DESIGN SOLUTIONS OF THE MECHANICAL PRESSES LEADING TO IMPROVEMENT OF THEIR TECHNICAL PARAMETERS WHILE IMPROVING THEIR ENERGY DEMANDS

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DOI: 10.17973/MMSJ.2022_03_2021189

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The article states that the significant improvement of technical parameters for mechanical crank presses of the current concept is already very limited. Significant improvements in technical parameters can be made at the cost of changing the design concept. To substantiate this statement, an analysis of the current situation is performed and the possibility of successful improvement of technical parameters for the set criteria is documented on the examples of a new conceptual solution.

KEYWORDS

press, forming, CAD, energy efficiency, press stand

1 INTRODUCTION

The essence of the design solution of all forming machines is the use of some system or mechanism to multiply the force and to accumulate the energy so that it is possible to perform the necessary technological operation of forming.

For many years, proven principles such as mechanical, hydraulic, pneumatic and other transmissions have been used, which can be adapted in various technical ways to become the required force and energy multipliers.

Over the years, the systems and design solutions of the designed equipment have been constantly improved, especially in order to ensure minimal losses in multiplication and refinement of technical parameters in order to improve the quality and accuracy of products and to increase the productivity of equipment.

The current development has gone so far that even renowned manufacturing companies of forming machines make only minor technical modifications to their new products, which will only cosmetically improve the technical parameters of the machine, but serve more as a marketing move to increase machine sales.

After the analysis of design solutions of today's produced forming machines, it can be stated that the existing design solutions in the existing concepts can only be "improved" to a very limited extent, and often the costs of partial technical improvements exceed their benefits.

If we want to see a greater technical benefit in improving the technical parameters of forming machines, we can't expect significant benefits by improving current solutions, but we must look for a way to change entire conceptual solutions.

At CVTS UWB in Plzen, we have reached the above conclusions after many years of monitoring new design solutions for the construction of forming machines and a thorough analysis of the results obtained.

We would like to present some solutions on the issue of mechanical crank forging presses. This approach can be applied to other types of forming machines also, such as hydraulic presses, hammers, etc.

2 DESCRIPTION OF THE CURRENT STATE

The conceptual solutions used today by the vast majority of world-renowned companies for the construction of mechanical forging presses use a crank mechanism as a multiplier to multiply the amount of force transmitted to the output members (on which the tools are) of the machine, with all other functional elements necessary to operate the machinery.

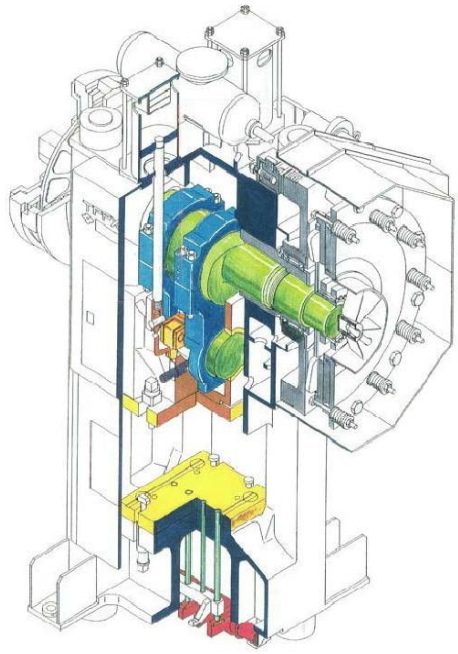

Figure 1. Partial section of the crank press (A typical representative of the conceptual solution of a modern forging crank press)

3 ANALYSIS OF THE MAIN CONSTRUCTION NODES OF MECHANICAL PRESSES

In order to improve the technical parameters and energy efficiency of the machine, research teams have so far focused on improving the basic nodes of the machine.

At the CVTS UWB in Plzen, in recent years we have focused on the analysis of selected design solutions of these nodes and we came to the following conclusions.

The following advantages or disadvantages of design solutions are based on analyses carried out over several decades and the collection of data on individual machines. The quantification of the potential benefits is based on analyzes that have already been carried out in the past.

3.1 Press drive mechanism

All design solutions with only small differences settled on the almost optimized crank mechanism system.

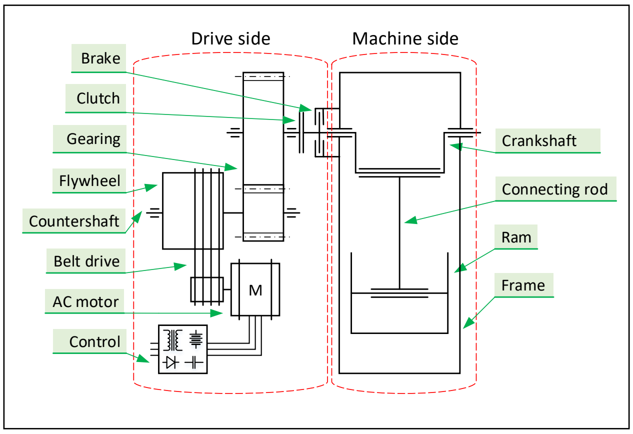

Figure 2. Diagram of the usual drive system of crank presses with a flywheel on the countershaft

Overview of used drive mechanisms

We came to the following conclusions from the analyses:

For the criterion of high rigidity and accuracy (even lower weight) of the machine - **Eccentric mechanism** (has higher energy losses)

For the criterion of good energy balance - **Crank mechanism** with longer connecting rod (less rigidity, less accuracy, more weight)

The possibility of influencing the technical parameters and energy demands by choosing a machine mechanism that has undergone design optimization

Stiffness (by the manufacturing quality)	up to 5%
Weight	up to 3%
Energy demands	up to 5%

3.2 Ram guide

The concept of the ram guide is also characterized by about four basic design solutions, which appear in various constructions:

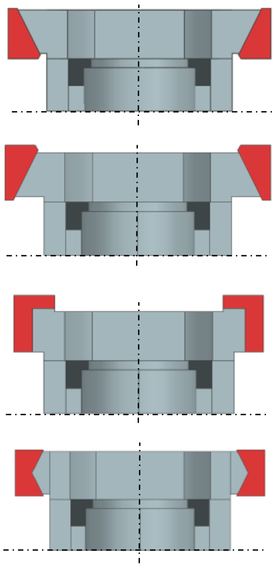

Figure 3. Types of guides - section [Chval 2015]

We came to the following conclusions from the analyzes:

Four-side guide „O" – structurally simplest way of guiding the ram, the cheapest, simple adjustment, is able to transfer large loads, inaccurate, must be adjusted with greater clearance to compensate for the thermal expansion of the ram. Universal use for machines capable of carrying heavy loads with not very high demands on guide accuracy.

Four-side guide „X" – structurally simple way of the ram guide, more expensive than the "O" guide, simple adjustment, is able to transfer large loads, is more accurate than the "O" guide, can be adjusted with little clearance, is not sensitive to the thermal expansion of the ram. [Cechura 2020]
Universal use for machines capable of carrying heavy loads with increased demands on guide accuracy.

Eight-side guide – made in five different designs and versions. For machines requiring the most precise ram guidance, various variants can be chosen for different types of machines.

Prismatic guide – structurally more complex, expensive, suitable for smaller loads, precise (can be built with little clearance during cold operation), easy adjustment, sensitive to thermal loading of the ram. Suitable for machines with precise but less load, low thermal stress.

The possibility of influencing the technical parameters and energy demands by choosing the ram guide for a machine that has undergone design optimization

From the above, it is clear that in terms of improving the technical parameters of the machine and energy consumption, based on the design optimizations can be evaluated as the most suitable guide eight-side, then four-side "X", finally four-side "O". Prismatic guidance is not universally applicable due to its low load-bearing capacity.

The question remains whether the technical benefits and lower energy consumption compensate the higher acquisition costs and the complexity of its frequent adjustment.

3.3 Stand design solutions

Stands are possible in two basic designs. One-piece cast stand or welded stand. The cast stand can better reflect the energy flow through the frame and there is no problem with cracking in the welds. However, the production technology is very time consuming. The welded stand is faster to manufacture. But it is necessary to place the welds outside the stress peaks, which complicates the construction of the machine.

In the following picture, a table is inserted in the welded stand and is not welded around to prevent cracks.

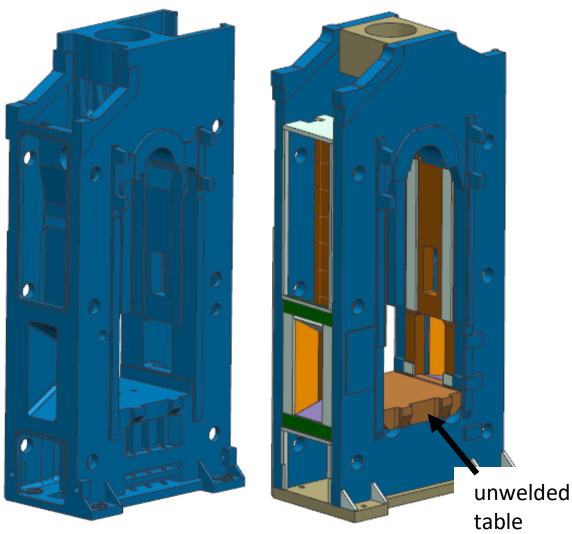

Figure 4. Comparison of cast solid stand and welded solid stand for crank press with a nominal force of 16 MN

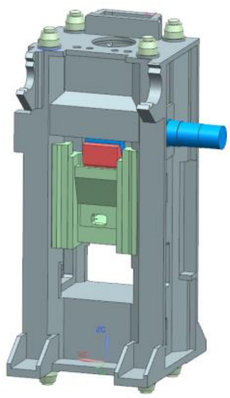

Figure 5. Crank press with a nominal force of 25 MN (illustrative torso) with preloaded welded integral stand (The stand can be made as a casting or weldment)

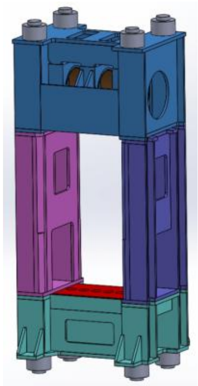

Figure 6. Segmented cast preloaded stand for a crank press with a nominal force of 80 MN (The stand can be made as a casting or weldment) /MMS: Development and specifics of the construction of a LKMK 8000 large crank press

Modern computer technology enables the optimization of the design of stands of all the above types, with optimization criteria for weight and strength.

For this purpose, topological optimizations are used for such optimization solutions in CVTS. [Raz 2020]

3.4 *Possibilities of further increasing the technical parameters of mechanical presses*

As is clear from the above, all the above design options do not lead to significant benefits of improving the technical parameters and energy efficiency of the machine.

Therefore, at CVTS UWB in Pilsen, we decided to change the concept of the design solution to help significantly improve some of the selected technical parameters and also to improve the energy balance of the machine.

4 NEW CONCEPTUAL SOLUTION OF MECHANICAL CRANK PULL-DOWN PRESS

If we set as the main improvement of the technical parameter the criterion of increasing the accuracy of the machine (which is one of the basic requirements for the ability to make precise forgings without the need for additional technological operations), it means increasing the rigidity of the machine and improving the guidance of moving parts and improving machine dynamic stability. As a bonus, there is a beneficial improvement in other technical parameters, especially in reducing energy demands, which will be an increasingly monitored criterion.

For this purpose, and with the above assignment, it was decided at the CVTS UWB in Pilsen to monitor and analyse the current solutions and look for opportunities to significantly refine the existing conceptual solution of crank presses. Unfortunately, the analyses performed confirmed that the existing conceptual solutions no longer provide much possibilities for further substantial improvements in terms of improving the accuracy of the machine. Therefore, we decided to create a new conceptual design solution for the crank press, which would give the precondition to significantly meet the improvement of the technical parameter "criteria" to increase the accuracy of the machine.

After the performed analyses and from many years of experience in the field of construction of forming machines, it was decided to change the conceptual solution, and to create a design solution for the **pull-down mechanical crank press**.

The design solution was carried out as an example for a nominal force of 25 MN.

4.1 *Potential advantages of a pull-down mechanical crank press*

- Greater rigidity of the press stand
- Greater dynamic rigidity of the press
- Greater rigidity of the moving frame guide
- Greater guidance accuracy with easy clearance definition
- Smaller installation dimensions above the floor of the hall (lower height of the hall, better accessibility of the crane track, better serviceability of handling equipment, easier automation)
- Better drive accessibility
- Possibility to place the drive parts outside the press construction (it is stored outside the press and does not cause much dynamic stress on the machine, less noise from the drive)
- Full balance of moving masses
- Possibility to set all clearances in the bushings
- The need for a divided stand
- Easy installation
- The grease of the mechanical parts will not contaminate the work area or bother the operator
- "Infinitely" rigid support of the ram on the foundation (structurally influenceable rigidity of the ram)

4.2 *Potential disadvantages*

- Deep and complex foundation
- Large moving masses
- Lower stroke frequency

We will try to further verify the potential advantages of the pull-down mechanical crank press according to our design by means of virtual modelling and optimization structural modifications of the basic conceptual design.

4.3 *Conceptual design of a new press*

The press concept is based on a firmly anchored ram in the base and a moving stand. The drive is located under the ram. The crankshaft is mounted in the ram and the connecting rod in the press bed.

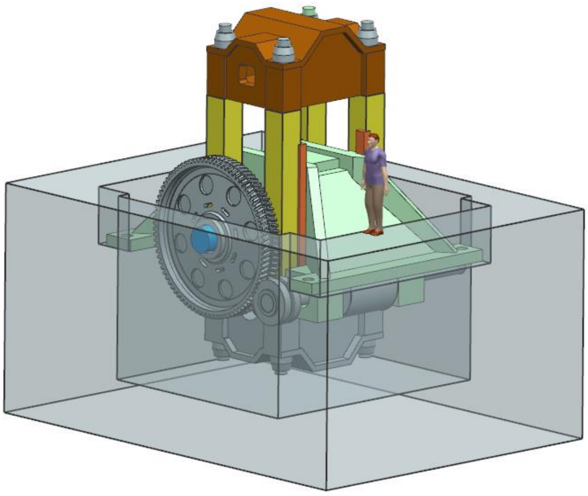

Figure 7. Conceptual solution of a pull-down mechanical press

Stand

The stand must be designed as a segmented stand so that the ram can be placed in the base first and then the rest of the machine can be assembled.

The stand consists of a press crown and press bed, an upper tool is placed on the press crown, and a connecting rod pin from the press drive rests on the press bed.

The bottom and the top part of the stand are connected by four columns (weldments) that are preloaded by tie rods and fitted at the bottom and top in both crossbars. The columns are precisely machined for precise guidance.

All parts of the stand are designed as weldments, except for the preloading tie rods. The tie rods are preloaded by hydraulic tensioners, which can also serve as a spreading device.

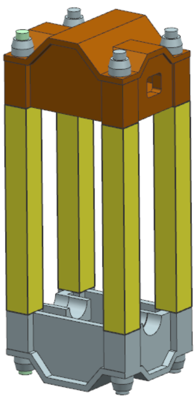

Figure 8. Stand of a pull-down mechanical press

Ram

The modification of the ram consists in anchoring the ram to the base and mounting the crankshaft.

Anchoring can be done in two ways (see Figure 10.), which are shown in the following figure.

The first variant allows the ram to be anchored between the columns on the shorter side of the press. The advantage should be in better accessibility of the working space of the press. The disadvantage is the need to resolve the collision with the press drive. The drive would have to be rotated 90 °. Another disadvantage is that a narrower anchoring of the press can mean poorer stability, or the need for larger sizing and thus a significant increase in the weight of the ram.

The second variant shows anchoring on the longer side of the press. This design ensures greater machine stability and drive accessibility. Anchoring to the floor will need to allow access to the work area.

In terms of the smaller number of disadvantages, the second variant of its anchoring seems better.

The ram is made as a weldment.

Great attention will have to be paid to the guides of the stand columns in the production of the ram.

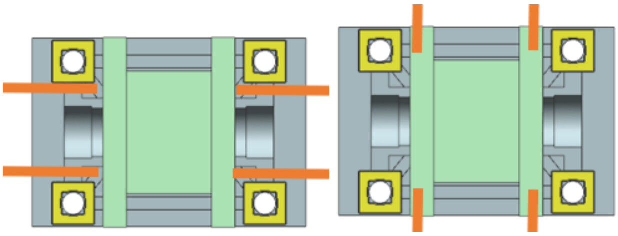

Figure 9. Variants of anchoring of the ram of a pull-down mechanical press

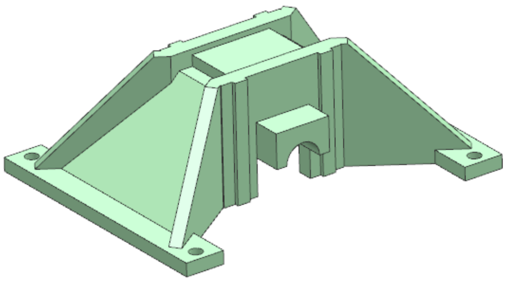

Figure 10. Ram of a pull-down mechanical press

Connecting rod

Due to the location of the crank mechanism below floor level, it will be designed as a split cast.

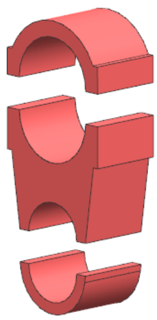

Figure 11. Connecting rod of a pull-down mechanical press

Crankshaft and pin in the ram

The crankshaft together with the ram pin can be used in the same design as existing machines - without change.

4.4 Overall design

The individual components of the press mentioned above have been completed with drive parts that must be part of the machine. Although the gear drive, countershaft with flywheel and belt drive pulley are mounted on a stationary ram, they cannot be completely separated from the machine, as it would be problematic to maintain the exact positioning of the gear. Belt drive to the motor allows small deviations, and therefore the motor can be mounted separately to the foundation of the machine.

The assembly of the machine will be different from standard machines due to a different concept. The process of assembling the machine will be similar to the pull-down hydraulic presses.

4.5 Additional notes on machine design

- Counterbalance system must ensure that the clearances in the crank mechanism are met and thus ensure lifting of the entire press stand. The device does not have to be directly part of the machine, but can be placed under the machine in the base. It is assumed to be hydraulic, with 4 cylinders
- The main gear drive wheel, which was calculated in the same way as for a classic crank press, is relatively large and complicates access from one side of the press. A smaller wheel would be more suitable, but it will cause further transmission problems.
- At the customer's request, the press can be driven by a direct drive. The height of the working space will be adjusted by a wedge table on the ram.
- Ejectors will be made in the same way as current presses.
- Accessibility of the workspace from above for automation or cranes is significantly better than with the classic concept.
- Due to the moving frame, it is necessary to secure access around the press.

5 INDICATIVE STRENGTH AND STIFFNESS CALCULATION

The design of the machine was subjected to strength and stiffness analysis. Optimization adjustments were made in terms of reducing stresses in stress peaks, and, conversely, removing material in places under low stress.

The strength and rigidity of the structure as well as its dynamic stability were assessed.

Siemenst NX software was used for all calculations. A detailed description of the boundary conditions for load calculations, displacements and modal analysis is given in a separate article.

Boundary conditions for computation [Zahalka 2014]

The press will be loaded with a force of 25 MN. In two load cases - centrically and eccentrically. The value of eccentricity is chosen with respect to similar presses of the classical concept, where it is considered for presses of the same force and the use of 300 mm.

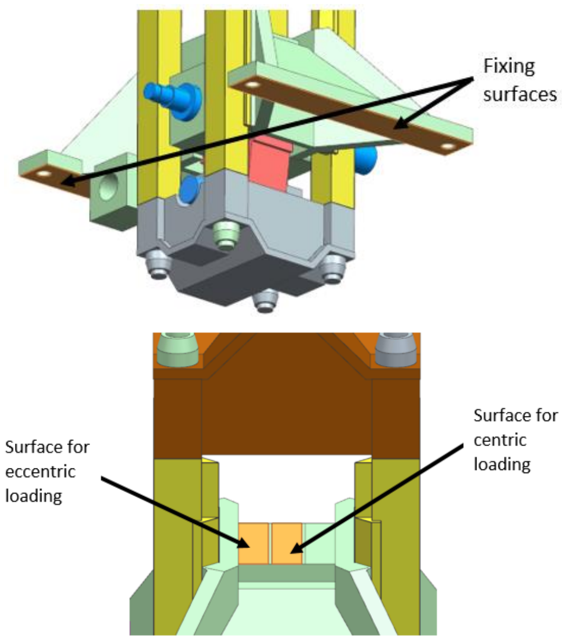

Figure 12. Boundary conditions

The clearance in the guide was set to 0.1 mm with a coefficient of friction of 0.08. The coefficient of friction in other contact bonds between individual parts is 0.1.

5.1 Modal analysis

The dynamic behaviour of the machine can be deduced from the modal analysis. The first natural oscillation has a frequency of 14 Hz. This value is sufficient enough as the maximum theoretical expected number of strokes is 60/min. In the case of future lightening of the structure, there is also possibility of reducing stiffness. The centric and eccentric loads of the press have no measurable effect on the natural frequency [Zahalka 2013].

Stiffness is most affected by clearances in the guide and stiffness of the columns.

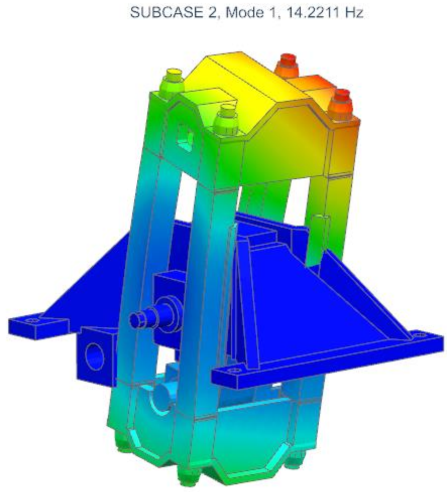

Figure 13. Shape of the first eigenmode

5.2 Structural analysis

The following figures show the displacement and stress of the entire machine. Large displacements of the tie rods are caused by their preloading by 7 mm. The displacements are enlarged 100 times for clarity in the all following figures.

The stress on the whole machine shows that the initial design is very oversized in some places. The most oversized is the solid ram. Conversely, some places in the press crown and bed will need to be reinforced or to choose a different ribbing solution.

Overall, this design can be described as able to be manufactured and functional. In the next stages of development, the optimization of individual components will be performed.

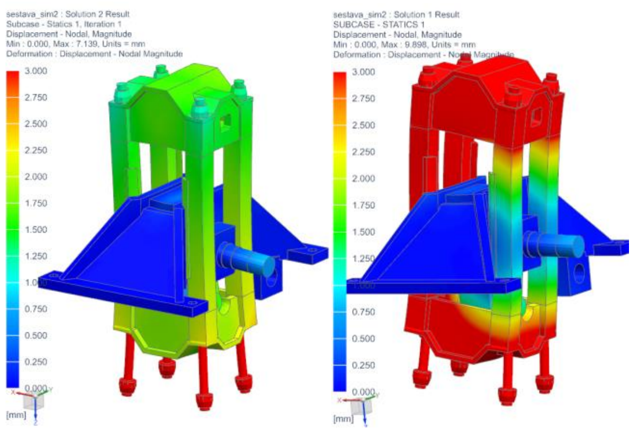

Figure 14. Total displacement under centric and eccentric loading

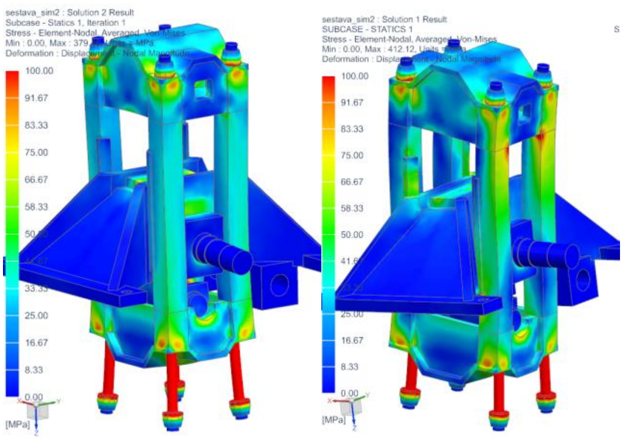

Figure 15. Reduced Von-Mises stresses under centric and eccentric loads

6 COMPONENT DESIGN MODIFICATIONS

The initial design was subjected to the first FEM calculation, on the basis of which several design modifications were made. Adjustments were made in several steps.

6.1 Ram modifications

From previous simulations, it is clear that the ram is very oversized and at the same time lightly loaded. Modifications of the ram aim to reduce weight while maintaining its rigidity. With reduced stiffness of the ram, the stiffness of the entire machine could be adversely affected.

The original ram weighed 48.9 t, with the new concept it was gradually reduced to 33 t. The first natural frequency of the whole machine with the ram modified in this way dropped from 14 Hz to 10 Hz. This value is still acceptable.

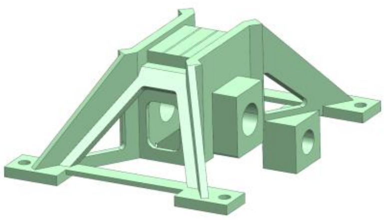

Figure 16. Ram before and after modifications

6.2 PRess bed modifications

The lower bar had to be redesigned due to the high stress under the crankshaft bearing. Gradual optimization suggested better ribbing, which also prevented a significant increase in weight. The weight of the original design of 14.6 t after reinforcement increased to 15.9 t.

The resulting design is evident from the following figures. For illustrative purposes, the scale of equivalent tensile stress up to 100 MPa is given in some figures.

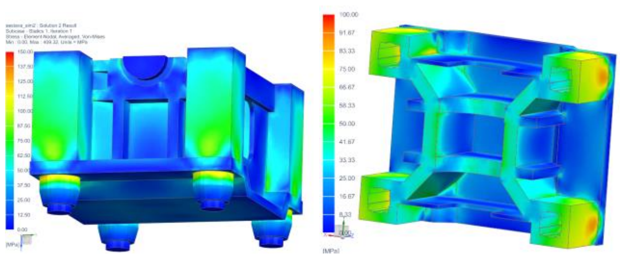

Figure 17. Centric loading of the press bed

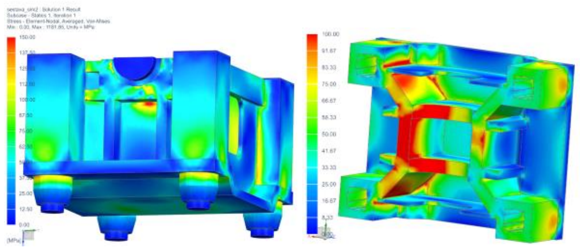

Figure 18. Eccentric loading of the press bed

6.3 Press crown modifications

The press crown had to be reinforced due to higher stresses under eccentric stress. The ribbing shown in the following figures has been optimized. The original transverse ribs were replaced by X-shaped ribs. The weight of the original design was 20.2 t and after optimization it dropped to 19.7 t.

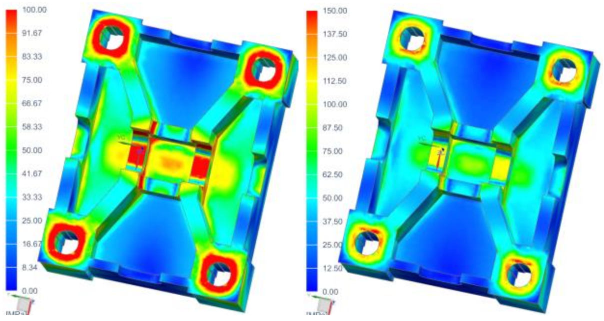

Figure 19. Centric loading of the press crown

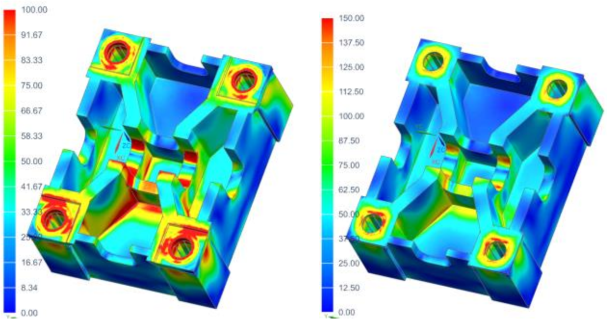

Figure 20. Eccentric loading of the press crown

6.4 Modification summary

The design modifications eliminated the strength deficiencies of the initial design of the machine. The machine designed in this way can be declared serviceable without susceptibility to failure of the supporting structure. Other development steps can be the gradual improvement of parameters, rather according to the requirements of a specific customer, or the detailed elaboration of construction details for the existing press design.

The customer very often requires changed press table dimensions, press strength, etc. Therefore, it is good to consider whether this design is saleable and to what extent to elaborate the design in detail.

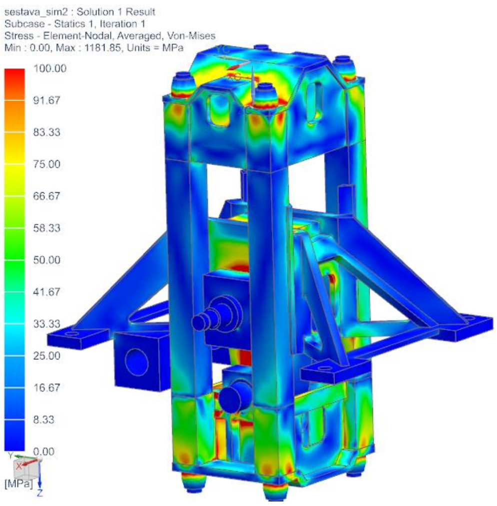

Figure 21. Stress distribution in individual parts of the designed press

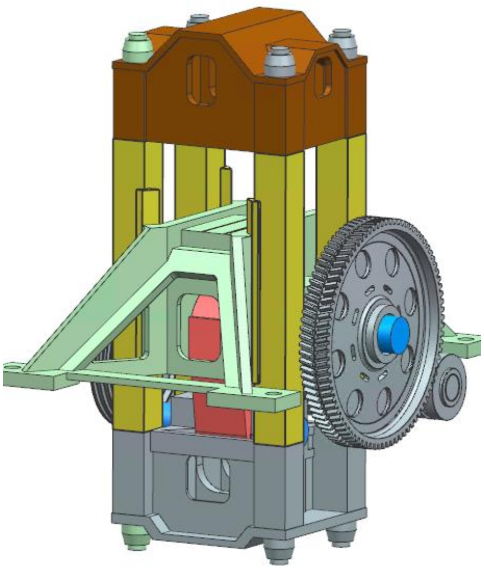

Figure 22. The press after modifications with X-shape ram guide

7 OPTIONS FOR INCREASING PRESS RIGIDITY

In the next chapters, another possible technical solution of the press will be described, which could achieve better parameters than the current design.

The first area of possible modification is the press guide. The originally designed X-shaped guide was designed due to the better thermal expansion properties of the machine. The set clearances in this guide are little affected by the changing ambient temperature and the temperature of the press itself during operation. The disadvantage of this line is the small number of contact surfaces and therefore the need to transmit large pressures.

For this reason, a guide has been proposed that has a larger number of contact faces. The toughest variant should be the design shown in the following figure. The ram of the press now encircles each pillar with its guides.

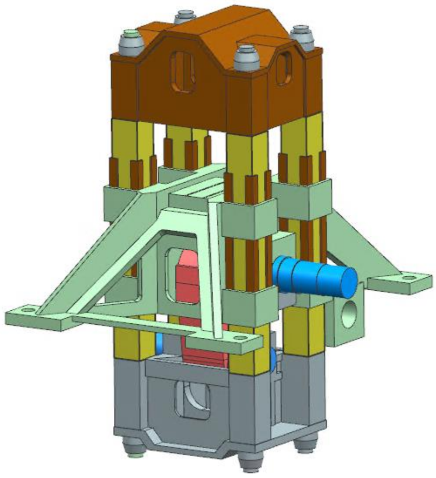

Figure 23. The press after modifications with enclosed ram guide

A certain disadvantage of this design is the more complicated adjustment of the clearances at the contact surfaces. The advantage should be a significant increase in stiffness. This assumption will be verified in virtual eccentric load simulations and modal analysis.

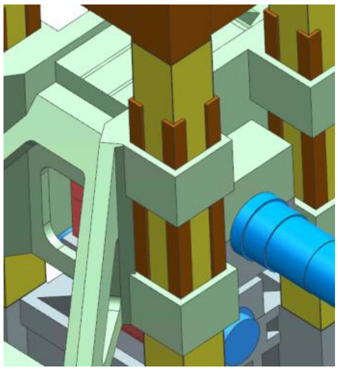

Figure 24. Detail of ram guide

The natural frequency of the press was, of course, compared with the original design. It will also be completed with a comparison of the effect of the size of the guide clearance on the old and newly designed solution.

Clearances of 0.2 and 0.1 mm will be considered

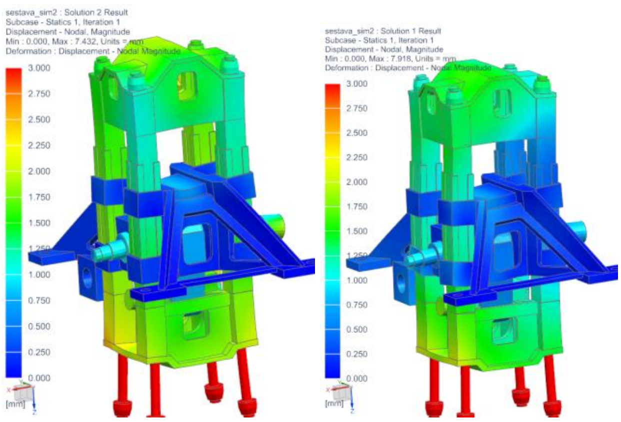

Figure 25. Displacement under centric and eccentric load

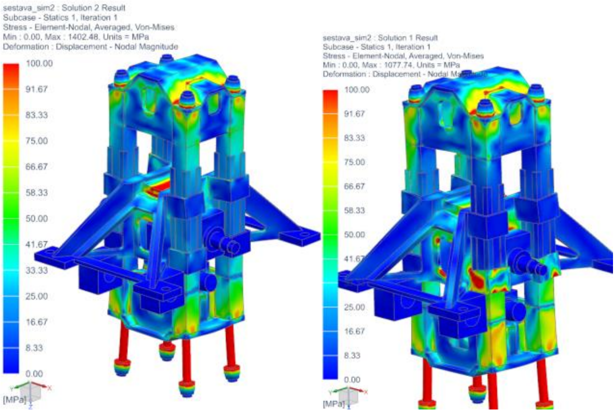

Figure 26. Stress distribution under centric and eccentric load

8 ACCURACY COMPARISON

The new design of the press guide led to an increase in the rigidity of the assembly of the entire press. This fact was described using modal analysis in the previous chapter. It would now be appropriate to focus on the influence of the new guidance on the accuracy of the machine.

The accuracy of the machine is certainly affected by the overall rigidity of the machine, which has increased. It will certainly be greatly affected by the setting of the clearances in the guide, which are difficult to adjust in the real operation of the machine with the new guide method.

The accuracy of the machine indicates the deviations of the final product from the theoretical dimensions. These dimensions are affected by the accuracy of the tools used, their setting in the machine, but mainly by the machine itself. Deviations in the machine guide are orders of magnitude higher than deviations in the production and setting of tools.

Thus, the relative displacement of the clamping surfaces of the machine on the fixed ram and the movable frame of the machine will be investigated.

Three tools are seated in each clamping surface. The displacement will be measured for the tool pair at position 1. This will therefore be the maximum eccentric load of the machine.

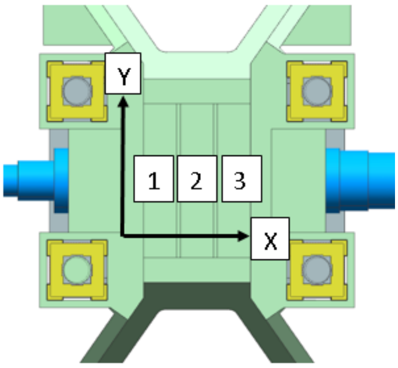

Figure 27. The order of positions in the machine

Another comparative criterion will be the influence of the clearance set in the guide. The same clearance set on all guide surfaces will be considered.

The clearance in the guide will certainly affect the accuracy of the press. The calculations will determine the accuracy of the press at different clearance settings in the guide. It will also be possible to determine which guide will be more susceptible to a change of set clearance.

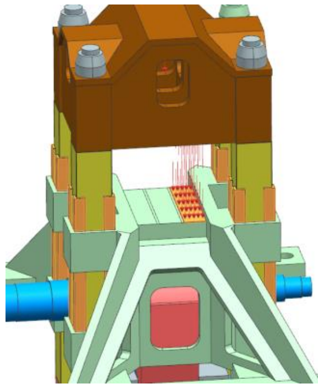

Figure 28. Machine load in the calculation

The loading of both machine variants will be performed in the same way as shown in the previous figure. The clearances in the guide will be changed in the range of 0.1 to 0.2 mm. The other boundary conditions remain the same as in the previous calculations.

Guide		Former - X	New - enclosed
Clearance 0,1 mm	Direction x	3,10 mm	0,56 mm
	Direction y	0,60 mm	0,20 mm
Clearance 0,2 mm	Direction x	3,30 mm	0,56 mm
	Direction y	0,07 mm	0,46 mm

Table 1. Accuracy of each guide type

The different behaviour of the two machines is evident from the determined values of mutual displacements.

The values of mutual displacements in the X direction are many times higher than in the Y direction. This fact corresponds to the position of the entered eccentric load and could be assumed.

The original X-shape guide is not able to reach the parameters of the newly designed closed guide.

The mutual displacement of the tools is more than 3 mm in the original design and this value hardly decreases with decreasing clearance. It follows that the displacement of the tools is caused by the unfavourable force transmission from the ram to the stand and thus by the large deformations of the stand. With reduced clearance, only the displacement in the Y direction decreases more significantly, which, however, is negligible in comparison with the main direction X.

The closed guide made it possible to achieve mutual tool displacements of about 0.6 mm. The increase in clearance does not have a large effect on the accuracy in the X direction, with a clearance of 0.2 mm the displacements in the X and Y directions will converge. The displacement in the Y direction is caused by the action of the crank mechanism.

The original idea of the advantage of X-shape guide, which is able to eliminate thermal expansion, has been refuted. Closed guide with large clearance settings that are able to allow thermal expansion are still much more accurate.

Another advantage of a closed guide is the ease of adjustment. Even if we allow a large number of guide surfaces, their precise set clearance does not matter so much.

In addition to finding specific accuracy values, it can be stated that the accuracy of the clearance adjustment in the guide does not have a large effect on the overall accuracy of the machine. Far more important is the design itself, which ensures better transmission of forces between the individual components.

9 DESIGN OF DETAILED GUIDE CONSTRUCTION

A closed guide on each column has a number of advantages and disadvantages. As mentioned earlier, the main advantage is its rigidity. On the other hand, a large number of guide surfaces causes a problem in its correct adjustment.

Overall, the solution is very complex. Next, two possible approaches are described, which are structurally elaborated in detail. The difference between the two variants is mainly in the way of assembly and adjustment of clearances.

9.1 Solution A

The principle of the first proposed solution is clear from the following figure. The guide is separated from the press ram construction, which does not move in our machine design, and is fastened with screws over adjustable wedge surfaces.

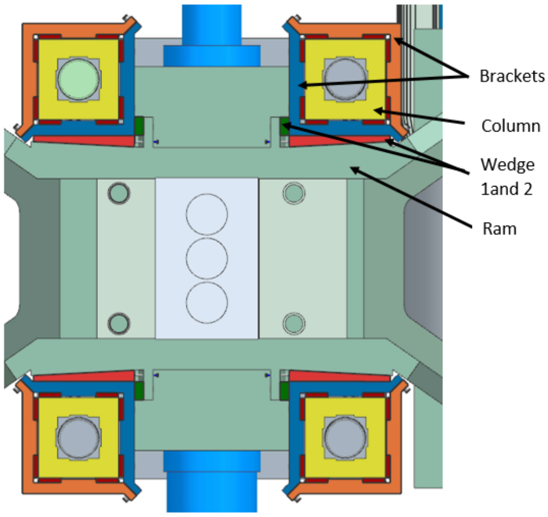

Figure 29. Arrangement of guide brackets

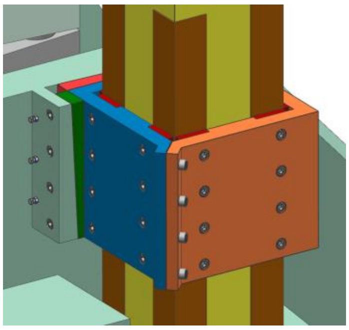

Figure 30. Closer look on guide

The basic positioning of the press ram between the columns is done by wedges 1 and 2, which are shown in the figure below. Wedge 1 moves vertically and wedge 2 moves horizontally. In this way, the exact position of the blue brackets 1 is first set. If necessary, the machine can be started in an emergency mode at this stage.

Maximum rigidity is achieved only after mounting and adjusting the orange brackets 2. These brackets are screwed onto the brackets 1. The clearance in the guide surfaces is adjusted by inserting washers between the bearing surfaces of the brackets. These washers must only be ground to the exact thickness when the guide is installed.

9.2 Solution B

Compared to the previous version, this line design is partly part of the ram. The outer bracket is attached to the ram firmly without the possibility of adjustment. In this case, the individual guide surfaces are set. The detailed system can be seen in the following figures.

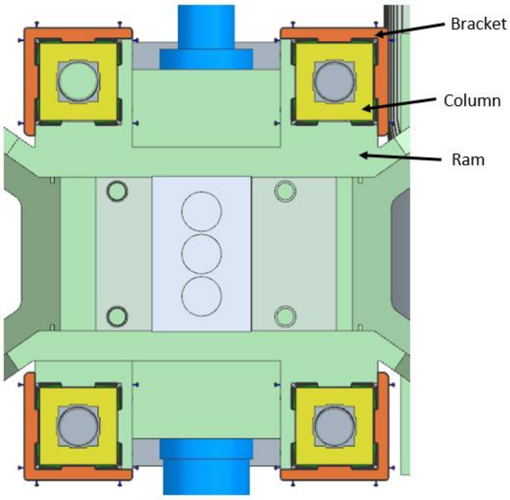

Figure 31. Arrangement of guide brackets

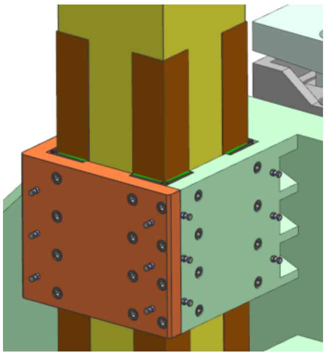

Figure 32. Closer look on guide

The individual wedge surfaces are individually adjustable. In this way, the best possible settings can be achieved.

The sliding guide stones have the shape of a wedge and rest on an adjusting wedge. For easier position control, the wedges are pressed with adjusting screws.

9.3 Variant comparison

Both variants are able to provide machine guiding. They differ in the complexity of production and the complexity of setup. The range of possible wedge position settings allows both guide surface positioning systems to eliminate the gradual wear of the guide surfaces on the columns. At the same time, it is possible to choose the amount of clearance according to the needs of the technology or the expected thermal expansion.

The first variant is simpler to manufacture. On the other hand, when adjusting the clearances, it is necessary to make washers that fit the current wear of guiding elements.

The second variant is more production-intensive. Part of the guide is part of the ram and the assembly has more parts in total.

In the previous text, one of the possible solutions was described in detail, which can solve the issues of significantly improving the accuracy of the press even at the cost of suppressing some other criteria, such as reducing the number of working strokes, i.e. productivity.

The published results of virtual modelling confirmed the expected benefits, for example, from the results of structural analysis (displacement) - sufficient rigidity, from the results of structural analysis (stress) - sufficient strength and longevity, from the results of modal analysis - better dynamic stiffness, from the results of guide analysis - its sufficient accuracy and rigidity, etc.

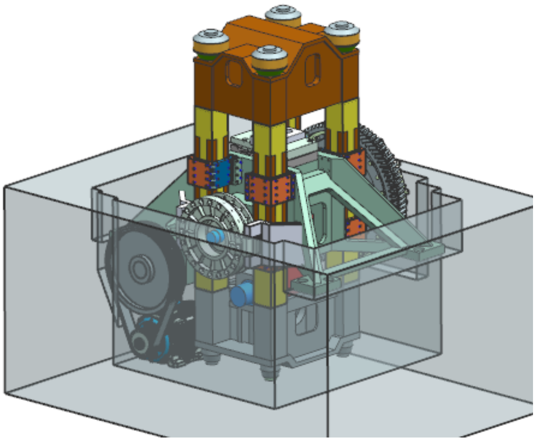

Figure 33. Total view of the conceptual solution of the pull-down mechanical crank press from the side of a brake

9.4 Assembled stand

If we were to address the issue (criteria) of increasing service life and easy repair and overhaul of presses, CVTS staff considered the idea of designing a press stand, which could easily replace damaged parts cracked by natural fatigue, or even accidents during press operation.

They therefore created the design of the assembled stand, lamellar stand, which allows some of the parts of the stand to be easily replaced if damaged or cracked.

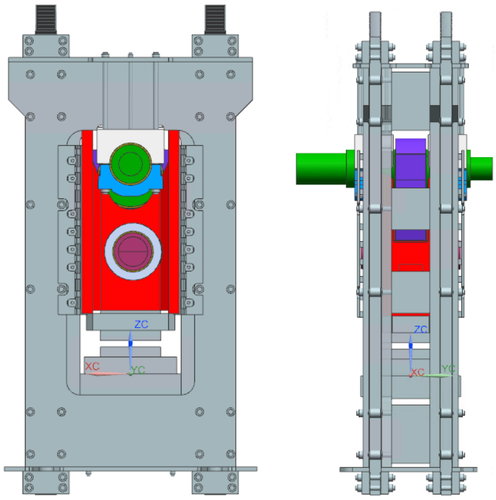

Figure 34. Functional torso of a crank press with a lamellar preloaded stand.

The press with the said stand has already been conceptually finished and designed so that it is ready for production.

10 CONCLUSIONS

It clearly follows from the above that the existing conceptual solutions of crank presses can no longer be expected to significantly improve their technical parameters while improving their energy consumption.

In order to satisfy the requirements for a more substantial improvement of the technical parameters of the machine, we will have to differentiate the requirements for improvement according to the importance of the parameter in relation to the needs of production.

If, for example, it is a criterion of increasing the accuracy of the product, we have described in detail, as an example, one of the beneficial possible solutions of the press, where, however, it was necessary to change the concept of the press design.

Likewise, if we prefer to increase the life of the press and its easy overhaul, it means again a change in the conceptual solution of the stand.

In this way, we could satisfy any preference for other criteria for improving the technical parameters of the machine by changing the conceptual solution.

This means confirming the view that the substantial improvement of the technical parameters of crank presses in general on the existing conceptual solution is already very limited, and that if we want to have more influence on any technical improvement parameter on the machine, it is sensible to change the conceptual solution.

In the above, two solutions are indicated. The improvement of energy conditions on the press has already been published by CVTS staff in the Advances in Mechanical Engineering journal under the title Sawing energy in mechanical crank press drives.

ACKNOWLEDGMENTS

This paper has been supported by the project "Manufacturing engineering and precision engineering" funded as project No. CZ.02.1.01/0.0/0.0/16_026/0008404 by OP RDE (ERDF).

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