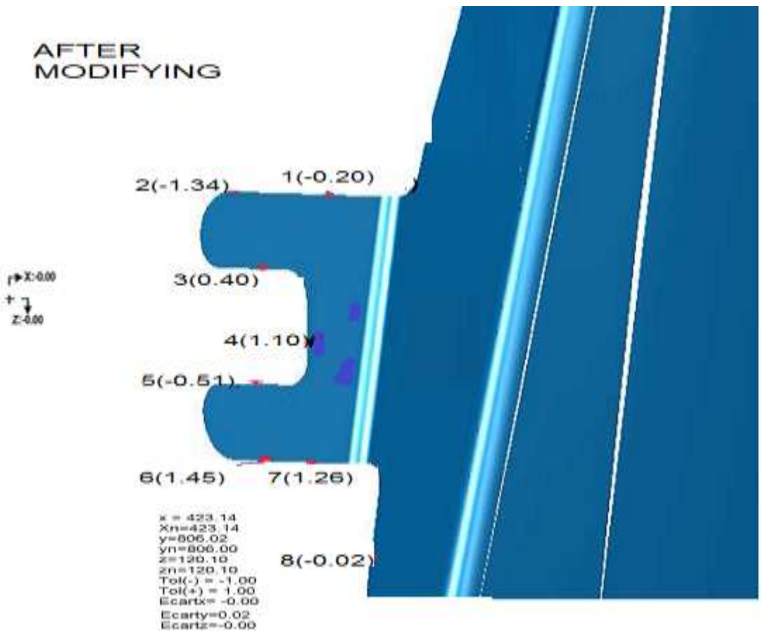

Fig. 5. Section of Fender part after modifying.

Thus are obtained the following data:

Table 2) Ecart values before and after modifying

Before modifying		After modifying
Edge no.	Ecart	Ecart
1	-0.80	-0.20
2	-1.23	-1.34
3	-0.66	0.40
4	0.78	1.10
5	-0.68	-0.51
6	1.33	1.45
7	0.92	1.26
8	-0.29	-0.02

Here was presented only the first trying. Usually the difference between experiment and simulation is between 5% and 10%, the simulation proving it very effective for calculating the optimum conditions regarding both press and die [12]. Thus, through an efficient and systematic tool tryout high quality demands can be achieved.

Part out of tolerance are got only when material not lying flat on the die surface, or parts damaged on ejection from die, or raw material variations or poor quality material, or poor or incorrect rigging in the die, or punch cuts part free before forming or part or blank development is incorrect, or die / press misalignment, or material is not reasonably flat.

6. Conclusions

The main scientific contributions of this paper are the studies on the die fitting and trying of the press. The topic is not enough presented in specialised literature.

Even the providers give the required instructions in the functioning manuals, the studies and researches for the fitting and controlling must be continued in order to facilitate the work and reduce the time for obtaining a proper final part. A lot of measurements and trying were made experimentally in order to see how many steps are necessary and to assess the repeatability of some of them.

It is necessary to reduce the number of tool tryouts and tool tryouts time and thus the manufacturing costs. Tool wear makes reconditioning necessary (regrinding). This can be compensated easily by the ram adjustment. Actually die life is determined of many other items such as fluid (concentration, thickness), correct hardness, metallurgy and coating, clearances.

The press parallelism is verified without the die with the help of the press regulator (about 0.2 bars). The maximum pneumatic pressure is applied on the boosters and the values of angles at TDC are recorded, at half of downward movement or at BDC, these angles corresponding to the 4 control positions of the machine. The distance between tables and ram is measured as follows:

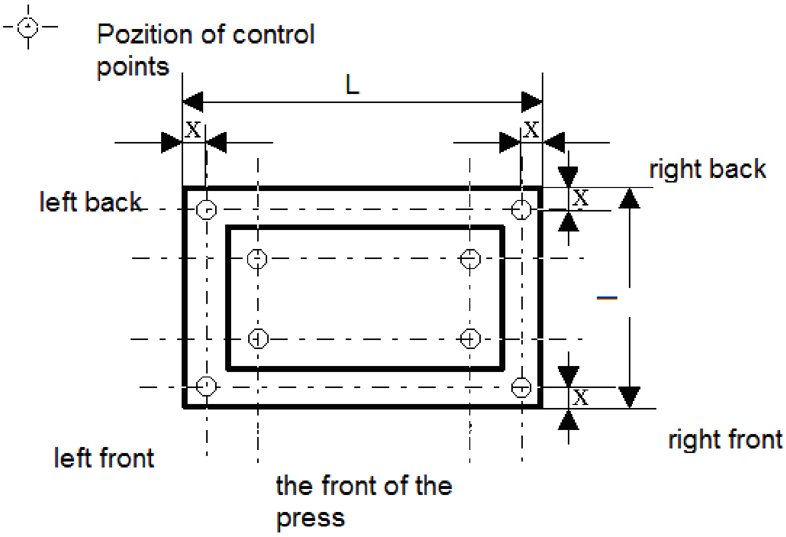

Fig.7. Position of control points.

For L<1000mm, x_{min} = L/10
For 1000<L<2000mm, x_{min} = 100
For L>2000, x_{min} = 150.

The record of parallelism errors in "idle" is done for the plungers and for the blank holder for the four positions: left front, left back, right front, and right back. In this experiment we used the data: Number of cushions - 2, Maximum force on a cushion - 300 kN, Maximum dimensions of dies, Nominal force - 4000 kN.

The new approach in this article compared to other specialised articles is the way of the rigging process and the suggestion of using effort cells in the entire controlling process of the die/press. There are dies today that offer energy and maintenance savings of up to 50% compared to old variants, as well as greatly reduced noise emissions, higher speeds and more control over the process [2].

Notations and/or **Abbreviations**

BDC – Bottom Dead Center

TDC – Top Dead Center

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