The sand casting techniques engineering essay

Sand casting is a casting technique where the mould is built up by shaping the sand around a model of the end product. After the mould has been made, molten liquid metal is poured into the cavity. This molten metal is left to solidify and the casting is retrieved by breaking the sand mould.

Quality- The surface quality of the sand casting was not as good as one can achieve by other casting techniques such as gravity die casting. Although, in our lab session we used the facing sand to cover a thin layer exactly around the model's surface. This aids in giving a better surface finish due to the facing sand being finer than the Petrobond sand. As one could see from the adjacent picture, some areas of the casting where a bit rough and not as even as the rest of the product. The roughness of the surfaces may be due to some pores forming whilst the molten metal was poured making a surface sink. Also, one can notice that at some points there are small misalignments of the mould due to the parting line when the two halves of the mould where closed. Some sand casting processes may also be susceptible to inclusions in the melt such as the sand itself, but as far as I could see, no inclusions were present into our casting.

Figure – Cast metal product

Picture taken during lab sessionFlexibility- The sand casting process is a very flexible one. This is due to the fact that sand casting may be done upon any model one desires. On the other hand, sand casting is not only viable due to its ease of casting any shape you want, but it is also flexible because the sand used can be recycled and used again for another sand casting patterns. In this way, sand casting's flexibility will also contribute to a cheaper way of producing metal components because even the pattern, in itself, is very cheap.

Cycle time- Sand casting's cycle time is a long one. As one could see from the lab session, the aluminium 13wt% silicon alloy had been melting in the gas-fired furnace for over 6 hours. The process itself takes up time to form the 2 halves of the casting moulds. Also, the time for the final product to be retrieved depends on the heat transfer of the molten liquid itself. For high production rates, multiple moulds are used but since we only had a lab session, we could not make the process run faster. (1)

2. Sand Casting process presents problems which may include:

Shrinkage in the final product

Micro-porosity

Rough surface texture

Explain these problems and indicate solution you might take as an engineer to reduce or eliminate these setbacks.

Shrinkage in the final product may be due to mainly the solidification stage. As the molten liquid metal is poured, this may start to cool before solidification starts. This will cause contractions in the product due to the phase shift from liquid to solid state; in turn this may lead to depreciation in the cast's height, much like a concave on the surface of the product. (2)

To solve the shrinkage problem, one must make sure to adjust the riser in a better position so that molten metal can be supplied at every possible cavity and retraction in the mould's design. Chillers may be also placed around the mould or at certain critical points to ensure solidification is even and thus preventing shrinkage. Another possibility to reduce shrinkage is to compensate for it. This can be done by checking the shrinkage percentage of the metal or alloy one is working with, in our case aluminium 13wt% silicon alloy. Thus one can calculate the expected shrinkage for the type of geometry complexity of the patter at hand and therefore redesigning the mould for the previously calculated shrinkage percentage. (3)

The source of micro-porosity in sand casting may be due to turbulences formed while pouring the molten metal in the cast. Nucleation and growth of these pores will induce defects and localised solidification occurs as the cast starts to cool. Therefore due to this occurring, it will also force shrinkage in the final product itself. The evolution of these pores comes into play when the molten liquid starts to solidify, in turn these gasses are absorbed during solidification and therefore form voids in the cast by localised shrinkage. Micro-porosity may also form between the dendrites spaces because this is the last place where solidification in the cast takes place. In turn the whole product will shrink due to hydrostatic tension. The latter example is another link between micro-porosity and shrinkage of the final product.

To solve the problems caused by micro-porosity, one can start off by using a good de-oxidation practice before pouring the molten metal in the cast. This helps to reduce any hydrogen or oxygen absorption while the metal is being melted. On the other hand these gases may be picked up while pouring the molten metal, so care must be taken while handling the molten metal. One should also consider re-designing the riser of the cast so that it will allow

……………… As a last remaining option one should consider changing the material to one having short freezing ranges because these have a low temperature gradient. (1)

There are many problems which attribute in having a rough surface texture; primarily the type of sand used is the major concern. The sand used may be too coarse for the total casting weight and pouring temperature used. Another reason for a rough surface finish may be due to a dirty pattern. Dirt particles on the mould pattern may become trapped within the sand and therefore when the molten metal is poured, these dirt particles will be caught into the liquid metal and then reside on the surface of the mould. Another similar problem is metal and sand (or non-metallic) inclusions which may become detached from the mould's side walls due to soft and uneven ramming of the mould. C: UsersJessicaDocumentsMy DropboxJulia, Jess&MarCasting100_2616. JPG

Solving these types of problems involves a good ramming practise and built-up of the mould because soft and uneven ramming of the mould causes defects on the surface texture. The sand used must have good permeable properties to allow any gas formation inside the mould to escape from the sand itself. An addition to this is poking the sand before the metal is poured to form passageways for the gas to escape from them. If this is not allowed, gas bubbles will form inside the molten liquid and will rise up to the top of the mould causing distortion in the mould's surface. As a last resort, one can perform grinding techniques after the cast has been made to remove and smoothen any rough patches on the surface. (3) (4)

3. List advantages for using aluminium – silicon alloy having 13wt% Si for casting.

Aluminium alloys are considered to be good castable materials and very light weight having wide range strength properties and easily machined. These alloys, in particular aluminium silicon ones, have other favorable casting advantages which are developed due to alloying with silicon. These are listed below;

Casting with this material is made easier due to the increased fluidity of the melt as a result of using Silicon.

Silicon lowers the temperature of the melt therefore it shrinks quickly and helps in reducing the risk of any shrinkage while the cast is solidifying.

Silicon is cheap as raw material to use it in conjunction with other materials therefore for this reason it may be preferred over other ones.

The produced casted components are light weight due to the low density of Silicon.

Silicon has a low solubility in aluminium and upon solidification this precipitates as pure silicon. Therefore for this reason aluminium-silicon castings have good corrosion and abrasion resistance.

Properties such as ductility and strength can be achieved by rapidly cooling the cast. (5)

4. Describe briefly the microstructure of the cast metal and alloys products. (Include aspects of nucleation, growth, melt temperature gradient and

constitutional undercooling). How would you expect the Al-13% Si used for the casting to solidify?

Describing microstructures for cast metal and alloys products;

Nucleation, some on homogeneous nucleation

Figure – Aluminium Silicon equilibrium diagram (5)Describing cast's solidification for Al-13% Si; phase diagram

Aluminium silicon alloys form a eutectic composition at ~ 11. 7 wt% silicon. (5) A cast containing 13wt% silicon would shift the alloy to the right hand side of the eutectic point making it hyper eutectic. In real fact, since for our cast we used a degasser to eliminate the chances of porosity, the sodium which is still contained in the molten cast shifted the alloy to the left of the eutectic point, thus making the final structure a hypo eutectic one.

Since Al-13wt% Si is a hypo eutectic alloy then it will start to freeze as aluminium phase (primary alpha) solid solution while the melt which remains between the dendrites will solidify as eutectic. Therefore we will have a rich dendrites in a eutectic matrix. In our case, since sodium is added to our cast, it will serve to modify our microstructure in making a finer eutectic structure which will in turn give good mechanical properties.

Adding a small quantity of a ternary element, here Sodium, causes modification of the microstructure. This addition effectively moves the eutectic point to a higher silicon concentration and lower temperature. This modifies the growth of the eutectic silicon to produce an irregular fibrous form rather than the usual flakes. The eutectic point has moved far enough to make the alloy, at this composition, hypo-eutectic instead of hyper-eutectic. So now primary alpha forms, rather than primary Si. This can be seen on its micrograph.

http://www. soton. ac. uk/~pasr1/graphics/Al-13sid. jpg

Aluminium silicon alloy forms a near eutectic microstructure at ~ 13wt% silicon and due to this reason it only has one solidification temperature, that of 577°C (as can be seen on the phase diagram on the left). Furthermore, constitutional undercooling does not form and growth occurs normal to the solidification front.

Further information

This sample is a casting alloy of eutectic composition. From the melt a eutectic is formed between aluminium solid solution and virtually pure silicon. Slow solidification produces a very coarse microstructure. The eutectic comprises large plates of silicon in the aluminium matrix. This microstructure displays poor ductility due to the brittleness of large silicon plates. The microstructure is normally refined through either rapid solidification, which lets the silicon phase assume a fibrous form, or by a process known as modification.

It may be noted that primary aluminium dendrites can be seen, although the composition is very close to the eutectic point and an entirely eutectic microstructure might thus have been expected. This effect is a consequence of the strongly skewed nature of the eutectic “ coupled zone” in the Al-Si system. The coupled zone represents the combinations of melt composition and interfacial undercooling (or growth velocity) for which (coupled) eutectic growth can occur. It can be plotted on the phase diagram by extending the two liquidus lines below the eutectic temperature. The Si liquidus line curves sharply back towards higher Si contents as the undercooling is increased. (This is associated with the facetted growth mode of the Si phase.) Thus, depending on growth conditions, a nominally eutectic alloy may solidify initially outside the coupled zone, leading to primary aluminium dendrite formation (before the melt composition rises sufficiently for the coupled zone to be entered and eutectic growth to occur). For more details, see, for example, Acta Mater. vol. 40 (1992) p. 1637-1644.

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Image of Aluminium Silicon (Casting Alloy)

Figure – Aluminium silicon casting alloy (6)

5. Discuss whether the feeder design for the casting produced during the lab session satisfied the basic feeding rules to produce a sound casting. Indicate how the feeder design could have been improved.