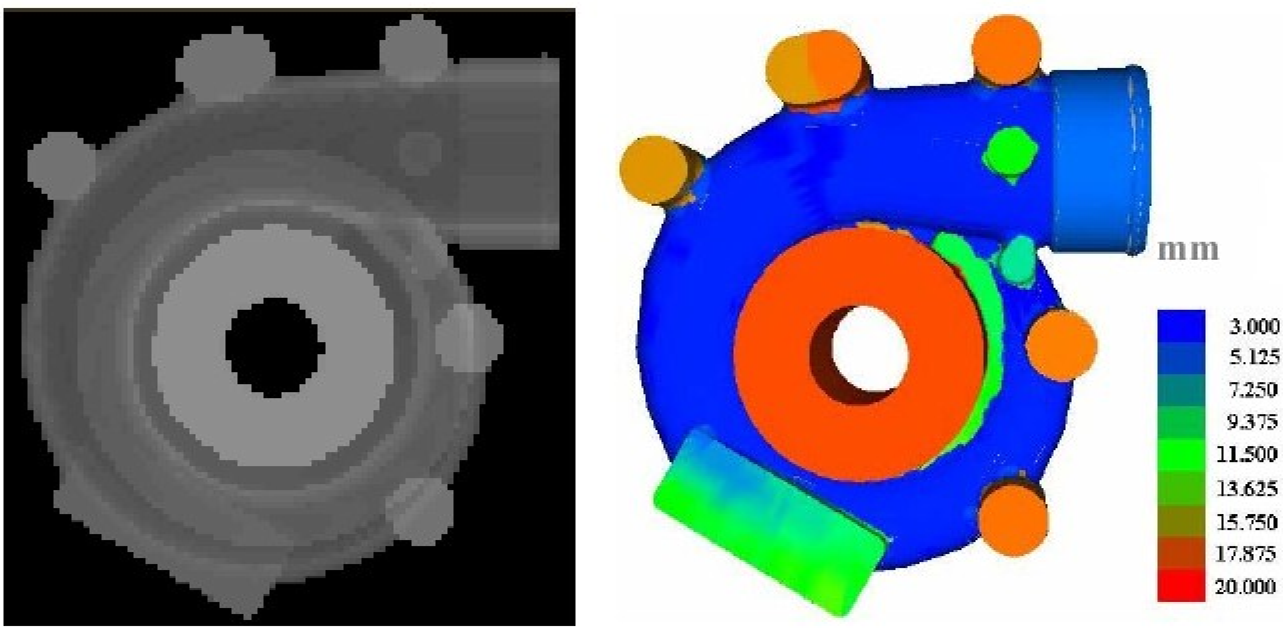
Model Verification and Application Requirements

The solid model has to be verified for its conformance to the actual shape being analysed or manufactured. Errors may be introduced during modelling, exporting or importing. The STL format files can have errors such as missing facets and edges, usually in small fillets at internal corners. It is therefore necessary to verify the model after exporting from one program and importing into another program. Model verification methods include visualization, dimensional measurements, property computation, thickness check, simulated radiography and Euler's equation.

Model visualisation and measurements: The model can be viewed as an orthographic, isometric, cross-sectional, hidden line or shaded image. It can also be panned, rotated and zoomed to visually verify all surfaces. Newer solid modelling programs have automated dimensioning facility driven by the part geometry, making it easy to check all key dimensions. In addition, check points can be clicked on the part surface and the distance between them can be measured for verification. It is also possible to check the angle between two edges and between two faces.

Geometric properties include volume, weight, centre of gravity and moments of inertia. The comparison of computed weight with the actual weight of the part is a widely used check to catch gross errors in modelling. This however, requires accurate modelling of even minute features such as fillets and tapers. The actual part must be free of manufacturing defects and the correct value of average density of the part must be available. A volume comparison is more reliable.



Model verification using simulated radiography (left) and thickness map (right)

Thickness check: This is very useful for models with intricate surfaces and internal features, which are more susceptible to modelling errors. This involves generating model cross-sections and interactively measuring the distance between two points specified on the opposite ends of any wall. More sophisticated approaches include producing a colourcoded thickness map of the entire model.

Simulated radiography: This is very useful for identifying errors such as missing facets in STL files, which can lead to problems during feature recognition and process simulation. In this method, parallel rays are passed through the model in a specified direction, and the model thickness along a ray is indicated by a grey shade (Fig.2.4). Any unexpected streaks of lines in the radiography image indicate errors in the model. The distance between the rays influences the size of the error that can be identified. Euler's equation is valid for facetted solid models, and is given by: $V+F = E+2$, where V, E and F are the number of vertices, edges and faces, respectively. The check must be available in the solid modeller (or the program which imports an STL file).

Application Requirements

Major casting software applications and their requirements with respect to the part model are listed below.

Casting design and analysis: A facetted model of the product in STL format is sufficient, and is indeed preferred owing to its simplicity and robustness. This format facilitates the generation of mesh required for numerical simulation of stress analysis, mould filling and casting solidification. If the model contains very small fillets, these may be eliminated before exporting the STL file to reduce its size, which improves the speed of subsequent analysis. This also minimizes errors (such as missing facets and dangling edges) in the solid model. Another way to reduce the file size is to use the STL Binary format, which is typically half the size of STL ASCII (or text) format.

NC manufacture of tooling: A complete and accurate description of the casting surface is required for generating the numerically controlled (NC) cutter tool paths using a computer-aided manufacturing (CAM) software. The IGES format file is suitable for this purpose. This enables accurate manufacture of the tooling (pattern, core box, mould) using an NC machine and also subsequent inspection using a coordinate measuring machine (CMM). However, there are several versions of IGES, and also the files generated by different CAD systems may not be exactly the same, creating compatibility problems. A preferred solution is to use the CAD and CAM programs from the same developer, so that data translation errors are eliminated.

Manufacturing resource planning: For materials planning, cost estimation and other planning tasks, non-geometric information related to the casting is also required. This can be best handled by the STEP standard for casting, after it is widely accepted.

Web-based collaborative engineering: In near future, castings will be collaboratively developed by product, tooling and foundry engineers (who may be located anywhere in the world) by exchanging relevant information with each other over the Internet. This will require web-friendly standards for handling casting life-cycle information.