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DESIGN OF A TIMER-BRAKE PRESS

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Abstract

The topic of the article is the modification of a mechanical arm press and its installation on the production line. After discussing the necessity of the development, the design process of a key component – the timer locking mechanism – is elaborated. This is followed by an overview of the press mounting and installation requirements, and the solutions as well as the key components of the equipment, such as the toothed part and the locking mechanism. Detailed assembly models are created, and load tests are performed on the components and surfaces supporting the press using both traditional calculations and finite element methods to verify that the designed structure can withstand mechanical loads without significant deformation. Finally, a development opportunity is presented that allows for the automation of not only the timer-brake press but also any other flanging press.

Keywords*: press automation, finite element analysis, manufacturing optimization.*

1. The project overview

The VW Touareg 536 model is a luxury "Premium SUV" category sport utility vehicle manufactured by Volkswagen. The assembly of the upper leather-covered plastic part of the off-road vehicle's gear shifter (in German, Oberteil, meaning upper part) (**Figure 1**).

The project was initiated due to a customer complaint indicating adhesion issues on the final product. To identify the root causes, laboratory tests were conducted in the facility, which revealed three main sources of error: incorrect fastening, poor manual edge crimping, and insufficient fixation time.

During the manufacturing process, a pre-cut leather piece sprayed with adhesive is applied to the injection-molded plastic component, and the edges held in a fixed position for a sufficient period to allow the adhesive to set properly (**Figure 2**).

The solution to the task required the coordination of the edge tools provided by the German parent company with an appropriate mechanical arm press. To achieve this, an adapter had to be

Fig. 1. *Touareg 536 transmission* **[1]**

Fig. 2. *„Touareg 536 Oberteil" final product*

designed for the upper tool, as well as a timing brake mechanism to prevent premature release of the press, thereby reducing scrap production. Since parts are also manufactured for right-hand drive vehicles, the installation of two separate presses was necessary. The company places high importance on space utilization, which is why the presses were mounted on a rotating support plate, allowing integration with the existing connecting presses. The sizing, manufacturing technology development, and bearing design of the support plate were also part of the project, ensuring an efficient and ergonomic design.

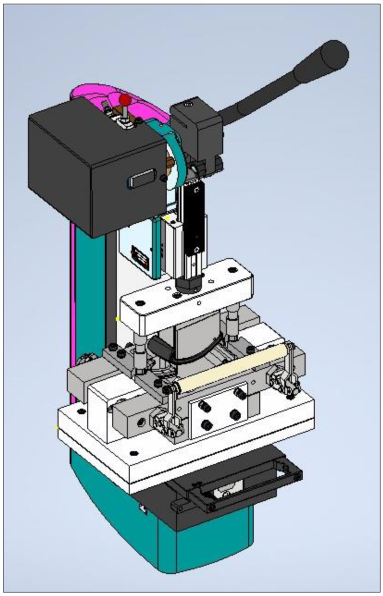
2. Description and Function of Timer-brake Presses

The task of the press is to secure the product for the required duration, applying the necessary force, and then re-flanging the product (**Figure 3**). To understand the operation, it is first necessary to introduce the upper tool and the locking mechanism. The operator places the product into the upper mold, then pushes the lower tool into position on a moving tray. After that, by pulling the lever, the pressing operation is initiated, which is ensured by the press head working against a spiral spring.

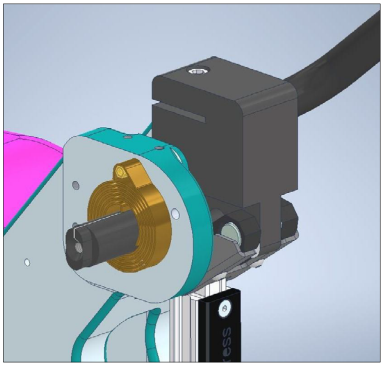
The locking mechanism is mounted on a shaft, which rotates together with the press arm against the force of the spiral spring (**Figure 4**). The concept is based on the connection of a toothed curved component and a locking unit, which prevents the premature release of the press. The operation of the system is supported by an inductive sensor, which initiates a countdown after a specified time. At the end of the countdown, a pneumatic actuator releases the lock, allowing the press to be disengaged.

A base plate was designed for the mounting of the locking mechanism and the actuator, ensuring proper positioning and providing enough space for the toothed arc (**Figure 5**). The base plate connects to the cast body of the press at three attachment points, two of which are connected to existing threaded holes, while the third requires the creation of a new hole. During the design of the structure, maintenance possibilities were also considered, and a manual release lever was incorporated, allowing the press to operate even in the absence of compressed air.

The central element of the timer is the 'ATmega328' microcontroller, which responds to the signal of an inductive sensor **[3]**. When the toothed part passes in front of it, a 60-second countdown



3. ábra. *Assembly model of the timer-brake press* **[2]**



4. ábra. *The spiral spring and the shaft stub* **[2]**

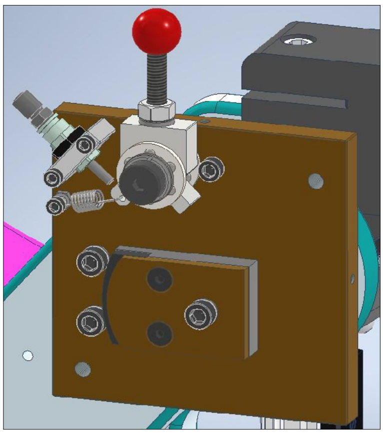


Fig. 5. *The locking mechanism, the toothed arc and the work cylinder in assembled condition* **[2]**

starts, which is displayed on a screen. After 5 seconds, a LED changes from green to yellow, and when the time runs out, it turns red, accompanied by an audible signal to alert the operator. At this point, the relay module switches 24V to the electropneumatic valve, which puts pressure on the work cylinder, thus releasing the mechanical lock. After 2 seconds, a new signal is received, indicating that the product should be removed from the tool. If this is not done, the spiral spring slightly lifts the press arm, but the guide pin prevents the full opening. The microcontroller monitors the return movement of the toothed component, so the counter can only reset with the next downward movement.

3. Installation of the press on the production line

To install the press into the production line, a rotating plate design is required, onto which two presses and two fastener placement presses will be mounted. During the design process, the loads, material quality, and mounting points had to be considered. Based on the model created with Inventor software, we determined the weight of the presses and the location of the bearings, which is essential for the finite element simulation (**Figure 6**).

When designing the plate, operator accessibility, safe and simple geometry, and aesthetic appearance were important considerations (**Figure 7**). To secure the plate, a spring pin was used, which, when inserted into a hole, prevents rotation. The operator releases it, rotates it 180°, and then the pin secures the plate again.

4. Results of the load tests

In the load testing performed using the finite element method, material quality is crucial as it determines the load capacity and rigidity. The company primarily uses aluminum for the shoulder, as it is lightweight, high-strength, and its natural oxide layer provides corrosion protection. Additionally, it is easily machinable, which reduces processing costs. The test showed four main results. The first is the reduced stress (**Figure 8**), which shows the specific load at the location of the highest stress. Its maximum value is 7,72 MPa, which does not approach the critical limit **[5]**.

The second is the equivalent deformation, which shows the total deformation energy of the material. Its value is $4.261 \cdot 10^{-5}$, a dimensionless value, which is negligible (**Figure 9**) **[5]**.

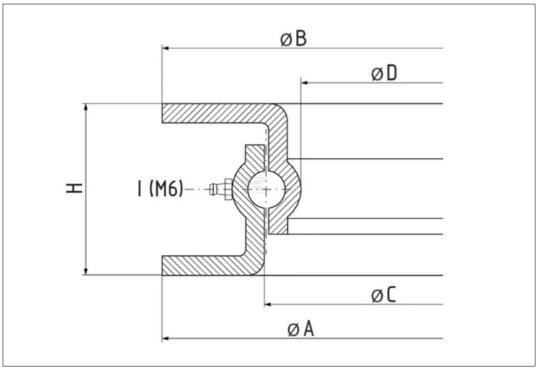


Fig. 6. *The key dimensions of the bearing* **[4]**

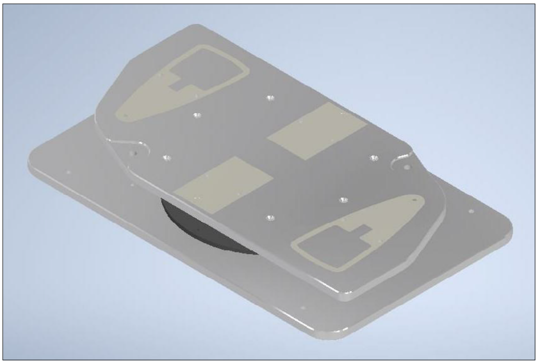


Fig. 7. *The rotating plate with the press pressure surfaces* **[2]**

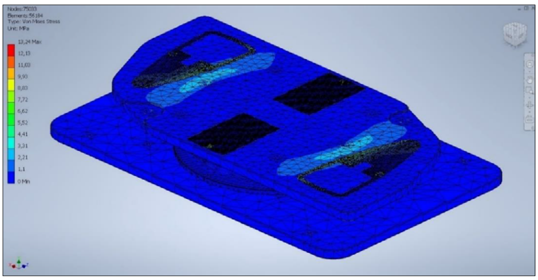


Fig. 8. *Illustration of the reduced stress* **[2]**

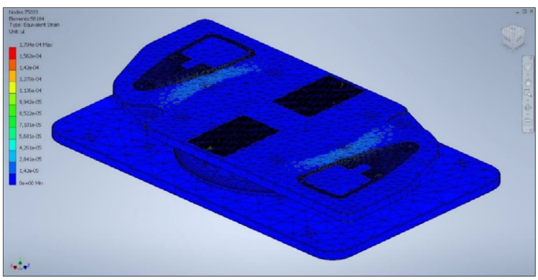


Fig. 9. *Value of the equivalent elastic deformation* **[2]**

The third is the examination of deflection, particularly at the two edges of the plate, where the maximum value is 0.04098 mm, which is insignificant (**Figure 10**) **[5]**.

Finally, a small angular rotation of 0.01 degrees was observed at the locations of the two timed presses, which is also negligible. These results confirm that the structure meets the design requirements, is stable, and its performance is adequate. The next step is to request a quote for the bearings and develop the manufacturing technology for the rotating plate and the base plate.

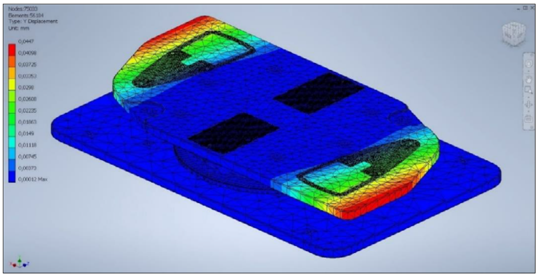


Fig. 10. *Lehajlás vizsgálata* **[2]**

5. Computer-aided manufacturing design of the toothed component

The rough and finish machining of the component, as well as the contour milling, were performed using "Inventor CAM" software, while the tooth formation was carried out with the "Edgecam" program. The machining parameters were determined with the help of the "Sandvik Coroplus® Tool Guide". The preform is clamped in a machine vice, and first, the roughing and finishing of side "A" are performed using a 50 mm diameter "CoroMill® 390" face mill. After a 180° rotation, side "B" is machined in the same manner (**Figure 11**) **[6]**.

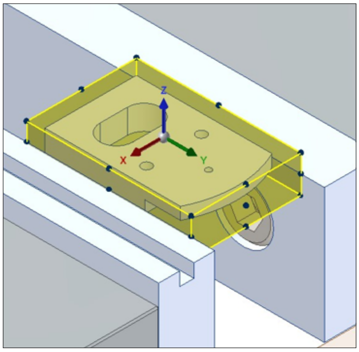


Fig. 11. *Fitting the semi-finished part to the workpiece* **[1]**

Next, the shoulder is shaped using a 10 mm Coro-Mill® Dura end mill, followed by machining the groove, drilling the holes, and preparing the thread (**Figure 12**) **[7]**.

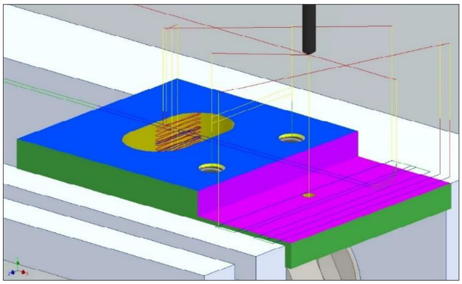


Fig. 12. *Shaping of features* **[2]**

For machining the outer contour, the workpiece is secured in a fixture held by a chuck, and the machining is carried out by fitting the STL model from the previous phase for continuity (**Figure 13**).

Finally, the workpiece is secured in a dividing fixture for the machining of the teeth (**Figure 14**), using a 10 mm diameter, 45° chamfering carbide mill (**Figure 15**).

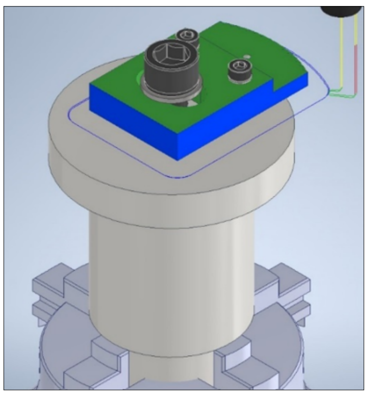


Fig. 13. *The device clamped in the chuck with the workpiece* **[2]**

6. Press development proposal

Analysis of the production data revealed that the press is efficient, but there is room for further optimization. The operators' workload varies, which increases the cycle time. With automation, non-productive time can be reduced: based on the development, the pneumatic cylinders would perform the pressing with a two-button start, while the operator could focus on other tasks. During the cycle of the modified press, three work cylinders would handle the movement of the tools, a timer would control the process, and a lamp would signal the completion at the end of

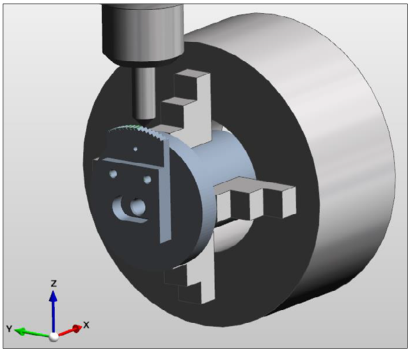


Fig. 14. *Machining of the teeth* [8]

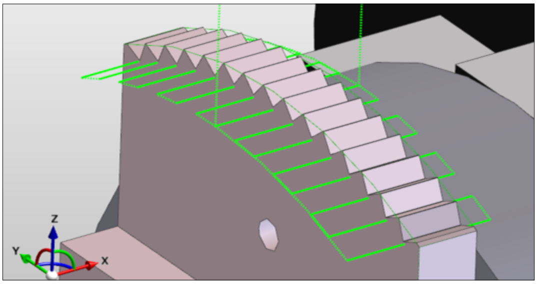


Fig. 15. *Toolpath for machining the teeth* [8]

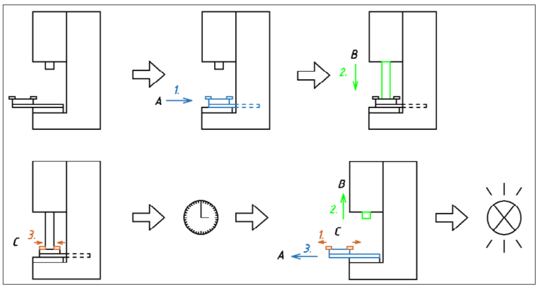


Fig. 16. *A complete working cycle of the press* [3]

the cycle (Figure 16). The automation requires 3 pneumatic work cylinders, 3 5/2 bistable valves, and a PLC.

During the modification, the press locking mechanism and arms are removed. The system uses sequential control, where the progression is conditional. The control process is built using a sequential process diagram that includes the operators and the steps. This is essentially a graphical representation that allows the control of automation systems to be documented and programmed in a logical, understandable way (Figure 17) [9].

Figure 18 provides an insight into the PLC program describing the process, for which a ladder diagram was created. The inputs are labeled as 'X' and the outputs as 'Y' [9].

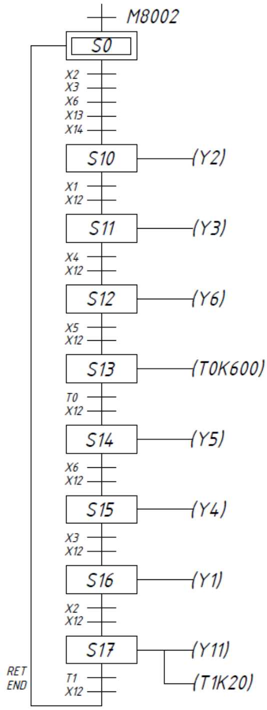


Fig. 17. *Sequential process diagram* [2]

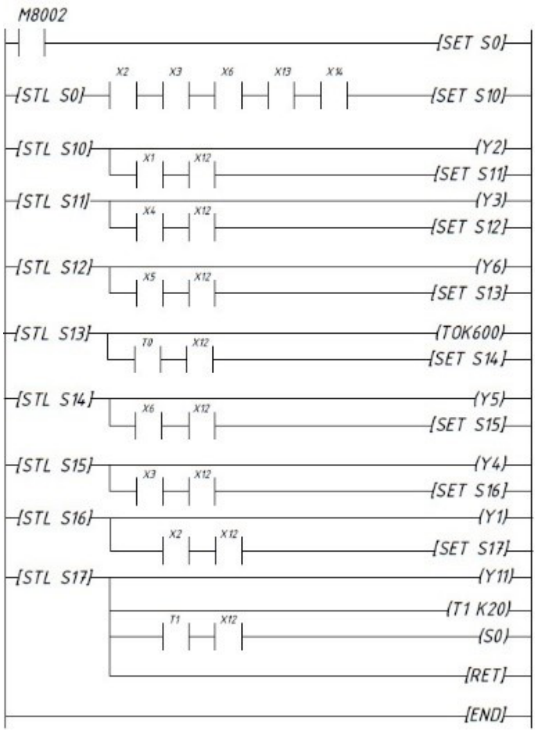


Fig. 18. *Ladder diagram* [2]

7. Conclusion

The load tests conducted using the finite element method during the project confirmed the stability and compliance of the designed structure. During the press installation, attention was given to space utilization, operator accessibility, and safety. During the development, the possibility of automating the press was also considered, aiming to reduce non-productive time and ease the workload of operators. The transformation with pneumatic cylinders and a PLC would enable automated operation, thus accelerating the manufacturing processes. Thanks to automation, production efficiency would increase, while manufacturing costs would decrease. This development is expected to be implemented as production volumes increase. The press with a timer brake ensured the proper product quality, and previous complaints related to delamination were eliminated. The application of the new system reduced scrap production, and with the regulation of the manufacturing processes as described in the article and the commissioning of the timer brake press, customer satisfaction improved.

Acknowledgments

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