WHITE PAPER

Accelerated Balloon Forming

Machine Solutions

Advancing Lives

BW-TEC

A MACHINE SOLUTIONS COMPANY

Abstract: The speed-up of the production of PTCA and PTA balloons is of great interest in the medical device industry. Optimization measures to decrease the heat-up time during the balloon forming process are studied: using an alternative mold material, an optimized heating block, the use of certified conduction paste and the potential of a process optimization. The heat-up time can be reduced by up to 50% for a 3x15 mm balloon produced on a 14.3x50 mm heating block. The presented measures are a simple and cost-effective way to increase the productivity of existing production capacities.

Introduction

During the last decade, the production of PTCA and PTA balloons increased rapidly. In the meantime, the market value of the produced balloons was reduced. The pressure on the manufacturing companies to reduce costs during production is high.

BW-TEC has launched a new generation of heating blocks for their balloon forming machines. The compatibility with the current, as well as the prior, machine generation keeps the investment costs low. The reduction of the heating-up time during the balloon forming process should be studied. This white paper discusses BW-TEC AG's theoretical considerations, the investigated measures and their impact on the heat-up times.

Theory

The core elements of a balloon forming machine are the heating block and the balloon mold, including the cones.

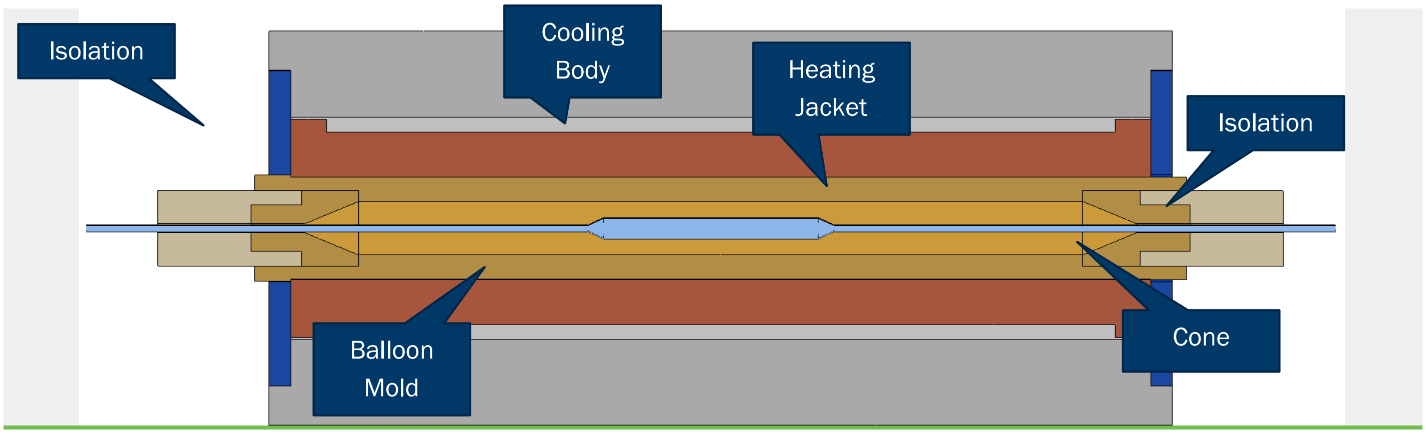

Figure 1: Sketch of a heating block

The heating block consists of a heating jacket and a cooling block. Inside the heating jacket, heating elements and sensors are placed. Into the heating jacket, the balloon mold and its cones are placed. The separation of heating elements and balloon molds allows a vast variety of balloon dimensions in terms of length and dimensions inside the same heating block.

The performance of the balloon forming machine dependence mainly on the time needed to heat up and cool the system. In addition, an easy loading and unloading of the product increases the efficiency as well. Some factors, such as the time to stabilize the product, are fixed and are given by the process itself. To understand the potential for optimizations, the heat transfer inside the system should be studied.

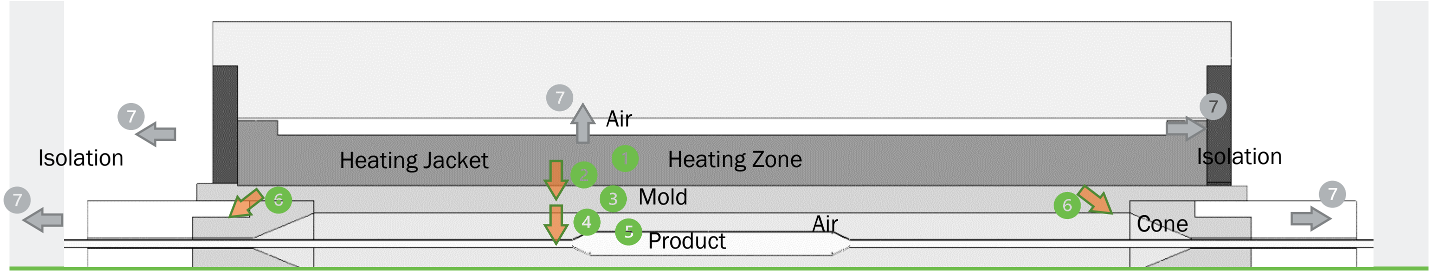

Figure 2: Schematic of the heat transfer from the heating jacket to the product as well as the heat losses

Figure 2 shows the heat transfer from the heating jacket to the product. The following lists describes the individual heat transfer and their major influences.

1. The heat is generated by the heating elements in the heating zone and distributed inside the heating jacket. Influenced by:
   a. The power of the heating elements.
   b. Mounting conditions.
   c. The material of the heating jacket.
2. The heat is transferred from the heating jacket to the mold. Influenced by:
   a. The tolerances, respectively the air gap between the jacket and the mold.
   b. Surface quality.
3. Inside the mold, the heat flows to the inner side of the mold and to the cones. Influenced by:
   a. Dimensions of the balloon: the smaller the balloon, the more mass of the mold has to be heated.
   b. Material of the mold.
4. The mold is heating up the air inside the mold. Influenced by:
   a. Dimensions of the balloon: the smaller the balloon, the less air has to be heated.
5. The air heats up the product.
   a. Material of the product.
   b. Dimensions of the product.
6. The mold also heats up the cones.
   a. Dimensions of the balloon: the smaller the balloon, the bigger is the heat transfer area but also the bigger is the mass to be heated.
7. Heat losses occur on the isolation points and over the air gap to the cooling block. Influenced by:
   a. Material of the isolations.

Measures & Method

To accelerate the balloon forming, the following measures were applied to decrease the heat-up time:

1. Use an optimized brass alloy as balloon mold material to increase the heat flow inside the mold and the cones.
2. Increase the heating element power to maximize the heating power.
3. Use NFS H1 certified conduction paste to bridge the heat transfer from the heating jacket to the balloon mold.
4. Optimize the PID values to the specific application.
5. Increase the pressure of the brackets to accelerate the heat transfer from the mold to the cones.

To evaluate the measures, a typical balloon forming process was imitated: first, the product is heated up to 70 °C. After a waiting time, the temperature increased to 130 °C. After another waiting time, the assembly is cooled. The second step is necessary to evaluate the PID parameters. The experiments were performed with a 3x15 mm balloon mold on a 14.3x50 mm heating block. During the experiments, a typical parison of PA12 is inserted into the mold. Inside, a thermocouple is placed to measure the temperature of the parison. No balloon forming is taking place during the experiments.

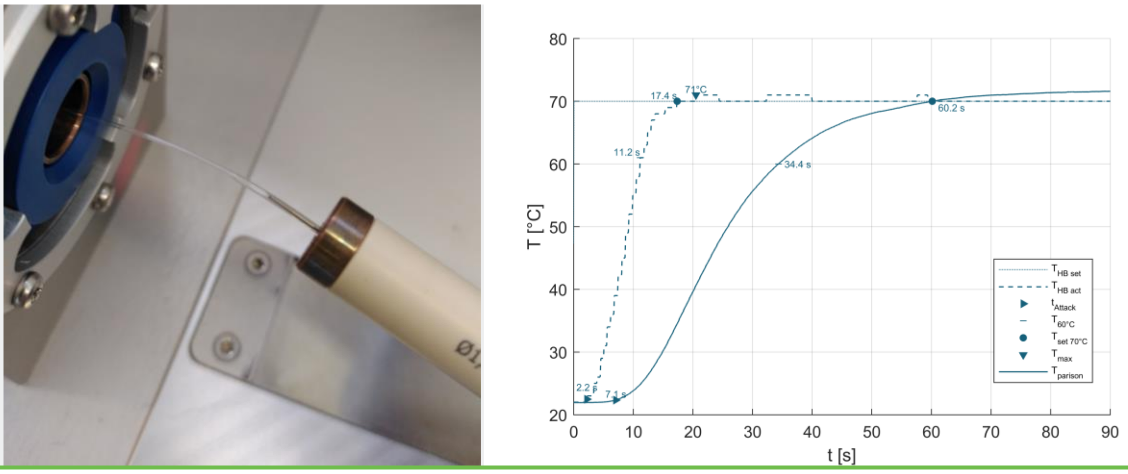

Figure 3: (l) Thermocouple inside a PA12 parison, (r) typical dataset with evaluated characteristic times.

The step response is evaluated in terms of attack time, time to reach 60 °C (which is a good measure to compare the heat-up time independently of the PID parameters), time to reach 70 °C, maximum and steady state temperatures, and times. The system was preheated to assure a comparable starting temperature of 22-24 °C. These evaluations are taken for the heating block temperature as well as the parison temperature.

Results

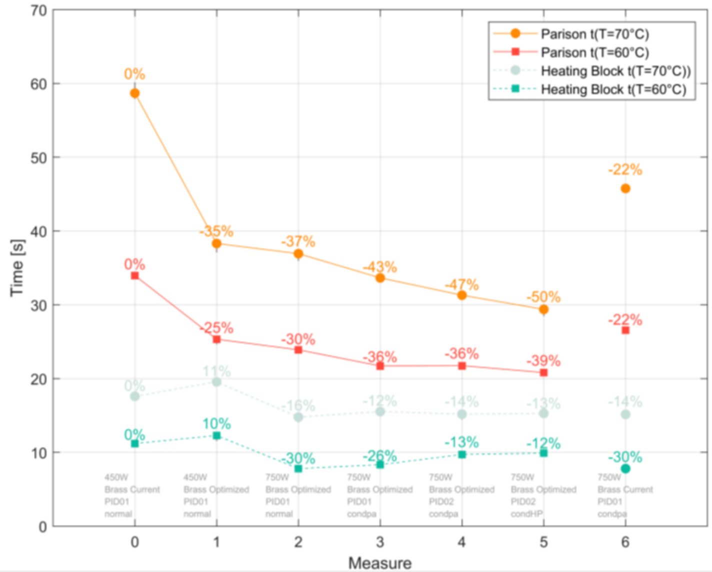

Figure 4: Resulting characteristic times for the applied measure as well as the best results for the current brass molds.

Figure 4 shows the characteristic times obtained for the different optimization measures. With a brass alloy optimized for heat transfer as balloon mold material, up to 50% time can be saved for the heat-up. Compared to the classical material, the saving is more than 20%.

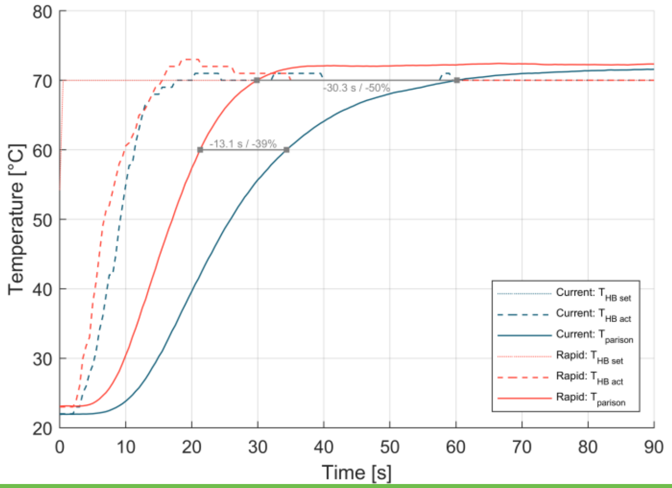

Figure 5: Comparison of the step response of the current system (blue color) and the optimized, rapid system (red color)

Figure 5 shows the current and the optimized step response to 70 °C.

Discussion

Applying all discussed measures lead to a significant speed up of the heat-up behavior.

These were the most effective individual measures in our research testing:

- Changing the balloon mold material to a heat transfer optimized alloy has the strongest impact (approx. -35%).
- Followed by the use of the optimized heating block. Even using original balloon molds, the improvement is significant (approx. -20%).

Additionally, the use of NFS H1 certified conduction paste can be considered.

The presented data was generated using a balloon mold for a 3x15 mm balloon. If any other balloon size is processed, the results can be different. The results give a good indication of the potential for the optimization.

Conclusion

The heat-up time can be improved significantly by changing the mold material, the use of an optimized heating block, conduction paste and process optimizations. The measures have small investment costs and can therefore be very attractive for manufacturing companies.

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