Mold Mesh Generation by Stitching Various Sources Incrementally

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1 Introduction

Autodesk Moldflow is a simulation package for plastic injection molding. As part of the solutions for Digital prototyping, it helps CAE analysts and manufacturers optimize the design of plastic parts and injection molds.
In general, models of the plastic parts are created at the first stage of product optimization and the major concern is the manufactured quality of the parts. Once the product design is satisfactory, optimization may be extended to mold design. However, the challenge is that models of the mold geometry may not yet exist in the analysis models. The plastic parts sit inside the mold geometry and have contact interfaces. If the analysis model is replaced by a new assembly which includes the mold components, all analyses will have to be re-run. In addition, it is also common that part geometry is optimized as a result of the part analyses. In order to extend analyses to molds based on legacy meshes for plastic parts, we provide an approach to generate mold meshes incrementally by stitching new CAD or STL bodies of the mold with existing part meshes.

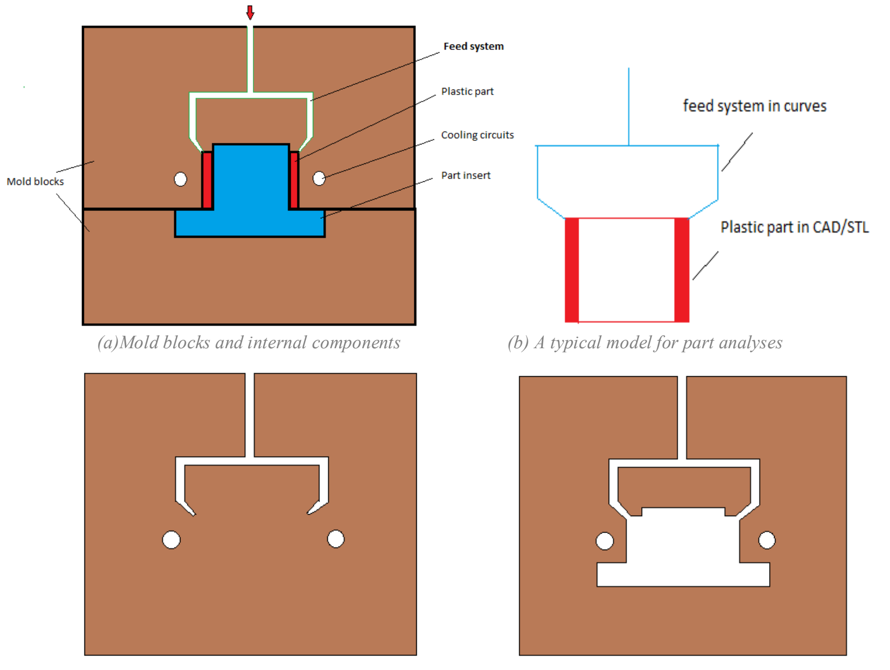
2 Mold Boundary Represented by Various Sources

A typical mold model may contain mold blocks, feed system, cooling circuits and inserts, as shown in Fig. 1(a). Part inserts are produced outside the molding cycle. During the manufacturing process, one of the mold blocks will move to allow ejection of the solidified part and attached part inserts. After ejection of a previous part and part inserts, a new molding cycle begins when the mold closes, followed by the injection of hot polymer (shown as red) into the mold cavity through a feed system. After the cavity is filled, a holding pressure is maintained while the polymer is cooled by contact with the mold. When the part is sufficiently cool, the mold opens and the part is ejected. The mold itself is cooled by a cooling fluid which is circulated through the cooling circuits.

For the purpose of part analysis, parts and inserts are represented by triangular or tetrahedral meshes generated from CAD or STL models; while the feed system is represented by curves or one dimensional beam elements. See Fig. 1(b). Flow, warp and stress analyses can be performed on the part geometry without the presence of a mold model.

Mold cooling analysis is needed in order to optimize the design of cooling circuits and the timing of the process cycle. A mold model is expected to enclose the part and insert meshes, while the part and insert surface serves to define the internal boundary of the mold model. Fig. 1(c) shows the model for mold blocks, which contains the feed system and cooling circuits but is not yet connected to the part and insert surfaces.

Fig. 1(d) shows the expected mold model for mold analyses. The mold model should be connected with part cavity surface at the end of feed system. In addition, contact interfaces between parts and inserts should not be included as mold internal boundaries. A tetrahedral mesh representing the mold is required in the shaded region.



(a)Mold blocks and internal components *(b) A typical model for part analyses*

(c)Mold model without parts *(d) Expected mold model for mold cooling analyses*

Fig. 1. A mold model.

3 Stitching Mold Boundary

The molded part and part inserts sit together inside the geometry of the mold cavity. However, since these bodies are usually meshed independently, the meshes will be discontinuous at the contact surface of the part and the insert.

The mold surface mesh is created by three separate stitching procedures:

(1) Stitch contact interfaces between surface meshes of parts and inserts. The outcome is a water tight triangular mesh with one single cavity.

(2) Create CAD models for molds by booleaning mold blocks with feed system and cooling circuits represented by curves. The curves are first converted into cylinders based on user defined geometry parameters (diameters).

(3) Stitch CAD model of mold with cavity surface mesh.
We cannot stitch by CAD booleaning operations, because part meshes may be generated from STL models.

After stitching, mold internal boundary is conformal to the original cavity surface, which could not have been guaranteed if a whole new CAD model were used for the mold.

4 Examples

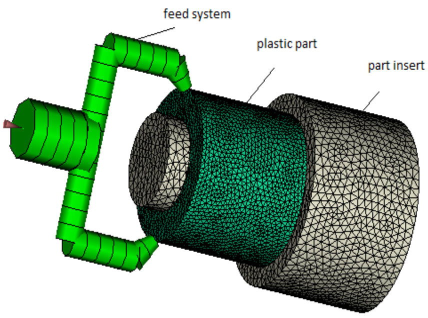
Fig. 2(a) shows a typical mesh for part analyses, which includes a part, an insert and a feed system. Part meshes can be generated from CAD or STL models.

Fig. 2(b) is the cavity surface mesh after stitching the part with the insert. Fig. 2(c) is the cross section of the stitched surface mesh. Triangles on contact interfaces have been removed. Fig. 2(d) highlights some triangles in a stitched area. The stitched cavity surface will be a part of the mold internal surface, which is conformal to the boundaries of plastic part and insert except for stitched areas.

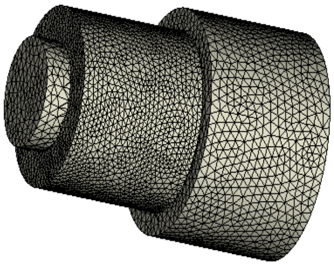
The mold model is constructed as a CAD body based on mold external boundary together with feed system and cooling circuits, as shown in Fig. 2(e). Cavity surface mesh is not included in the CAD model.

The CAD model for the mold is then meshed by the Autodesk geometry engine after being stitched with cavity surface mesh, as Fig. 2(f). Fig. 2(g) shows a stitched area connecting feed system and cavity surface.

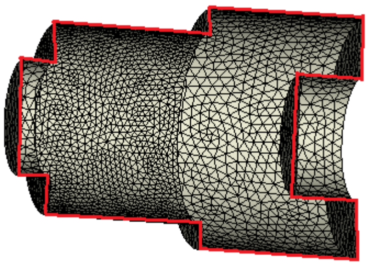
At this stage, a water tight triangular mesh of all mold surfaces has been created. An anisotropic tetrahedral mesh is then generated from the stitched mold surface mesh by Autodesk Moldflow Insight software, see Fig. 2(h).



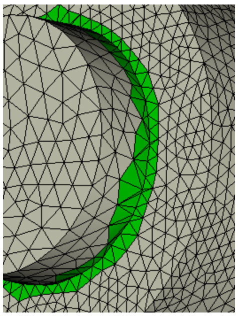
(a) Plastic part, part insert with feed system in beams



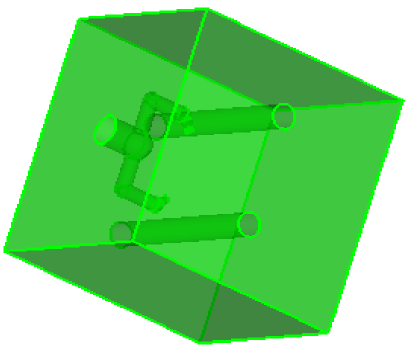
(b) Cavity surface after stitching with inserts



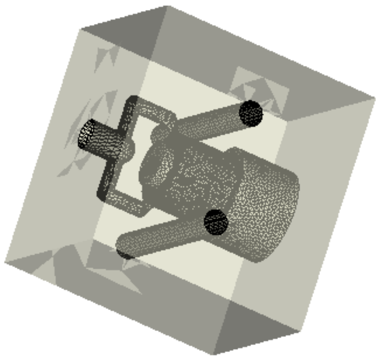
(c) Cross section of the stitched surface mesh



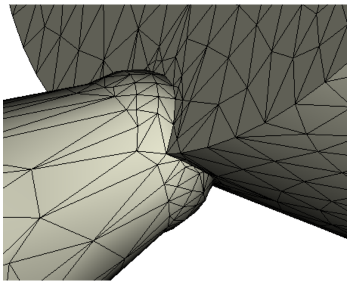
(d) Stitched area highlighted



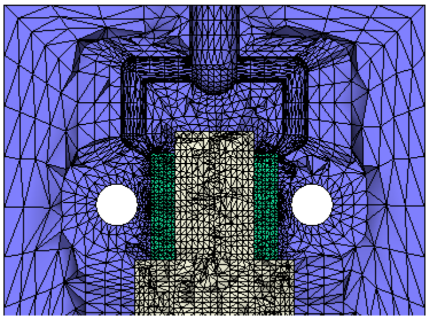
(e) Mold model without cavity surface



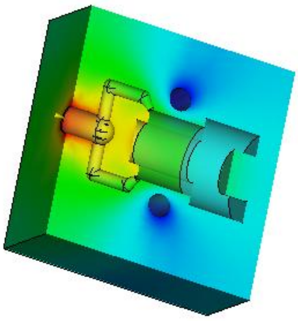
(f) Mold internal surface mesh after stitching with cavity



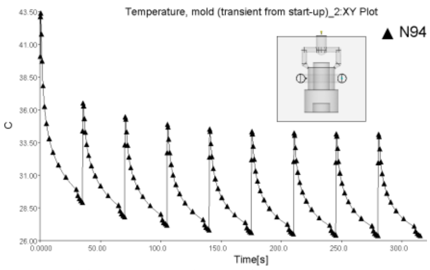
(g) Local area connecting feed system and part



(h) Tetrahedral mesh for mold (blue)



(i) Mold average temperature



(j) Mold temperature history from startup

Fig. 2. An example of mold model for cooling analysis

Transient mold cooling analysis is performed on the tetrahedral mesh by the same software. Fig. 2(i) shows the average temperature on mold, and Fig. 2(j) shows the temperature history of a particular point inside the mold. Mold designs and process parameters can be optimized based on the results of this analysis.

5 Summary

A practical approach for mold mesh generation has been provided in real industry. Starting from legacy part and insert meshes, mold meshes are generated incrementally by stitching new CAD entities with the legacy meshes. The mold mesh boundary is conformal to legacy meshes except for stitched areas, and legacy analysis results are not lost.