# Case Study

## ZAP Mechanika reduces heat treatment costs by 30% with the installation of a CaseMaster Evolution D6 two-chamber furnace for vacuum carburizing and quenching in oil

**ZAP Mechanika** is a renowned company providing mechanical processing services, including machining and precise measurements. The company operates a specialized machinery park equipped with numerical lathes and CNC machining centers, serving domestic and foreign companies from the machine industry. The company was established in 2000 in Ostrow Wielkopolski in Poland, and currently employs 150 workers.

### CaseMaster Evolution®

**CaseMaster Evolution** furnaces are a new generation of vacuum furnaces replacing traditional furnaces which work with an endothermic atmosphere (Figure 1). The system uses vacuum carburizing (LPC) which has the benefit of shortening process time, excellent uniformity when carburizing complex shapes and high density charges, elimination of oxidation on the austenite grain boundaries, high accuracy and repeatability of carburized layer shaping, minimal consumption of process gases (hydrocarbons) and energy, lack of combustible and explosive atmosphere and open flame, lack of CO and $CO_2$ emissions and environmentally neutral. These are industrial systems, operating safely and fully automated. Hands-on operation is limited to loading and unloading, selecting a recipe and starting the process. The furnace operates in a continuous or task mode. If necessary, the equipment can be switched on and switched off immediately and no time is needed for process atmosphere change or conditioning.

The **CME D6** furnace is a two-chamber vacuum furnace with a heating chamber and quenching chamber in oil, both chambers are able to operate under vacuum or a partial pressure of inert gas. Both chambers are separated from each other with vacuum-tight and pressure-tight internal doors. The charge is transferred between chambers with an internal transport mechanism. Integrated into the transport mechanism is a load elevator to quench and remove the load from quench oil. The heating chamber is used for thermal and thermo-chemical process (LPC FineCarb® method), and is equipped in thermal insulation and heating system. It allows operation at temperatures up to 1200$^{o}$C (2200$^{0}$F) with uniformity of +/-5$^{o}$C

under vacuum in the range of $10^{-2}$ hPa, at partial pressure or in nitrogen. During vacuum carburizing, hydrocarbons are inserted to the working area in the proper time sequence. A transfer mechanism for horizontal and vertical transport is located in the quench chamber, equipped with mixers and heat exchangers used for circulation and oil temperature control (Figure 2). The charge is loaded into the quenching chamber where it is transported under vacuum into the heating chamber, where it is processed. It the returns to the quench chamber where it is lowered into the oil quench. After completion of the process, the batch is removed from the quenching chamber. The D6 furnace size has a load charge capacity of 600 x 400 x 600 mm (W x H x L) with a maximum charge weight of 400 kg.

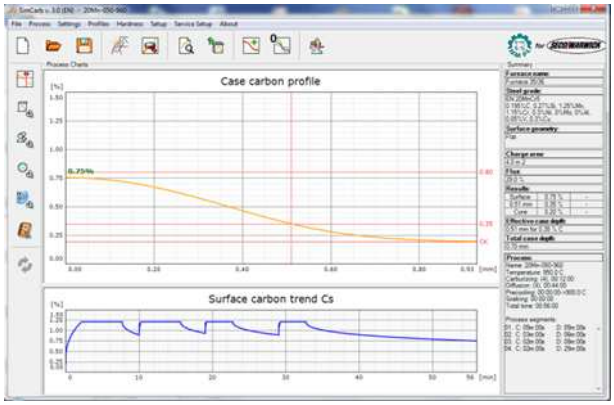
## Delivery and purpose

The **CME D6** furnace for **ZAP Mechanika** was produced in 5 months, then it was installed, commissioned and put into operation within 4 weeks, in the middle of 2013. It is designed for carburizing and quenching of tools used for the manufacture of hydraulic system components (Figure 3).

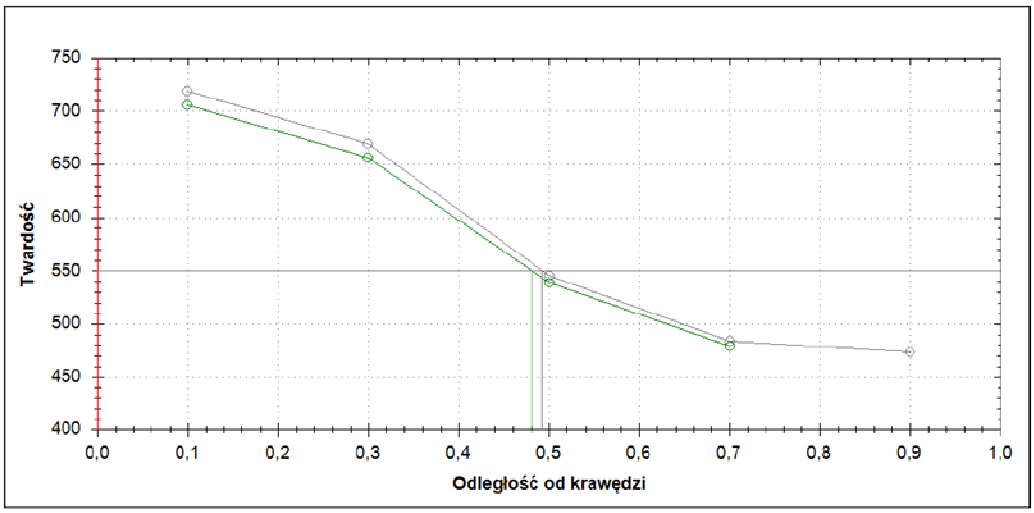
Parts made of 20MnCr5 steel are carburized to the layer of 0,5 mm, quenched and tempered in order to obtain a surface hardness in the range of 58-62 HRC. In the layer's structure, oxidation on the grains boundaries and emitting of carbides is unacceptable. Parts' mechanical fatigue is required counted in 20 000 working cycles (50 000 for type test).

## Process and results

Parameters of vacuum carbonizing process are defined with a help of SECO/WARWICK's patented simulation program, SimVaC® (Figure 4), which accurately predicts the profile of the carbon in the layer based on the load and quantity of hydrocarbons used. The charge (Figure 5) undergoes the carburizing process at 950°C for 60 minutes and is quenched in oil from the temperature of 860°C (Figure 6). After quenching, parts are cleaned and tempered at 180°C.



The process results in obtaining a hardness profile with the following parameters (Figure 7): thickness of the layer – 0,50 mm +/- 0,05 mm, surface hardness 61 +/-0,5 HRC. The results obtained meet required criteria and confirm high accuracy, uniformity and




CHD 0,492 mm HV 1
Hardness Limit 550 HV 1

| Specimen | Row | Distance | Hardness | Method | Diagonal | CHD - Value |
|---|---|---|---|---|---|---|
| Próbka 80 | Szereg 1 | 0,100 | 719 | HV 1 | 50,779 | 0,492 |
| | | 0,300 | 669 | HV 1 | 52,662 | |
| | | 0,500 | 545 | HV 1 | 58,312 | |
| | | 0,700 | 484 | HV 1 | 61,883 | |
| | | 0,900 | 473 | HV 1 | 62,599 | |
| | Szereg 2 | 0,100 | 706 | HV 1 | 51,234 | 0,481 |
| | | 0,300 | 656 | HV 1 | 53,182 | |
| | | 0,500 | 539 | HV 1 | 58,638 | |
| | | 0,700 | 479 | HV 1 | 62,208 | |

repeatability of the processes results performed in a CME furnace.

## Consumption and costs

The full charge contained 196 parts weighing about 150 kg (330 lbs) and occupying 4 $m^2$ area. During 5 h of the entire process, furnace uses 260 kWh of electrical energy, 3 kg (6.6 lbs) of liquid nitrogen, 300 g of hydrocarbons (acetylene / ethylene), 75 l of hydrogen and insignificant amount of compressed air.

## Performance and economy

The furnace is operated in a continuous mode and it performs four processes per day and within 12 months it performed more than 1000 processes, processing 200 thousand

parts. Use of the CME furnace resulted in measurable economic benefits. Heat treatment costs decreased by about 30 % in comparison with the costs of external services and the cost of transportation and logistics were eliminated. It is estimated that the total investment of CME furnace will be recovered in six years.

*The investment in modern technologies of heat treatment performing in **CaseMaster Evolution** furnaces, definitely improves the quality and efficiency of heat treatment processes, reduces costs and is safe and friendly for natural environment. In the second half of 2014, a second two-chamber CaseMaser Evolution D9 furnace was delivered and commissioned to ZAP Mechanika.*