SIMULATION AND THERMAL ANALYSIS OF GLASS BLOWING

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1. Introduction

The process of making Christmas balls is still largely a human-dependent process. The process of blowing Christmas baubles manufacturers try to automate, but only on the basis of experimental settings. In connection with this, the topic of scientific considerations emerged: how to choose the parameters of glass blowing, in order to obtain the best final results.

2. Glass properties

The thermal properties of glass refers to those properties, which depends with high range from temperature. The first is the heat capacity C or specific heat c – defined by heat needed to change the body temperature in a unit mass by one unit.

The specific heat c_p depends from the temperature, what is shown in the fig. 1. The research done by the Ulrich Fotheringham[1] shows, that is very important to do the variety of research before simulating the process.

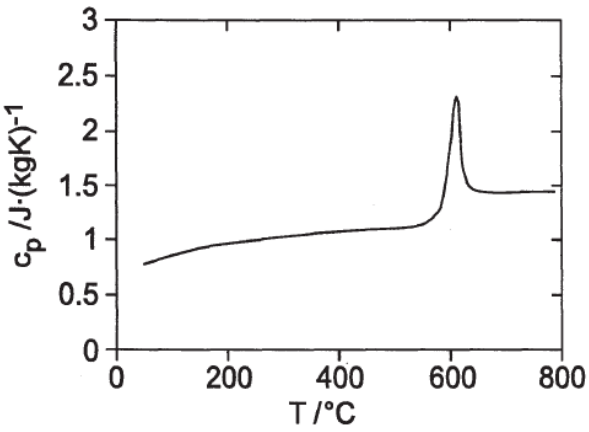

Fig. 1. Measured Cp of optically cooled Schott BK 7® glass [1].

The thermal properties that need to be defined for the analysis are:

- specific heat,
- heat capacity,
- thermal conductivity,
- thermal expansion,
- viscosity,
- emissivity.

To prepare the simulation also the mechanical properties need to be defined.

3. Thermovision measurements

Thermovision measurements were done in the factory, that produces Christmas balls. The measurement were done on each step of the process: from heating the glass tubes, thought blowing balls to melting the tube to cut out the balls. The process of blowing glass balls consist of 5 stages:

- heating tube,
- stretching to make narrowing,
- heating end of tube,
- blowing the ball,
- cut out the ball by heating and melting the tube.

View of the process is shown in the fig. 2

Fig. 2. Semi-automated process of blowing glass balls.

Thermal measurement are shown in the fig. 3-4. The temperature of annealing point is 570 °C, softening point is 820°C and the melting point is 1250°C.

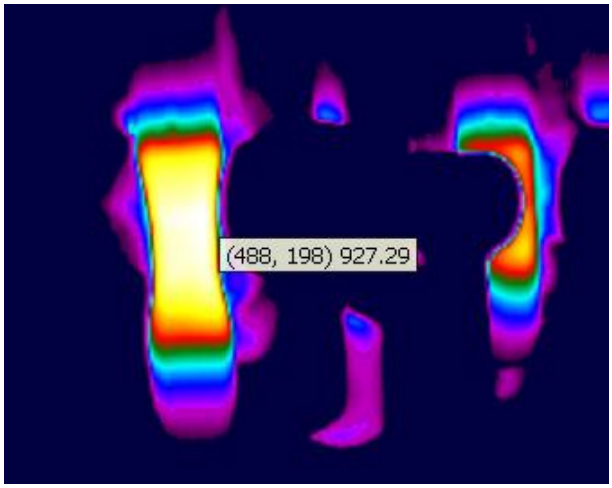

Fig. 3. Temperature during heating tube.

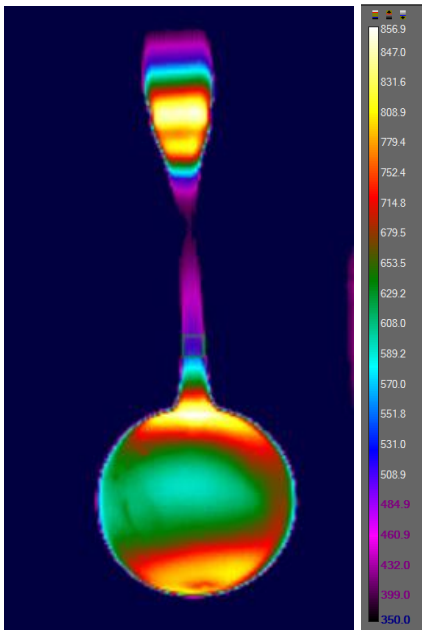

Fig. 4. Temperature after blowing ball

The measurements were done for three different size of glass balls.

4. Simulation of glass blowing

Simulation of the glass balls blowing process has been carried out in several stages. The calculations were done in Abaqus and in NX Siemens. The static, thermal and dynamic analysis were conducted[2,3]. Some of the results from the analysis are shown in the fig. 5.

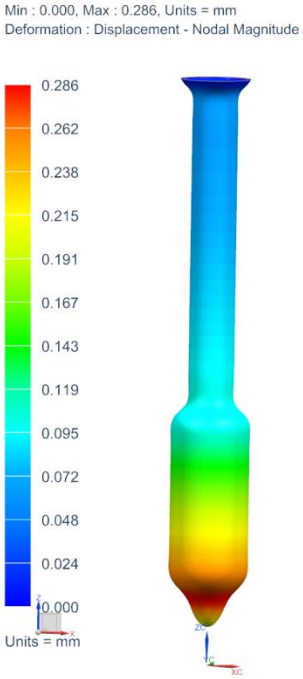

Fig. 5. Analysis of stretching to make narrowing – displacement [mm].

In the full article more results will be shown.

5. Conclusions

To prepare the good quality simulation of the glass blowing it need to get many data of glass temperature-dependent properties.

The simulation was correlated with the experiment.

After correlation it was possible to prepare new simulation for other thickness of glass tube and variety of temperature in process to predict how the glass will behave.

References

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[3] Rusiński E., Czmochowski J., Smolnicki T.: *Zaawansowana metoda elementów skończonych w konstrukcjach nośnych*, Oficyna Wydaw. PWroc., 2000