

Sand casting techniques

Profession



**ASSIGN
BUSTER**

MME 3210 Materials Processing Techniques Laboratory Assignment - Sand Casting of an Aluminium 13wt% Silicon Alloy 1) Process Attributes Waste shown yellow* Waste shown yellow* After taking part in the sand casting laboratory session it was made clear that the process possessed many advantages and disadvantage, both from the process itself and from the final part produced. Observing the process step by step it was noted that the tasks carried out by the operator were not very difficult (i. e compacting sand, pouring liquid metal) and so giving the advantage of only requiring a low skill level.

However, although the process did not involve a large amount of skill it was observed to be very labour intensive and took a long time to complete one cycle of the process (around 30mins). Having a long cycle time is clearly a disadvantage as time is money in the manufacturing industry but this could be slightly reduced if multiple moulds were prepared simultaneously. Another advantage observed during the sand casting procedure was that the equipment used was not very expensive and unlike other casting processes the mould was reusable.

With only a low capital investment needed this would make short production runs viable. Probably the most noticeable disadvantage to the sand casting method was the low material utilization. In the labs example (seen left), almost a third of the material used is lost to the riser, runners and feeder. Particularly in today's waste conscious culture this can cause many problems, however it can be tackled by better design. 2) Process Problems Shrinkage: Shrinkage defects in the final product are usually the result of a feeding defect.

As shrinkage naturally occurs during the solidification process, if liquid metal is not sufficiently fed through the feeding system to compensate then it will result in an indented surface. The surface defect was clearly shown in the lab example (shown left). A shrinkage defect normally occurs on the last part to solidify, so logically in the lab case the shrinkage occurred on the surface of the thickest part. Furthermore the big defect problem of a surface sink was observed in the sand casting lab session (shown left).

A sink such as this would give major dimensional inaccuracies and would probably have to be redone as it would be unsuitable and uneconomical for further processing. Solution: One way in which an engineer could reduce the effects of shrinkage is to design the mould to compensate for the shrinkage during solidification (i. e making the mould larger). Also due to shrinkage being mainly associated in being a feeding problem, the redesign of the feeding system would reduce the set back. Making the feeding sprue thicker would ensure that the system continues to feed liquid metal to the cavity, thus preventing shrinkage.

Furthermore utilizing a uniform part thickness would also tackle the problem reducing residue stresses and leading to uniform cooling. Rough Surface Texture: The defect causes an undesirable distorted surface finish and is formed due to the texture created from the compacted sand used to create the mould cavity. The effect was observed in the part created from the lab session and can be seen right. Solution: The rough surface effects created from the mould sand can be significantly reduced by using sand with very small grain size.

Particularly for the face sand which lines the surface of the mould cavity, if the grains used are very fine then surface finish will be improved dramatically. Porosity: The defect of porosity occurs because of the liquid metal used to create the part can hold large amounts of dissolved gasses. As the liquid metal solidifies, the materials new solid form can no longer hold these gasses and so they form bubbles. These bubbles can be generated both on the surface of the material and internally, thus they effect the strength of the materials solid form and resulting in a decrease in mechanical properties.

Effects of porosity shown above* Effects of porosity shown above* In the lab example holes were added in the sand to allow gas and moisture to escape, however effects of porosity were still clearly visible. Solution: The solution to eliminating the undesirable effects of porosity is based around minimizing the amount of gas that is in the liquid metal. One way in which gas inclusion to the liquid metal can be reduced is to minimize the effects of turbulence experienced during the filling process.

Similarly to solving the problem of shrinkage, this can be solved by redesigning the filling system. The design used in the lab example used the bad design set up. With the sprue placed at the top of the mould cavity, the liquid metal flows fast splashing in to the mould cavity below and resulting in turbulence and gas inclusions. If the good design set up is implemented then the liquid metal will flow slower and because runner is fed into bottom of the mould cavity with several gates, splashing will be significantly reduced, turbulence minimised and inclusion of gasses eliminated.

Good design Good design Bad design Bad design 3) Advantages for using Aluminium - Silicon alloy having 13wt% Si: * Aluminium alloys supply reasonably high tensile strength in relation to density, compared with other alloys such as cast steel. * Corrosion resistant in normal environment. * High fluidity of composite melt provides easy transfer and pouring of material to mould (demonstrated in lab shown below). * Utilizes a Eutectic system, reducing defects such as porosity. * Silicon within eutectic results in: Increased corrosion and wear resistance. * Reduced thermal expansion coefficient. * Improved casting and machining characteristics. * Increasing silicon content within alloy will magnify these properties accordingly * Different Al and Si within Eutectic act as a hindrance to dislocation movement. * On part completion, alloy material can be easily polished and painted for an aesthetically pleasing surface finish. 4) Nucleation Solidification does not happen instantaneously but occurs by a process of nucleation and growth.

All pure crystalline solids have a given melting temperature (T_m), although when above this temperature the material will be in a stable liquid state, if cooled to a temperature equal to T_m then the material will start to crystallize. This usually involves some degree of undercooling for crystal nuclei to form. Free Energy Of system Free Energy Of system From the graph above it can be seen that by increasing the undercooling ΔT , the free energy also increases ΔG . Gets steeper as T is decreased Gets steeper as T is decreased There are different types of nucleation, homogeneous and heterogeneous.

Although homogeneous almost never occurs in real life it can be used to build a model of the more realistic heterogeneous nucleation. Heterogeneous

occurs on an existing nucleant but unlike homogeneous the nucleated cap is a solid rather than a sphere, thus less atoms are required. Process usually requires liquid to wet the nucleant surface. Growth For growth to be sustained, the temperature of the melt must be less than the melting point. The speed in which growth occurs can be controlled by the amount of undercooling applied, with a large amount of undercooling resulting in rapid growth.

In addition the growth also depends on how fast latent heat is removed during crystallization. Both these aspects contribute to the temperature gradient of the melt which affect crystal formation. Constitutional Undercooling Usually caused by non-equilibrium concentration gradient, constitutional undercooling is more likely to be found in alloy casting rather than in pure materials. Seen in the diagram right, the amount of constitutional has a large impact on the type of crystal growth. Looking at the solidification of Al 13% Si, it would be expected to solidify under eutectic solidification.

Due the fact that it is a composition of two materials, aluminium and silicon, and that during the lab the material solidified at a single temperature (room temperature). Furthermore it also provides the lowest melting temperature for the materials used. This is an energy savings in a production area. 5) From the many defects created during the creation of the lab example part it was clear that something in the process needed to be changed in order to produce a part of a more acceptable quality.

As highlighted earlier, a main area for improvement was with the method of delivering the liquid material to the mould, particularly focusing on the <https://assignbuster.com/sand-casting-techniques/>

design of the feeder. The current feeder design used is very basic and can be seen right. The set up uses a thick single vertical cylindrical shaft with a very small taper, delivering liquid metal directly to the cavity via a single runner. Concentrating on feeder design, one way in which defects can be reduced is by supplying the cavity with a smooth constant volume of flow.

As the current feeder is very thick, the material is delivered very fast to one area of the cavity causing turbulence and inclusion of unwanted gas. This undesired effect could be minimized by changing the set up of having one large feeder to possibly 3 smaller ones. The use of multiple feeders would allow a more evenly distributed and constant metal flow. In addition the angle of taper could be increased to assist constant volume flow. Cavity Cavity Multiple feeders Multiple feeders Each of the feeders used should be reduced in thickness as much as possible, still maintaining the desired flow rate.

This is important as although deliverance of material is critical, the amount of waste material must be reduced as much as possible. Although only visual inspection was applied to the produced lab part, if it was discovered that the defects main cause was that of impurities within the solidified material than the Cosworth "upward fill" system could be employed. Due to its upward fill the process eliminates the problem of impurities within the liquid melt and impurities that sink or float are discarded. References <http://www.acetake.com> <http://www.rheocast.com> www.electrochemsci.org/papers/vol4