Thermoset-based composite materials exhibit distortions as a result of the manufacturing process. The shape of a composite part deviates slightly between the beginning and the end of the cure, owing to several irreversible phenomena. If these distortions are not anticipated, the assembling of several components together may require unacceptable forces or lead to internal stresses detrimental to the in-service behavior of the structure.

Despite numerous studies about cure-induced distortions, the literature still lacks tried-and-tested methodologies for their reduction. The increasing complexity of the designs makes rules of thumb obsolete, while relying on experimental trial-and-error sequences results in prohibitive additional costs and delays. The present thesis focuses on the development of numerical tools capable of predicting the shape of the mold which minimizes the deviations with respect to the target design. The use of numerical simulation enables to bypass expensive experimental studies. Three complementary methods are proposed, focusing on their applicability to complex geometries in an industrial context.

In another contribution, the thesis improves the feasibility and accuracy of the curing simulation methodology by answering to the deep need for material properties. Instead of relying on material characterization at the composite level, homogenization is used to predict the properties of the multi-phase material based on those of the constituents. The novelty of the approach resides in making finite element homogenization applicable to coarsely-modeled woven textiles, for which the geometrical representation of the yarns usually overlaps. Instead of spending resources on suppressing the penetrations, the latter are accommodated by using non-conformal meshes and a procedure to reallocate the fiber volume within the overlapping regions.

In a final stage, the homogenization and mold compensation methodologies are put into practice to manufacture composite parts in Cenaero's laboratory. The non-compensated and compensated parts are compared to confirm that the distortions are largely reduced by the developed techniques.

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