Advanced Design of Continuous Roller Furnace for Hot Forming Line

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Introduction

The popularity of high-strength parts continues to drive increased demand for hot stamping presses. Stamping manufacturers using hot forming technology to reduce vehicle weight, fuel consumption, and environmental impact fall into two categories.

1. The newcomers that are forced to step into this technology by their OEM customers.

2. Manufacturers already hot stamping that face a huge price pressure on the parts and therefore need ways to increase productivity and reduce their own manufacturing costs.

Although its capital costs remain high compared to conventional stamping, hot forming is an economical resolution to those pressures, even if it requires longer cycle times and specialized equipment, because it enables stampers to form light, strong, complex, and dimensionally stable parts in one step.

So the challenges for making this technology more adoptive, one must make this process Energy efficient and ensure part quality stability.

For energy efficient and good part quality, the well-designed roller furnace (Fig. 1) is a key to success.

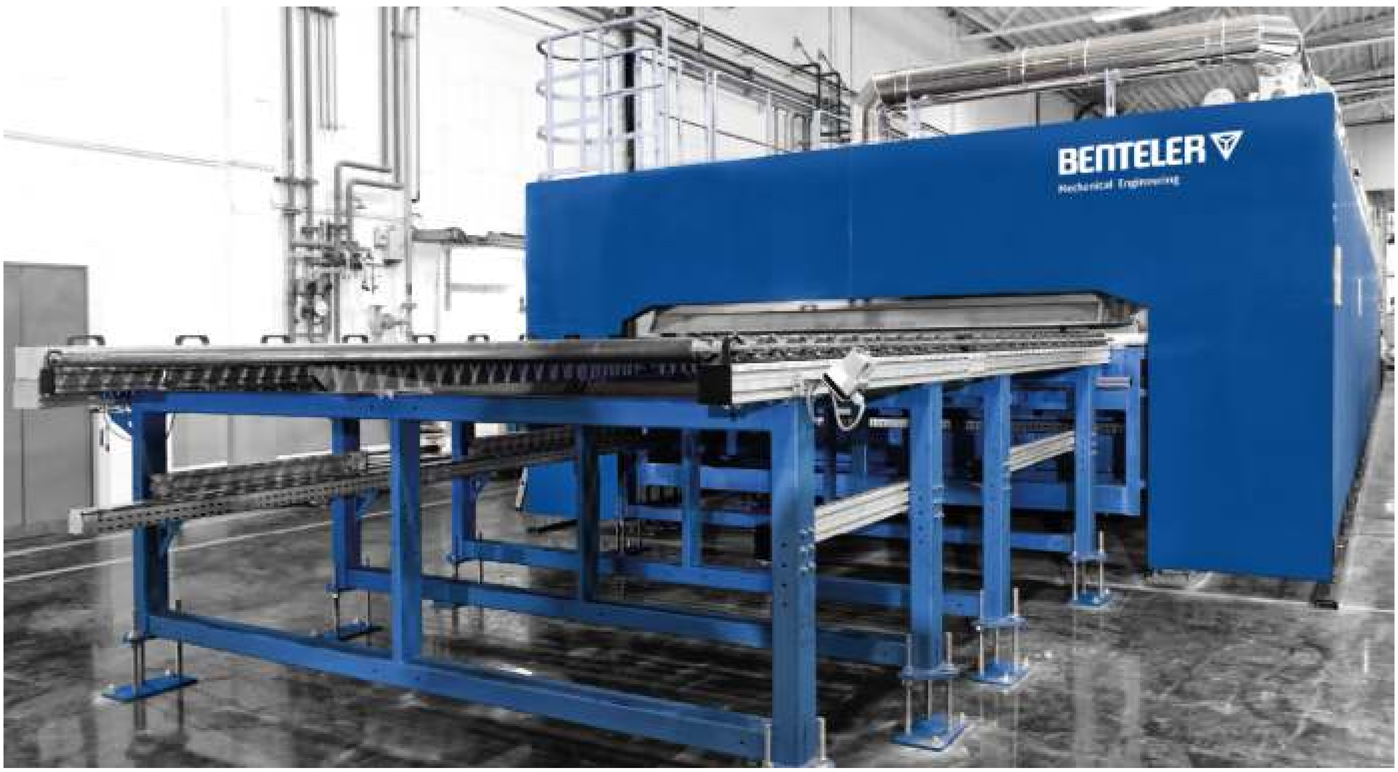

Figure 1 : Example of Roller Furnace for Hot Stamping Line [Source : BENTELER Automotive]

New technics are used. New roller furnaces were designed using modern methods including the FEM analyses for numerical simulations of heating processes and heating power distribution. Carrying out the numerical analyses allows the simulation of the wide range of external and internal conditions and different technological processes, whose testing would be extremely expensive, dangerous or absolutely impossible.

Design Characteristics

There are many design consideration used for designing and manufacturing roller furnace for hot stamping application. Due to New varieties of materials both coated and uncoated, furnace needs to be adaptive for future requirements. Following few key design characteristics are explain in detail.

Heating Concepts

Heating concepts include basic models like the recuperative gas burners (Fig. 2) with the radiant tubes or electric resistance heaters. The most advanced system is based on highly efficient recuperative burners using the FLOX (Flameless oxidation) technology equipped with the silicon reinforced silicon carbide radiant tubes.

Numerical Simulation of the Heat Transfer

FEM analysis of heat transfer was used as the main tool for the design of heating system. This calculation takes into account all

Figure 2 : Example of Efficient Recuperative Burner [Source : WS GmbH]

Temperature of Furnace [°C]	870	900	920	930,0
Temperature of Blank [°C]	25	600	900	920,0
Emissivity	0,38	0,12	0,54	0,7
Convection Coefficient h [W/m2K]	9,0	9,0	9,0	9,0
Heat Flux Radiation [kW/m2]	36,6	8,9	4,1	2,7
Heat Flux Convection [kW/m2]	7,6	2,7	0,18	0,09
Ratio between	4,8	13,3	22,8	29,4

Table 1 : Heat Transfer Inside the Furnace [Source : BENTELER Mech.-Eng.]

mechanisms of heat transfer, i.e. conduction, convection and radiation. Table 1 shows an overview of different regimes of heat transfer for different temperature difference between the blank and the furnace. Radiation is the dominant heat transfer mechanism.

FEM Analysis

Figure 3 shows the model for FEM simulation of heating. This model is designed to monitor the temperature development of the blank during its way through the furnace. Due to large temperature ranges, it was necessary to consider all the material properties (specific heat, thermal conductivity, density, and emittance) as temperature dependent.

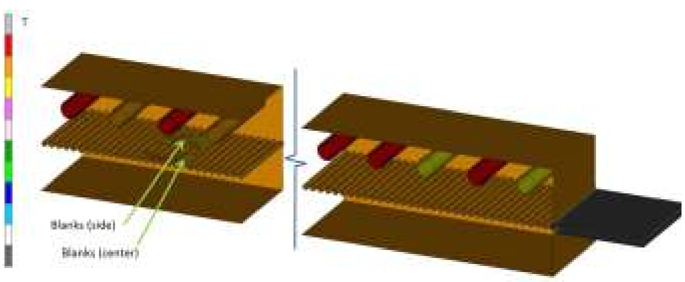

Figure 3: Radiation Heat Transfer [Source : Benteler Mechanical engineering, TU Liberec]

Design of Furnace Openings – Input and Output

During the development phase the big attention was devoted to the design of the input and output opening. The opening conception (Fig. 4) was designed to eliminate necessity of placing here any movable curtains or barriers (source of maintenance problems) as it is sometimes seen in other furnace's concepts. It was also necessary to eliminate heat losses and ensure safety. The tunnel solution was chosen as the best one. Results of the numerical simulations and tests show that the heat losses through opening are negligible and reach approx. 650 Wm². Bodies placed in the vicinity of the openings are not heated to more than 45 °C.

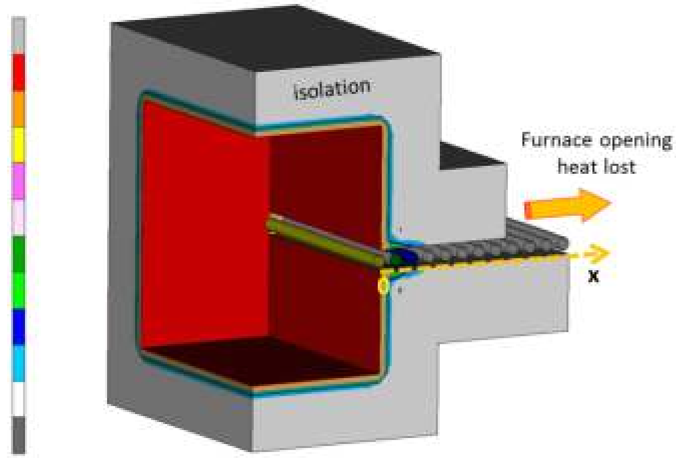

Figure 4 : Thermal Simulation of Furnace Openings [Source : BENTELER Mechanical Engineering]

Due Point Regulation

The dew point is the temperature at which the water vapor in a sample of air at constant barometric pressure condenses into liquid water at the same rate at which it evaporates. Basically the dew point temperature is a function of the content of water vapor inside the furnace atmosphere. Hydrogen embrittlement (Fig. 5) is the process by which various metals, most importantly high strength steel, become brittle and fracture following exposure to hydrogen. Hydrogen embrittlement is often the result of unintentional introduction of hydrogen into susceptible metals during heating, forming or finishing operations and increases cracking in the material. The water inside the furnace atmosphere is the source of hydrogen which can cause the embrittlement in processed blanks.

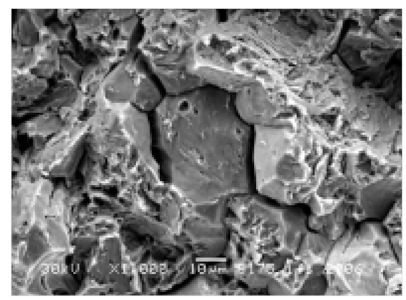

Figure 5 : Example of Hydrogen Embrittlement Crack [source : Dr-maiko.com]

Conclusion

Furnaces following the latest trends and modern practices used during the production of hot stamped parts are essential for efficient hot stamping process. Well-designed furnace can improve OEE (overall equipment efficiency) of hot stamping line. For economically viable process, energy efficient furnace is

BENTELER mechanical engineering and Technical University of Liberec is actively working in the field of developing and manufacturing high quality roller furnaces.

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