Glass Windscreen Forming Optimization By Finite Element Analysis Using COMSOL Multiphysics

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Abstract

Introduction: Glass products are widely diffuse in the everyday reality. Windows, doors, furniture parts, kitchenware, bottles etc., are few example of goods made with glass. In the basic formulation, the glass is made by fusing of silica with a basic oxide [1]. An interesting glass application field, from a technological point of view, is the transportation area. In fact, in the last years, the design of vehicle is developed toward a major fantasy in the shapes [2]. This required a deeper studies in the manufacturing glass process, in particular in the forming process, where a windscreen is obtained from a "raw" sheet of glass. In the paper, a "common" windscreen forming process, for automotive application, is described (see Figure 1). Usually, when a change in the windscreen shape is decided from the designer, a series of trial and error manufacturing tests have be done, in order to obtain the expected final shape. Often, this means to stop the single manufacturing line to carry out the forming tests with loss of money [2]. In this paper, the results of a preliminary study on the forming sheet glass process are shown. A first optimization study, in order to reduce the forming time, is here presented (Figure 2) [3]. The constitutive relationships: The forming process of glass sheets into windscreens can be modeled by a stress-strain relationship accounting for the temperature. In [4], the relationship is described as follows. In this study the system is simplified by the following assumption: neglecting the pre-heating step and consider, in the numerical simulation, the glass sheet as viscoplastic material. In the post processing of results, the equivalent stresses are compared with the yield stress in order verify the initial assumption. Use of COMSOL Multiphysics: In the present study the secondary creep for the glass sheet forming is modeled in COMSOL Multiphysics 3.5a by using a coupled analysis. The 2D Structural Mechanical interface is coupled with the PDE interface in a general form for a transient analysis. Figure 3 shows the sheet geometry used in this study together with the 2D simplified subdomain. Results: The subdomain equivalent von Mises stress is evaluated to verify the simplifying assumption. The deflection in the middle of the span, against the time, is evaluated for different load conditions. The achievement of an pre-assigned deflection value, fixes the end of the forming process. Comparison between the time process and the maximum stress during the forming process allow to value the "best" process parameter to carry out the forming process. Conclusions: In this paper a preliminary approach in order to optimize the forming process of glass windscreen at high temperature, was showed. COMSOL Multiphysics was a suitable tool to study the coupling of physical phenomena such as the structural mechanic with the thermal state in order to account for the viscoplasticity of glass. The computed results allow to value the "best" forming parameters in order to speed up the production rate.

Reference

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Figures used in the abstract

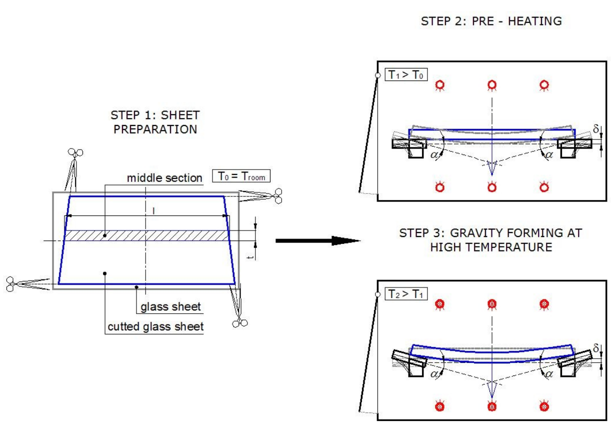

Figure 1: Traditional windscreen forming process.

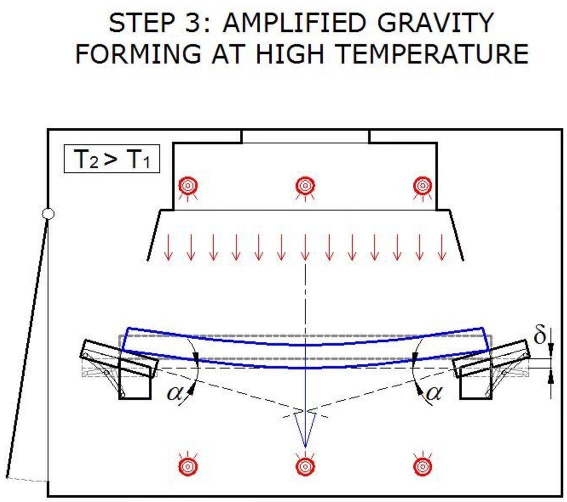

Figure 2: Modified windscreen forming process.

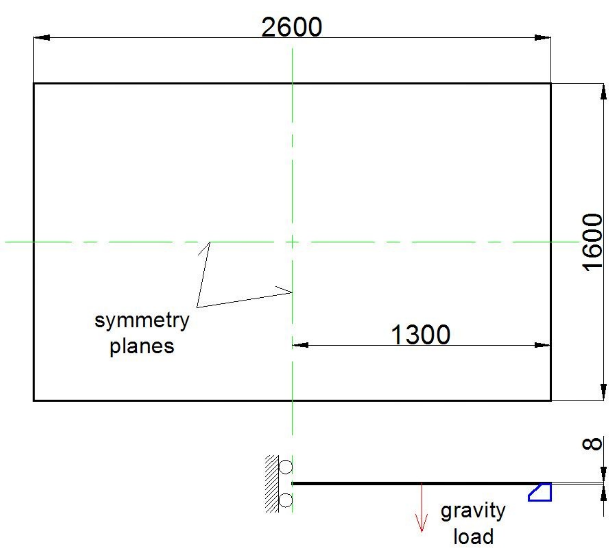

Figure 3: Analyzed windscreen geometry.