Key sand casting design considerations

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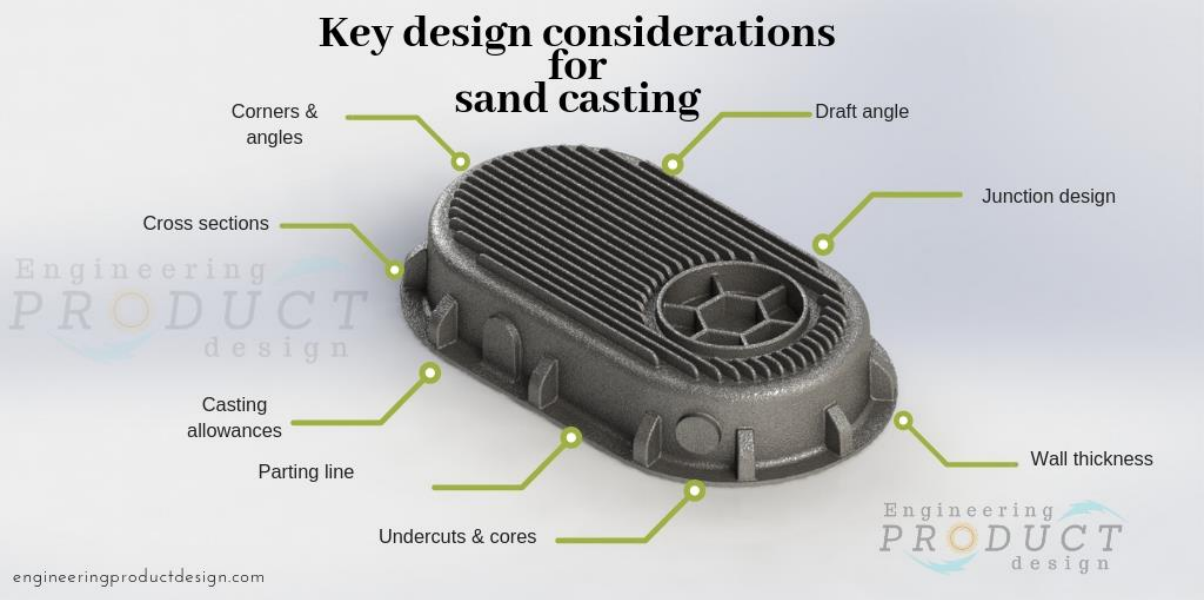
What is sand casting?

Sand casting is the most versatile among the manufacturing methods that enables to manufacture very detailed and complex parts from unlimited number of metals and their alloys.

A casting design would be useless unless the design can be made in the foundry, satisfying all the functional requirements within budget. The cost effectiveness of the process depends highly on the design as this is reflected on the final cast. The decisions made during the design changes would make a big impact on the cost and some of the disadvantages of sand casting can be avoided by designing the part to suit casting. However, there are key sand casting design guidelines to be followed in order to keep costs down. Engineering product designers should understand the reasons as to why some of these techniques are used and consider those during the design stages of the cast.

Key design elements of sand casting:



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Draft angle

Draft angle is the angle applied or allowed on all vertical faces of a pattern to aid easy removal from the sand mould without damaging its walls. Angle required depends on the moulding process, cast design and pattern depth inside the mould.

Design engineers often overlook this aspect of sand cast design even though it is critical for a successful cast. Allowing suitable draft angle and utilising the tapered surfaces in the design will increase castability and reduce tooling cost due to increased metal flow and ease of tooling.

If it does not critically affect the functionality of the design, a draft angle as per ISO standards will help produce cheaper and consistent sand moulds. Generally, foundries as a rule of thumb use 1-1.5◦ of draft angle under normal conditions.

Parting line

A **parting line** in sand casting is the borderline in which draft angles change direction. Although the foundry will have the knowledge and experience of placing the parting line, engineering product designers should be aware of parting line placement as it dictates the quality and the cost of the cast. Parting line should be wide, short, horizontally flat and placed as low as possible. Change in parting line placement will affect core usage, gating placement, weight of the cast and dimensional accuracy.

Undercuts & cores

Undercuts in sand casts are features that prevent and stop the pattern from being removed during the mould making stage. Usage of core sand loose pieces increase production time and cost. Parts should be designed in such a way that it reduces or eliminates core usage. Early parting line definition helps to understand the features to avoid undercuts.

Cross sections

Uniform cross sections, also referred to as uniform wall thickness is generally preferred but they are unfeasible in many engineering product designs. The principle requirement is that not to leave thicker sections of the casting isolated when cooling. The thicker section takes longer to cool while all the metal around it had already solidified. As the thicker section continues to solidify it cannot "feed" from the sections around it leading to defects such as porosity or tearing. It is worth discussing with the foundry about thickness limitation of your material before deciding.

Wall thickness

In sand casting, volume to surface area ratio is critical in getting even solidification and to avoid formation of cavities. Solidification is directly proportional to the square of volume/surface area ratio. Sections in the casting with low volume to surface area will solidify faster than sections with higher volume to surface area.

It is good/ recommended practice to use ribs and gussets rather than increasing the overall thickness or adding thicker sections in load-bearing places. These not only add strength but also reduces localised thick walls and aids molten material flow. Isolated heavy sections can also induce stress concentrations and cause shrinkage and tears.

Corners & angles

Cooling characteristics of the cast and mould material have a major influence on the quality of sand castings. Sharp angles at intersections and corners produce local hot spots and provide sources of stress concentration. This causes the cast to distort, shrink and tear during and after the production process, hence should be eliminated by fillet radii.

Junction design

Since sand casting is a near net shape manufacturing technique, the parts can often be very complex in shape and contain lots of junctions. These junctions are generally grouped under five types viz., L, X, V, Y and X-T junctions.

They create localised mass concentrations, and these can create defects such as shrinkage, tears and cracks. Ideally, these junctions should be designed in a way to reduce or eliminate localised mass concentrations.

Casting allowances

Most metals such as steel, aluminium, magnesium, zinc and copper shrink when they solidify and need to be considered and managed carefully. The amount of shrinkage depends on the freezing point of the material and the volume to surface area ratio of the product.

Machining allowance should be added for mating interfaces of two sand cast parts and curved edges should be avoided at the interface. Recommendations for the machining allowances are included in the published standard ISO 8062.

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