Simulation of the residual stresses and distortions in a high pressure die casted part and validation by experimental measurements

**Motivation & objectives**
This project consists in developing a numerical model for the simulation of the residual stresses and distortions in a high pressure die casted part. The validation of the simulation by experimental measurements is part of the project. The prediction of the distortions is necessary in order to reduce the number of scraps and the reworking of the tooling. A better knowledge of the residual stresses makes possible to reduce the security factors and thus to decrease the weight of a new component. The simulation in Magma includes heating cycles, filling, solidification and stresses computations of a car door frame. The distortions of the simulated and real parts are compared for the validation.

**Methodology of the numerical modelling**
- Pre-processing with CAD
- Import geometry
  - Importing the STL files and definition of elements that are not geometrically modelled (such as vents).
  - Structured hexahedral mesh, large but thin wall part makes the number of cells to increase
- Parameters definition
  - Definition of all the material and process factors as used in the production of the part

**Simulation results**
- Simulation of the residual stresses
- Heating cycles, filling, solidification and stress simulation
- Analysis of the results and comparison with the experimental measurements

**Geometry & mesh**
- Eight kinds of material are imported as STL files: cover die, ejector die, tempering channels, runnels, gates, overflows, machining allowance and casting.
- In addition, the inlet, vents, thermocouple and dummy boxes (necessary for the meshing) are directly defined in Magma.

The mesh is hexahedral and structured. Thus, the sizes of the cells are propagated throughout the mould, which increases dramatically the number of cells.
In order to have at least 3 elements on the thickness of the part, 2.94 millions of casting cells and a total of 205.78 millions of cells are necessary.

**Experimental work**
The experimental measurements are done with a Coordinate Measurement Machine (CMM). The part is fixed isostatically with the RPS-method. Fifty points are measured on three raw parts and six finished parts (after the removal of the casting system). A program is used for positioning the probe and for computing the deviation between the measured points and the reference geometry. The parts are much less twisted after the removal of the casting system by punching than before.

**Conclusion & future work**
The matching between the simulation and the measurements is good for the raw parts. The amplitude of the deviations is not exactly the same, but the direction is correct. The punching process (removal of the casting system) is not simulated accurately. In Magma, it is modelled as an ideal removal while it is likely that the real process generates additional stresses. This project does not include the simulation of heat treatment, which is necessary in order to predict the shape of a part at the end of the whole production process. In the future, a sensitivity analysis must be done, in order to know which parameters must be controlled with special care.

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