Understand in situ industrial PU foaming & filling using numerical simulation

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ABSTRACT

Polyurethane chemical foaming is a complex process that implies several physical and chemical phenomena. A first reaction releases CO_2 gas and conduct to an increase of volume and a decrease of density. The polymerization reaction then induces a viscosity increase as well as a heat release. This second reaction has an influence on the first one, as they are both enhanced by temperature.

These phenomena are well understand by foam producers and processers, and it is easy to characterize a foam by a simple free expansion experiment. This experiment enables to obtain information such as final density, rising time and heat creation. However, in an industrial context, flow behavior through narrow and confined areas, coupled with a viscosity increase, leads to a high density heterogeneity and possible underfillings. This heterogeneity prevents from predicting necessary mass for whole filling, and can lead to great discrepancies between reality and expectation.

In this work, we present a fully coupled model taking into account each phase of the PU foaming. This model enables to handle interactions between gas production, polymerization, heat transfers and flow. An innovative model enables us also to handle end of foaming problematics, such as gas escape and cells collapsing under shearing.

Several simulations using the REM3D® software, which includes all these developments, are presented. These examples are taken from different industries like automotive, aerospace and others. In each case, we are able to predict foam evolution into the cavity, including underfilling phenomena. The local density for every point of the final part is also a result, as well as pressure inside the cavity, and end of polymerization time.

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