# Numerical and Experimental Study of the Glass Behaviour in the Blow & Blow Forming Process

VIDRESIM 2016 - NUCLIS DE RECERCA INDUSTRIAL I DESENVOLUPAMENT EXPERIMENTAL

Ramon Clemente GLASS

The **design of the mold cavities** and the **definition of machine operation times** and **process temperatures are key issues** to develop and mass produce optimal containers.

**Glass forming** to produce perfume bottles with specific thickness distribution profiles **is based on trial and error and requires several tests** in production line. These **tests are expensive and time-consuming**, which increases time to market. **The use of a numerical model aims to reduce the number of prototypes** by performing virtual tests of the mold equipment and the process conditions.

The **blow and blow glass forming process** takes place inside two different molds, the industrial process is carried out by **blowing the glass against the walls of the mold cavity.**

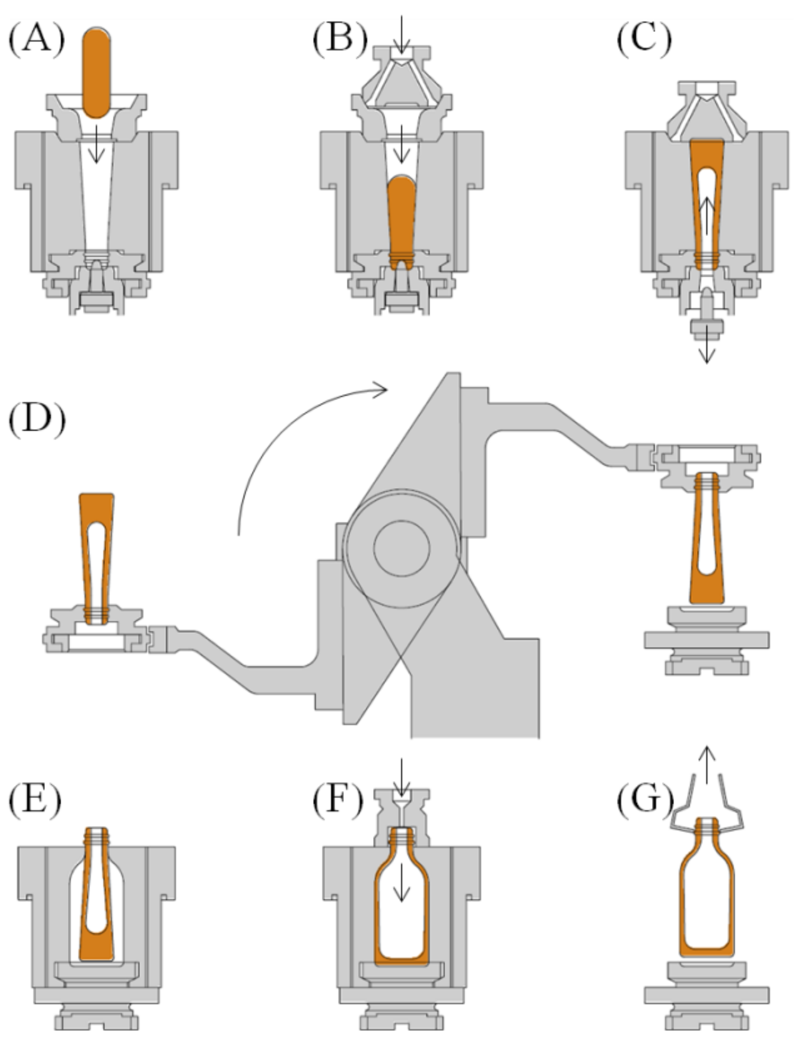


**Figure 1.** Container forming IS machine stages of the blow and blow forming process: (A) gob loading, (B) settle blow, (C) counter blow, (D) inversion, (E) reheat and stretch, (F) final blow and (G) take out.

**Temperature profiles on the glass skin** in the different stages of the forming process where glass is visible **can be obtained measuring with an infrared thermal camera**. These data is used to verify the numerical results (see Figure 2).

**Temperature of glass decreases from 1,030ºC to around 650ºC in few seconds.**

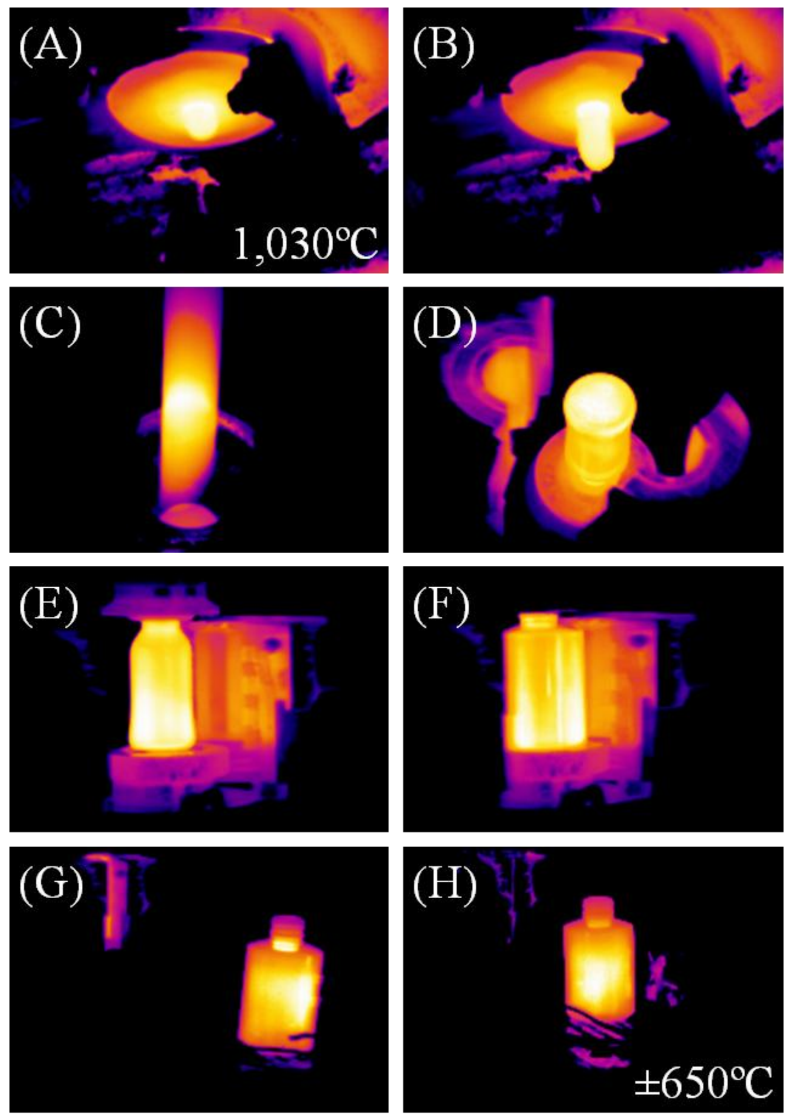


**Figure 2.** Infrared thermal captures of the glass forming stages were glass can be seen: (A) and (B) gob forming, (C) gob loading, (D) blank mold open, (E) parison reheating, (F) blow mold open, (G) and (H) take out.

The blow and blow **glass forming is a complex process** and **a full understanding has not yet been reached:**

**(a) It is not possible to see the glass flow** within the molds **during the blowing stages.**

**(b) Accurate values** of glass and forming tools properties **are very difficult to obtain due to high temperatures, corrosive environment and fast-paced forming process.**

Numerical and experimental results are shown in Figure 3, the simulation steps are briefly explained below:

**Simulation** time **starts after the gob loading** stage **(A)**. Heat transfer begins immediately at the glass-mold contact interfaces of the walls of the blank mold cavity and the neckring. Due to the contact heat transfer, a temperature distribution in the glass domain is defined before the counter blow stage **(B)**, defining in turn a viscosity distribution that will define the glass flow. **In the counter blow stage, pressure is applied and glass expands through the blank cavity to create the parison (C–E)**. After expansion, glass continues to cool in contact with the walls of the mold cavity **(F)** until the blank mold is opened. Then, the parison skin is allowed to start reheating **(G)** and **the parison is transferred to the blow side (H)**. During the parison reheating, the internal temperature gradients in the glass domain redistribute the temperatures until the parison is ready to be blown inside the blow mold **(I)**. **The final blow expands the parison throughout the blow mold cavity (J–L) to define the glass thickness distribution of the final perfume bottle.** The simulation time ends after the expansion of the glass has finished.

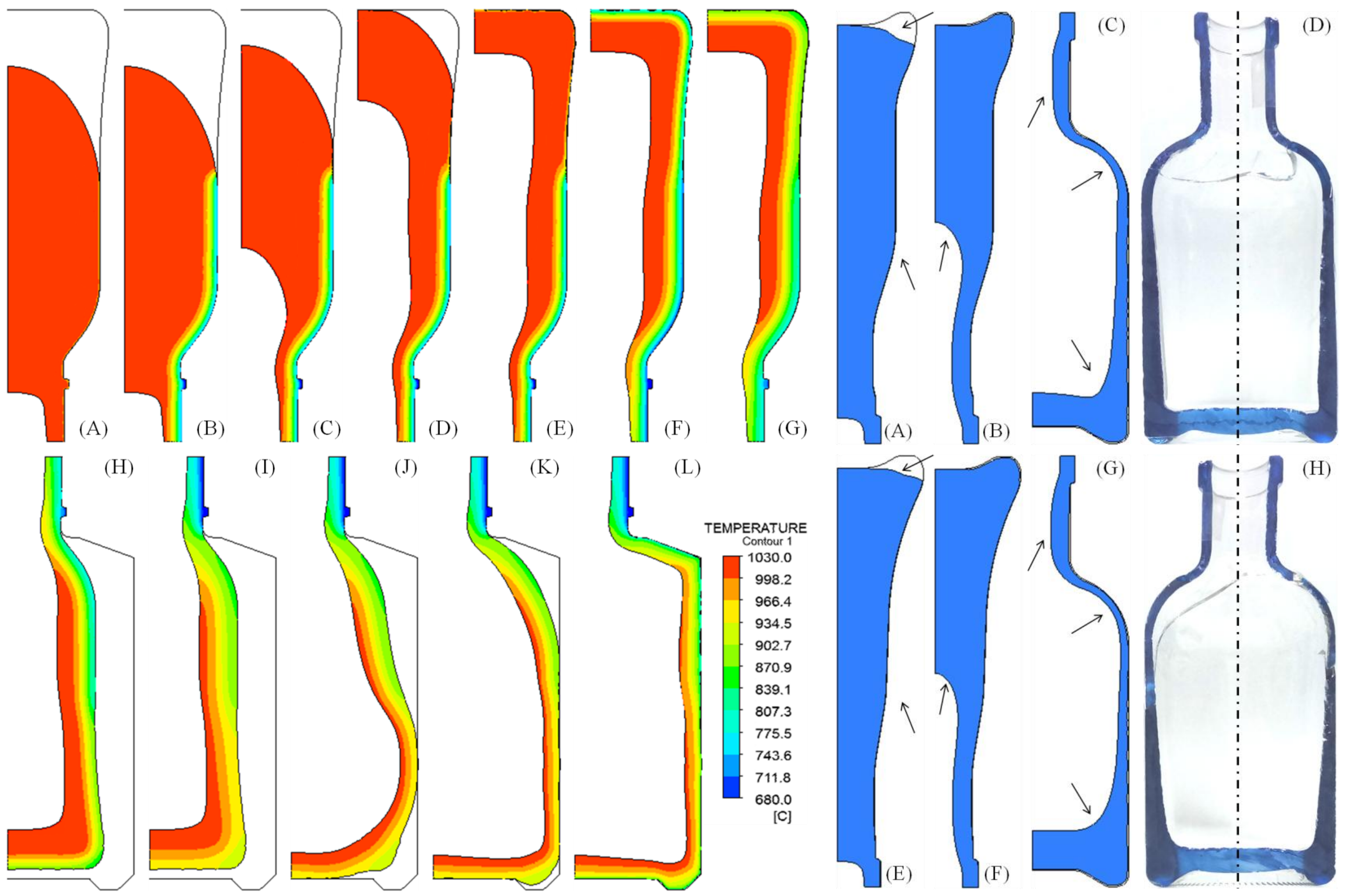


Figure 3. Left: numerical results of the evolution of the glass domain and its temperature throughout the forming process of the SIERRA 60 bottle. Right: Numerical results of the initial step, parison and final bottle compared with a cross section profile of the bottle ALFA 200. Results of the initial blank mold (top) and optimized blank mold (bottom).

**Numerical simulations** of the blow and blow glass forming process **have been performed using axysimetric glass containers representative of the wide range of Ramon Clemente's most common perfume bottles. The comparison of the** cross sectioned produced bottles with the predicted **results** of the numerical model **shows a good agreement for the glass thickness distribution.**

The numerical model predicts consistent results in the glass thickness distribution. **This example demonstrates the capability of the blow and blow numerical model to predict the influence of the blank mold cavity in the thickness distributions of perfume bottles.**

The implementation of **the presented numerical model will be a very useful simulation tool for Ramon Clemente.**

With this research project, results have been obtained in:

**(a)** Numerical simulations of the blow and blow forming process to **predict glass thickness distribution.**

**(b) Correlation of the simulation results** of the glass temperature **with experimental infrared measurements** on the glass skin.

(c) **Experimental validation** of glass forming simulations **and influence of the blank mold cavity in the thickness distributions of perfume bottles.**

(d) **Validation of the** results of **axisymmetrical and three-dimensional models** for axisymmetric bottles.

**Figure 4.** Initial (left) and optimized (right) glass thickness distribution from the container base.


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