CASE STUDY No 8

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CAD Modelling for Patternmaking

Modern CAD-CAM systems are an invaluable tool to the Patternmaker. In conjunction with his existing skills, the patternmaker can use 3D CAD application software to manipulate geometric models of the cast part to identify cores, undercut areas and parting planes etc. for the subsequent CNC machining of patterns and core boxes.

Modern CAD systems incorporate powerful tools such as draft checking and parting-line silhouette curve functions to assist the Patternmaker / CAD Engineer perform these essential tasks in tooling design. Whilst for simple parts, identifying these areas is relatively easy, for more complex castings this can be less obvious. It is in these cases that the advanced capabilities of 3D CAD modelling programs become essential in reducing mould and tool design lead times.

From the 3D geometric model of the casting, the software allows the extraction of appropriate features for the production of pattern / core-box models, which are then exported to CAM software packages to facilitate CNC machining.

This shift from traditional 2D design to 3D modelling creates a definitive model that completely retains the original designer's intent by eliminating any shape ambiguity often associated with drawings, and reduces production lead times.

Manufacturing Considerations

Cast components are rarely designed in isolation but are part of an assembly.

The functionality of many modern CAD systems enables the design engineer to create products which comprise many components, and within these assemblies he can check for interference of the individual parts, simulate mechanical movement and perform stress analysis.

However, there is often little or no regard given to downstream manufacturing operations at this stage. In terms of castings, this may mean that draw taper has not been included, for example, or the design calls for features that are costly, time consuming to incorporate into pattern equipment, and often necessitate requests for design concessions.

CAD Model

Compatibility

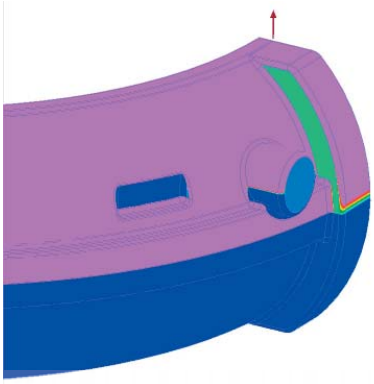
Modern manufacturing necessitates the electronic transference of product data. In the case of 3D CAD geometry file exchange, the first consideration must be the compatibility of the CAD systems of both sender and receiver.

Where these are both the same (i.e. native file: Pro-Engineer into Pro-Engineer) little or no problems are encountered provided good modelling practices have been adopted.

In this case, all the feature creation history (i.e. a record of all the CAD modelling techniques and size parameters of the part) will be contained within the file; this allows the component to be modified relatively easily if any design concessions or alterations need to be made for tooling design.

However, if the file is produced in a different CAD package, then the geometry must be imported using a neutral file such as .iges or .stp (a neutral file being a file which complies to a set standard and can be recognised by both systems engaged in the data transfer).

Increasingly, many CAD packages now include dedicated direct interfaces to particular systems but still do not retain the creation history; essential in the modification of the part geometry.



Draft analysis showing undercut areas. Dark blue indicates undercut areas requiring design concession, loose pieces or cores.

With a vast array of CAD systems available, data transfer using a neutral format can give varying results. Some of the data transfer standards available such as '.iges' are quite flexible in the way geometric features are described but whilst two communicating systems both claim to comply with the standards, some incompatibility can still exist.

In these cases, the degree of success of a data transfer can range from having full component integrity exhibiting full volumetric properties, to a model with slight gaps between surfaces, or badly disjointed and untrimmed surfaces that render the model useless without considerable reworking.

Many cad systems have 'healing functionality' which enables repair work such as closing gaps and inconsistencies between surfaces to be made to the imported CAD geometry, thus overcoming some of these variations. The level of this remedial work requirement is very much dependant upon the downstream use of the CAD files i.e. rapid prototyping, finite element stress analysis etc. However this 'healing process' can be very time consuming and very reliant upon the level of training given to the CAD Engineer / Patternmaker and the expertise attained.

CAD in the Pattern Shop

The functionality within the CAD software package is of particular importance for pattern shop applications. Pure solid based modelling software will not import geometry which includes gaps or exhibits missing surfaces, if a neutral file transfer is used.

Hybrid modelling packages handle both solid models and surface geometry, thus allowing the CAD geometry to be imported as surfaces even if there are gaps present. Depending on the severity of the inconsistencies, the time spent repairing surfaces and closing gaps can be considerable, resulting in increased lead times.

These problems need to be addressed if the model is to be used for stereo-lithography or finite element analysis, where solids based analysis is required. Occasionally the extent of the inconsistencies renders a model unworkable, but generally if the gaps are small then the model can still be worked on and is suitable for CNC machining.

Many CAD systems include powerful functions specifically relating to mould and tool design, although these options may only be available as additional modules. All systems will allow a part to be scaled uniformly for contraction; whilst some applications will allow a part to be scaled along different axes with different values, permitting varying contraction rates to be incorporated into the model.

If the part is to be manufactured in a process which requires 'draw taper' during moulding, then ideally this draft should be added at an early stage of the CAD model generation. In this way the draft becomes an editable feature. Therefore early liaison between the part designer and patternshop is highly desirable.

Further, if the model is from a native part file, then the recipient will have the flexibility of using the model history tree, mentioned earlier, to insert draft at relevant points of the part creation. It should be remembered that draft should always be added before filleting the component edges.

Adding draft to 3D models can be achieved easily on simple parts but for more complex geometries the action of removing fillets, adding draft and then re applying the radii can have an impact on the design intent of the original model further down the history tree. This can lead to regeneration problems with features that were previously part of the referencing geometry now having been deleted. The integrity of the model is now dependent on the resolution of these problems.

Parametric features within a 3D model all interact and relate to each other in some way with many types of geometric references. Bad practice and inconsistencies in modelling techniques can cause unpredictable results when design changes are made. This is where collaboration between the CAD engineer / Patternmaker and the customer becomes crucial. For the CAD engineer attempting to modify customer part geometry, there is a significant danger that the original design intent may not be preserved. If the draft work is significant then it may be more efficient for the original part designer to make the changes with guidance from the pattern maker.

Finishing the Pattern Design

Only after the casting model geometry has been established, can work begin on the modelling of the constituent components of the mould and core assembly. A global contraction allowance can be added at this stage so that all subsequent parts make reference to the scaled master model. If there are two or more contraction rates then this should be applied after the pattern and core surfaces have been separated but before modelling of the core prints.

Using the master model as the first component in an assembly will allow parametric modelling of all print and loose piece geometries. Core surfaces can be quickly extracted and copied to a new part where prints can be added. Pattern surfaces can be copied to a separate part and print surfaces modelled to reference the core prints including clearances.

Undercuts can be accommodated by modelling the loose piece surfaces, including draw taper and cutting from the pattern model. The surface can then be offset for clearance and the cut reversed to create the loose piece.

Summary

The key to a smooth transfer of CAD data between customer and CAD engineer is the compatibility of software packages. It is clear that working with compatible files leads to greater efficiency and flexibility in the design process. However, absolute compatibility of CAD software does not rule out problems completely. Bad practice and modelling inconsistencies can lead to unpredictable results. It is also important that good communication exists between customer and patternmaker.

Using these guidelines to produce models will enable the CAD engineer to produce a flexible assembly allowing any changes made to filter down through the individual components, resulting in accurate parts that can be produced quickly and efficiently.

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