MINIMIZATION OF SHRINKAGE DEFECT IN CRANKSHAFT CASTING

بسم الله الرحمن الرحيم

Organisation of Islamic Cooperation

A thesis submitted to the department of Mechanical and chemical Engineering (MCE), Islamic University of Technology (IUT), in the partial fulfillment of the requirement for degree of Higher Diploma in Mechanical Engineering.

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CANDIDATE'S DECLARATION

It is hereby declared that this thesis or any part of it has not been submitted elsewhere for the award of any degree or diploma

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We seek excuse for any errors that might be in this report despite of our best efforts.

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ABSTRACT:

In our present study, we mainly focused on the reduction of the casting and moulding defects that mainly occurs during metallurgical process and we are able to depict some of those severe problems that might hamper the casting procedure. Among them temperature gradient, time difference in alloy solidification, surface area of casting material, impact of varied amount of volume of molten metal and the shape of the mould opening which we concluded should be squared instead of tapered to enhance the performance of the casting process.

CHAPTER ONE

1.1 General Background Information

Casting Process

Casting is a Manufacturing process whereby a liquid material is poured into a mold, the mold contains a hollow cavity of the desired shape, and then is been to solidify. The solidified part is also known as a *casting*, which is removed or broken out of the mold to complete the process. materials used in casting are usually metals or various *cold setting* materials that cure after mixing two or more components together; examples of them are epoxy, plaster, concrete and clay. Casting is most often process used for making complex shapes that would be otherwise difficult or uneconomical to make by other method.

Casting is an old manufacturing process and people known this process from a very long time and the old process is the casting of copper. The process uses a liquid material which is literally poured into a mold, which contains a cavity basically hollow and we can obtain the desired shape, and then allow them to solidify and that's our required product. It is mostly used for making tedious and complex shapes that would be difficult to make by other methods.

There are several types of casting, which includes:

Metal.

Plaster, concrete, or plastic resin.

Fettling.

A method of manufacturing a crankshaft having crank pins, which comprises (i) casting in place a hollow metal tube within the crankshaft, and (ii) laser piercing bores in at least the bearing surfaces of the crank pins of the crankshaft to connect with the interior of the metal tube, the metal tube being pre-formed to a desired shape that is able to insert into a casting cavity of a mold, the shape having sufficient length to not totally encapsulate the tube in the cast material or mold during casting, and the part of the tube lying outside the mold during casting serving to keep the tube straight within the mold.

History of metal casting:

Casting is an old manufacturing process and people known this process from a very long time and the old process is the casting of copper. The process uses a liquid material which is literally poured into a mold, which contains a cavity basically hollow and we can obtain the desired shape, and then allow them to solidify and that's our required product. It is mostly used for making tedious and complex shapes that would be difficult to make by other methods.

Metal Technologies has comprised of brief timeline of metal casting so that we can get an overview of the long and proud history of our industry. Since its discovery, metal casting has played a vital role in the advancement and development of human civilization. After many years of technological advances, metal casting plays a greater part in our everyday lives and is more essential than it has ever been.

What is a crankshaft?

Crank shaft is a main part of an engine that rotates, and is stick on the connecting rod that can undertake the up and down movement into rotation of connecting rod. Its material is made of carbon steel or cast iron, there are two important parts of crankshaft: 1) main journal and 2) connecting rod journal. Main journal is installed on a cylinder block, and connecting rod is connected with the big hole piston. Lubrication is usually done to the bearing between the rocker arms.

Crankshaft Design:

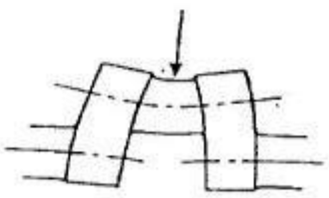
Design and Stresses In Crankshaft

The crankpin is like a built in beam with a distributed load along its length that varies with crank position. Each web like a cantilever beam subjected to bending & twisting. Journals would be principally subjected to twisting.

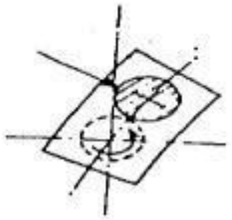
1. Bending causes tensile and compressive stresses.

2. Twisting causes shear stress.

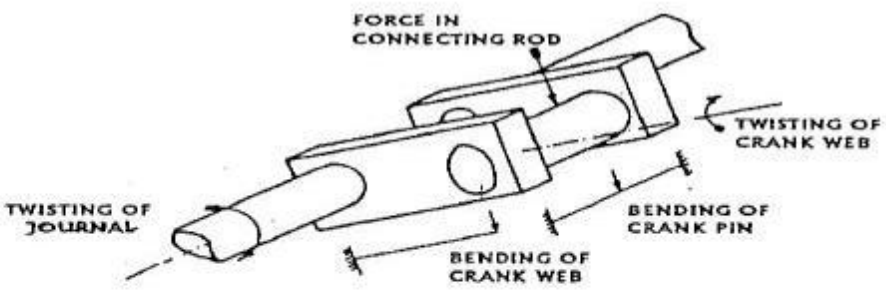
3. Due to shrinkage of the web onto the journals



BENDING OF PIN



BENDING OF WEB AND TORSION OF JOURNAL



Compressive stresses are set up in journals & tensile hoop stresses in the webs. The equality constraint is geometry limitations or fixed dimensions. And finally the design variables are upper and lower limit for size and geometry, material alternatives, and manufacturing processes. Size

optimization is an optimization approach, where the parameters do not change the overall shape of the component and only the size is modified. Geometrical
properties parameters such as thickness, diameter, and area are used as design variables in size optimization. There are other optimization methods such as Shape Optimization and Topological Optimization, which change the appearance of the geometrical domain.

Crankshaft material:

Crankshafts materials should be readily shaped, machined and heat-treated, and have adequate strength, toughness, hardness, and high fatigue strength. The crankshafts are manufactured from steel either by forging or casting. The main bearing and connecting rod bearing liners are made of Babbitt, a tin and lead alloy. Forged crankshafts are stronger than the cast crankshafts, but are more expensive. Forged crankshafts are made from SAE 1045 or similar type steel. Forging makes a very dense, tough shaft with a grain running parallel to the principal stress direction. Crankshafts are cast in steel, modular iron or malleable le iron. The major advantage of the casting process is that crankshaft material and machining costs are reduced because the crankshaft may be made close to the required shape and size including counterweights. Cast crankshafts can handle loads from all directions as the metal grain structure is uniform and random throughout. Counterweights on cast crankshafts are slightly larger than counterweights on forged crankshafts because the cast metal is less dense and therefore somewhat lighter.

Crankshaft Material: Casting:

Automotive crankshafts may be cast in steel, iron, or malleable iron. The big advantage of the casting process is that the material and machining cost should be less than forging. The machining is only required for the crankshaft to remove the undesirable parts and make it at the exact shape by grinding or whatever required.

Crankshaft used in the engines are made either by forging or by casting but forged crankshaft is stronger than the cast one but they are high in cost. Cast crankshafts have a fine line and they got it from the mold the mold is made of two pieces that's why there is a separation line in between the crankshaft where the mold parted. And these lines can be used for identification.

. Sourcing the Casting

In the case of our crankshaft example, it is sourced as a ductile iron casting due to the lower cost that can be achieved. First think to consider is that, what type of foundry can cast a ductile iron crankshaft? ductile iron crankshafts have been cast in three molding processes green sand, shell and lost foam. But how does an end-user choose the process?

At this point, the decision must be based on discussions with various foundries that determine which plant can provide the optimized cast component (including all post-casting processing) at the lowest system cost. If the sourcing decisions were based only on the cost of producing the casting itself, then the process decision would be, according to GM: 1. green sand; 2. shell; and 3. lost foam. This decision, however, would only focus on the unit cost.

The molten metal that solidifies in the mold at a foundry is a casting; however, in most cases, this alone is not what is being supplied to the customer. Many castings require heat treatment, grinding, machining, polishing, painting, assembly and other value-added services after they leave the mold. It is vital for casting designers and buyers to incorporate all of these services (and their costs) into their final decision on part design and where to source a component (whether the foundry performs all these operations or not) because this is the only accurate method to determining if one manufacturing method (green sand casting, lost foam casting, forging, welding, etc.) is more cost-effective than another.

Green sand—The majority of GM's ductile iron crankshafts are cast in green sand molds. In this process, sand, clay, water and other stabilizing materials are compacted around two halves of a pattern to form a mold for pouring. Due to the high-production nature of the process (GM casts 5.6 million crankshafts/year in North America alone), it is the most economical casting process to produce the component. However, according to GM engineers, in comparison to the identified two competitive techniques of shell and lost foam, green sand process capability may require more finish stock on the casting for machining later in production. Because no as-cast internal cavities are required in most crankshafts, the production and insertion of sand cores in the mold is generally avoided on each of the processes described.

Shell—Shell mold casting holds tighter tolerances and tooling draft angles than green sand by allowing the production of a mold that is narrower with deeper pockets, reducing the machining cost and increasing dimensional accuracy. The reason is that this process cures the sand around the pattern with heat to "glue" the grains together. In addition, its surface finish is superior to green sand molding. However, its unit cost is higher because it uses resin-coated sand that is then heated to form the molds.

Lost foam—The third process is lost foam casting. Although it has the highest unit cost of the three processes, lost foam's advantages are recognized after the component has been cast. This loose-sand process, which replaces polystyrene patterns with molten metal, has the best dimensional repeatability (in terms of tolerances) of the three processes, reducing machining time. It also allows designers to cast-in holes and passageways for improved functionality or the reduction of mass that otherwise would require machining or additional cores. In the case of the lost foam crankshaft, holes can be cast-in at the bearings to reduce mass.

With all of these processes, metal solidification time is another factor to consider. A foundry that is able to control the solidification and cooling times of its castings through its molding and shakeout (separation of the solidified casting from the mold) processes can aid in the development of the specified component's mechanical properties and eliminate the need for subsequent heat treatment. Once shaken out, the cast components undergo rough finishing and grinding in anticipation for any value-added services or operations.

1.2 Problem Statement

Shrinkage and dispersed shrinkage are the most common casting defects of ductile iron, which are the key factors influencing the quality of casting. From the test results, shrinkage often appears in the solidifying location finally of the crankshaft, such as the hot spots of crankshaft, that is the joints of crankshaft balance block and the shaft neck, crank arm and shaft neck, which are the holes connecting interior with exterior of crankshaft. The holes in wall are generally rough relatively sometimes crystals in developing dendrite can be seen attached to the inner surface of the holes. Due to the "mushy solidification" feature of ductile iron, as well as the complexity of shrinkage, shrinkage porosity formation, shrinkage is the inherent defect and it is difficult to completely eliminate by the traditional treatment process. There are many inconsistent or even contradictory views on formation mechanism and preventing measures of shrinkage and dispersed shrinkage which are confused. How to eliminate the shrinkage and dispersed shrinkage defects of nodular cast iron has been the research topic of foundry workers. Adding cold iron and other methods often are used in production to drive the shrinkage to internal, which cause the defect disappeared on the surface. But with the progress of science and technology, customers' demand for casting quality is improving. Non-Destructive Testing is usually performed to expose the defect. Therefore, how to use a new process to solve completely the shrinkage defects of nodular iron crankshaft has become the common concern of manufacturers, which has significantly theoretical and practical value. Self-developed shrinking eliminating agent for nodular cast iron was used to defective part of crankshaft specimen with dispersed shrinkage, by changing the growth mode of regional ductile iron and refining grains during solidification, to reduce or eliminate the shrinkage defects in the region.

Casting defects could largely affect the mechanical properties of casting products. A number of test pieces made of ductile iron with different levels of shrinkage porosity were prepared and then tensile and fatigue tests were performed to investigate the impact of shrinkage porosity on their mechanical properties. The results showed that the tensile strength decreases linearly with increasing of the shrinkage porosity. The tensile elongation decreases sharply with the increase of the shrinkage porosity mainly due to the non-uniform plastic deformation. The fatigue life also dramatically declines with increasing of the porosity and follows a power law relationship with the area percentage of porosity. The existence of the shrinkage porosity made the fatigue fracture complex. The shrinkage pores, especially those close to the surface usually became the crack initiation sites. For test pieces with less porosity, the fatigue fracture was clearly composed of crack initiation, propagation, and overloading. While for samples with high level of porosity, multiple crack initiation sites were observed.

So, our main concern is that to study the behavior of ductile cast iron in casting process and come up with an idea or solution of minimizing the shrinkage defect affecting crankshaft during casting in order to improve the casting efficiency.

CHAPTER TWO

2.1 Literature Review

Defects in castings

The general origins of defects lie in three sectors:

- 1. The casting design
- 2. The technique of manufacture–the method
- 3. The application of the technique–‘workmanship

Categories of Defect

- 1. Shaping fault arising in pouring.

- 2. Inclusions and sand defects.

- 3. Gas defect.

- 4. Shrinkage defects due to volume contraction in the liquid state and during solidification.

- 5. Contraction defects occurring mainly or wholly after solidification.

- 6. Dimensional errors.

- 7. Compositional errors and segregation.

Casting Quality

- There are numerous opportunities for things to go wrong in a casting operation, resulting in quality defects in the product.

- The defects can be classified as follows:

– Defects common to all casting processes

– Defects related to sand casting process

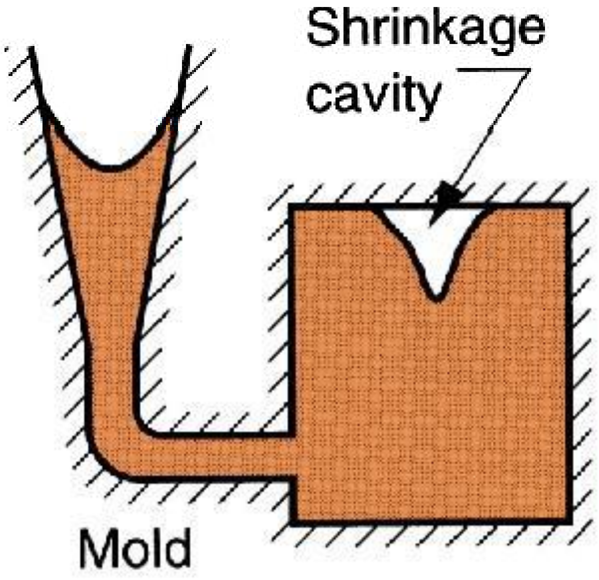
Shrinkage Defects

Shrinkage defects occur when feed metal is not available to compensate for shrinkage as the metal solidifies. Shrinkage defects can be split into two different types: open shrinkage defects and closed shrinkage defects. Open shrinkage defects are open to the atmosphere, therefore as the shrinkage cavity forms air compensates. There are two types of open air defects: pipes and caved surfaces. Pipes form at the surface of the casting and burrow into the casting, while caved surfaces are shallow cavities that form across the surface of the casting. Closed shrinkage defects, also known as shrinkage porosity, are defects that form within the casting. Isolated pools of liquid form inside solidified metal, which are called hot spots. The shrinkage defect usually forms at the top of the hot spots. They require a nucleation point, so impurities and dissolved gas can induce closed shrinkage defects. The defects are broken up into macroporosity and microporosity (or microshrinkage), where macroporosity can be seen by the naked eye and microporosity cannot.

Possible Causes

The density of a die casting alloy in the molten state is less than its density in the solid state. Therefore, when an alloy changes phase from the molten state to the solid state, it always shrinks in size. This shrinkage takes place when the casting is solidifying inside a die casting die. At the centre of thick sections of a casting, this shrinkage can end up as many small voids known as ‘shrinkage porosity’. If the shrinkage porosity is small in diameter and confined to the very centre of thick sections it will usually cause no problems. However, if it is larger in size, or joined together, it can severely weaken a casting. It is also a particular problem for castings which need to be gas tight or water tight’.

Depression in surface or internal void caused by solidification shrinkage that restricts amount of molten metal available in last region to freeze

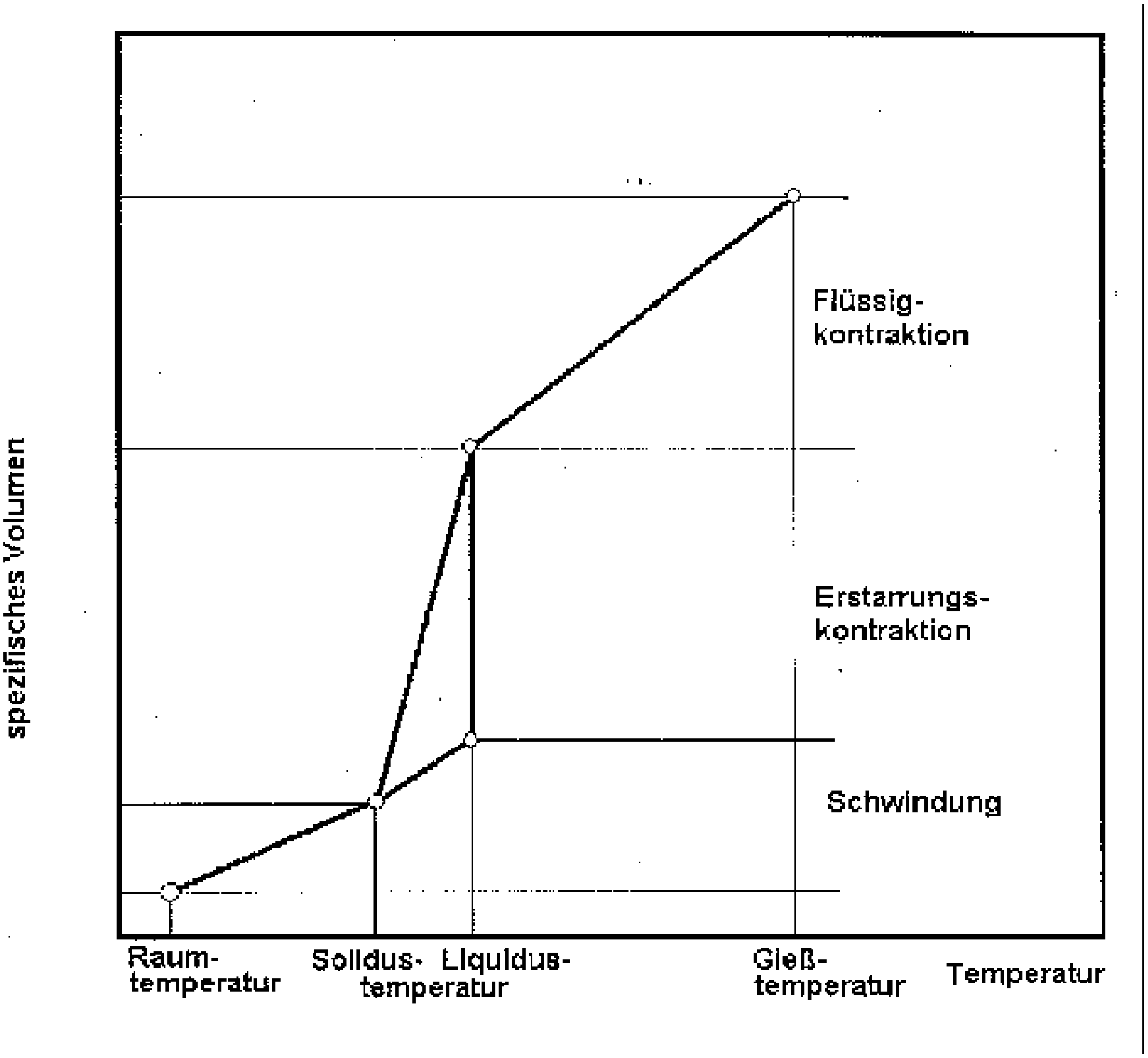


(d)

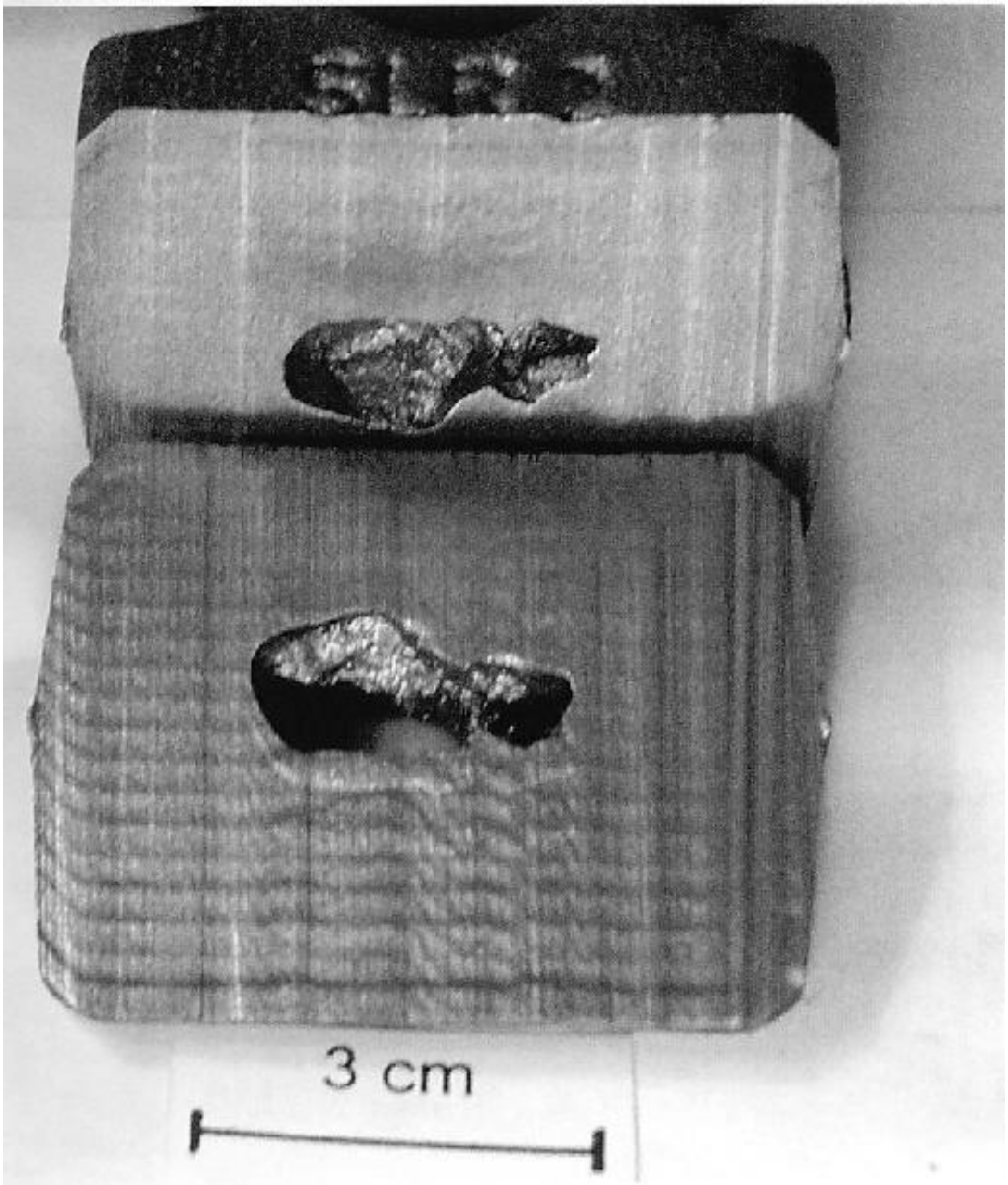
Shrinkage cavities

Description and reasons
:

- Specific volume of melt is higher than the specific volume of solid
- Contraction during solidification and cooling.
- feeding is necessary – if the feeding is not optimal □ formation of shrinkage cavity.
- The shrinkage volume of cast steel is about 4-7%
- The inner surface is rough.



spezifisches Volumen
Flüssig-kontraktion
Erstarrungs-kontraktion
Schwindung
Raum-temperatur
Solidus- Liquidus-temperatur
Gieß-temperatur
Temperatur



What does *Shrinkage* mean?

Shrinkage is a process occurs during the solidification of metal from liquid to solid state. This phenomenon occurs in processes like casting and concrete solidification.

Corresponding explains Shrinkage:

Metals contracts when solidifying and cooling, because the specific volume it contains is larger than in liquid state than in the solid state for casting any metals. Therefore, it is a function of the casting material.

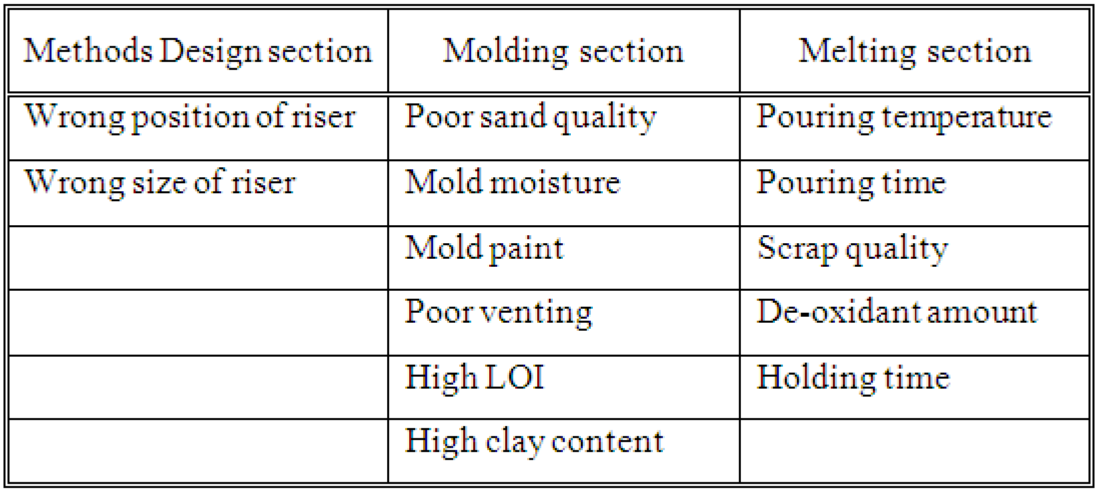
In metals, shrinkage occurs in three phases:

- Solid
- Solidification
- Liquid

In casting shrinkage occurs when there is no enough liquid metal to pour to feed the mold during solidification. Areas with higher module are the last to solidify, so as the module increases then there is high risk of shrinkage. Areas that are hotter for a long usually in thick sections and in the corners solidify later than the surrounding sections.

Shrinkage results in several casting defects such as porosity and stains in the product. This can be avoided by altering the casting geometry and using risers.

PARAMETERS CAUSING SHRIMKAGE CAVITY:

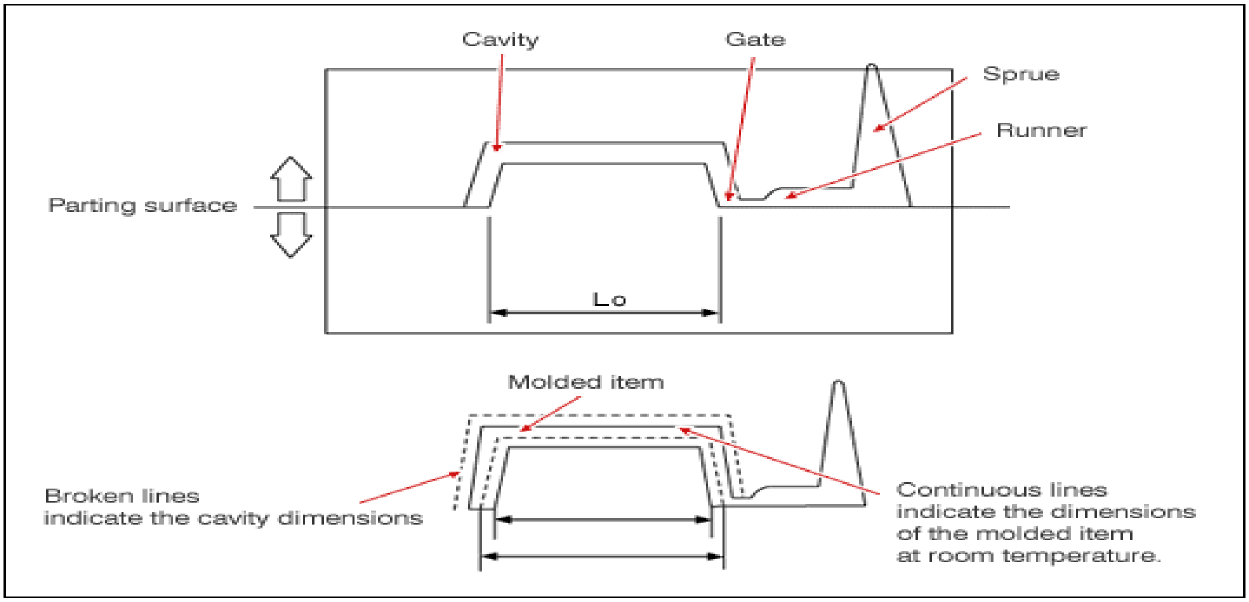


Methods Design section	Molding section	Melting section
Wrong position of riser	Poor sand quality	Pouring temperature
Wrong size of riser	Mold moisture	Pouring time
	Mold paint	Scrap quality
	Poor venting	De-oxidant amount
	High LOI	Holding time
	High clay content	

What is the Molding Shrinkage Phenomenon?

By injecting thermoplastic plastics, it is possible to obtain a molded product with the desired dimensions using the mold shrinkage phenomenon. Mold shrinkage is process of filling up the gaps in the solidifying process as the metal undergoes cooling and its starting to shrink then this comes into action.

The solution for this shrinkage is called the "molding shrinkage factor", and if this molding shrinkage factor is known both scientifically and by experience, then by making the mold a little larger could give us a helpful results, and it is possible to form the molded item by so that it has the intended dimensions.



CLASSIFICATION OF SHRINKAGE

SHRINKAGE:

There are several types of shrinkage. Regarding of understanding shrinkage gratefully we dive deeper into the classification.

1) Liquid Shrinkage
2) Liquid-to-solid shrinkage
3) Patternmaker’s contraction

Liquid Shrinkage:

This is the first and important topic of shrinkage. And it is just the consideration of the liquid metal for solidification and the shrinkage occurs, it is relative to the designing perspective

Liquid-to-solid shrinkage:

The second stage is called the Liquid-to-solid shrinkage. It occurs when the liquid metal changes from the liquid state to the more of the integrated block like state to build solid metal state which is known as liquid-to-solid shrinkage. It is different from alloy to alloy and also from high to low shrinkage volumes.

Directional solidification is the rate of moving the solidification from the start to the bottom of the core and is deeply dependent on the design. Eutectic type of alloys involves lesser solidification shrinkage and lower sensitivity to the sudden causes of geometry.

Patternmaker’s contraction:

It occurs when the solidification completes and the ambient temperature is now cooling and when the contraction occurs it is called the patternmaker’s contraction, and the proportion is changed significantly due to this contraction. And the tools has to be design on such a way that the dimensional accuracy has to be achieved.The defects caused by material shrinkage or gas usually not visible on the surface of die cast, gas porosity displays smooth and regular porosity.

HOW SHRINKAGE OCCURES IN CRANKSHAFTS:

In one research they measure the shrinkage of an alloy of different types and they concluded a result that the shrinkage occurs in casting depends on the size and surface area of the materials e.g. when the specimen is more denture-sized the shrinkage will be lower than of crown sized with larger surface area and also on the pressure, the increase in casting pressure decreases the shrinkage. The effect of location of shrinkage changes with the changes of the previously

Types of Casting Shrinkage

There are four types of shrinkage that can occur in metal castings: cavity, sponge, filamentary, and dendritic shrinkage.

- **Cavity shrinkage**: This defect occurs when two different sources of molten material are joined to create a common front while solidification is already taking place. A lack of additional feed material to fill in the accumulating gaps can further exacerbate the cavity shrinkage problem.
- **Sponge shrinkage:** This usually arises in the thicker mid-section of the casting product and causes a thin lattice texture similar to filament or dendrites to develop.
- **Filamentary shrinkage:** This results in a network of continuous cracks of various dimensions and densities, usually under a thick section of the material. It can be difficult to detect, and the fracture lines tend to be interconnected.
- **Dendritic shrinkage:** Dendritic fractures are narrow, randomly distributed lines or cavities that are often unconnected. They are typically thinner and less dense than filamentary cracks.

How Temperature Affects Casting Shrinkage

To reduce the potential for metal casting shrinkage, it is helpful to work within a delineated temperature range. Metal should be heated to achieve appropriate molten characteristics, but without reaching its full liquid state. This usually entails heating the material to slightly above its flow point, but well below its melting point. Preventing overheating can be just as important to effective casting as cultivating a molten flow.It is also useful to note that castings can cool at a rate of up to 100 degrees per minute once molten pouring is complete. Since shrinkage can be caused by working material while solidification is under way, it is important to have equipment prepared to treat the workpiece before it solidifies.mentioned factors, and these factors can be explained by temperature gradient in the alloy and the time difference in alloy solidification and also the volume of alloy supplied in the mould.

2.2 Discussion on Relevant Research

The following are Research summary Related to Shrinkage defect on crankshaft casting :

From the existing and recent literature citations it is found that the currently available casting solidification simulation software's have a lot of capabilities to analyze the defects and have received considerable attention from researchers in the past. Various research and their finding related to improvement in casting quality and minimization of shrinkage defects using simulation software has been mentioned in this section. The casting simulation using ProCAST software for aluminium wheels. Here, shrinkage index was used to predict the casting quality of aluminum wheels to find the optimal parameters affecting the casting process**.[1]** The composition of shrinking eliminating agents play an important role to reduce or completely eliminate the shrinkage defects of crankshaft specimens. Adding No.3 can eliminate completely the shrinkage defects of crankshaft. The crankshaft specimens are respectively added in different amount of shrinking eliminating agents 4g, 6g, 10g, which are cut after casting, . The shrinkage defects of crankshaft eliminate completely when the addition is 6g. Adding 10g shrinking eliminating agents reduces the defects to a large extent. It illustrates that the addition of shrinking eliminating agents makes important influence. The composition of shrinking eliminating agents play an important role to reduce or completely eliminate the shrinkage defects of crankshaft specimens. Adding Anti-graphitization, Grain refinement can eliminate completely the shrinkage defects of crankshaft **[2].**

Another scholar, has studied the influences of using a pouring cup (a standard gating) and a pouring basin (an alternative gating) on formation of surface quality problems on steel casting due to entrained air. His experiment constitutes two steel wedge-block castings poured from a bottom pouring ladle the first one utilizing a pouring cup and the second, a pouring basin with a dam, with or without a submerged ladle nozzle extension (shroud) into the pouring basin. Prior experiments showed that 30 – 60% air entrainment by volume in a typical ladle bottom pouring operation **[3]**.The air entrainment and thus surface defects increase with poured metal head height. The second poured blocks with the alternative gating had a lower metal head in the ladle, but the ladle was raised to clear the pouring basin thereby, decreasing the difference in pour heights between the two castings. The average pour heights taken from average metal head in the ladle to sprue base were 45.5” for standard gating and 43.0” for alternative gating. The molds were prepared using silica sand having an AFS grain size of 55 bonded with 4.5 % by sand weight dextrin modified (5 %) sodium silicate (50 % aq.) binder. The heats F5083 and F5085 were meant to be poured with submerged ladle nozzle extension. However, the shrouds started to split longitudinally during pour A and were fully open during pour B. Since use of a shroud is an optional operation, these castings were effectively poured without a nozzle extension. After removing the gates and risers and the castings get cleaned**[4]** Root Cause Analysis as an analytical tool that can be used to perform a corrective and comprehensive, system based review of critical defects. It includes the identification of the root and contributory factors, determination of defect reduction strategies, and development of action

plans along with measurement strategies to evaluate the effectiveness of the plans**[5]**.

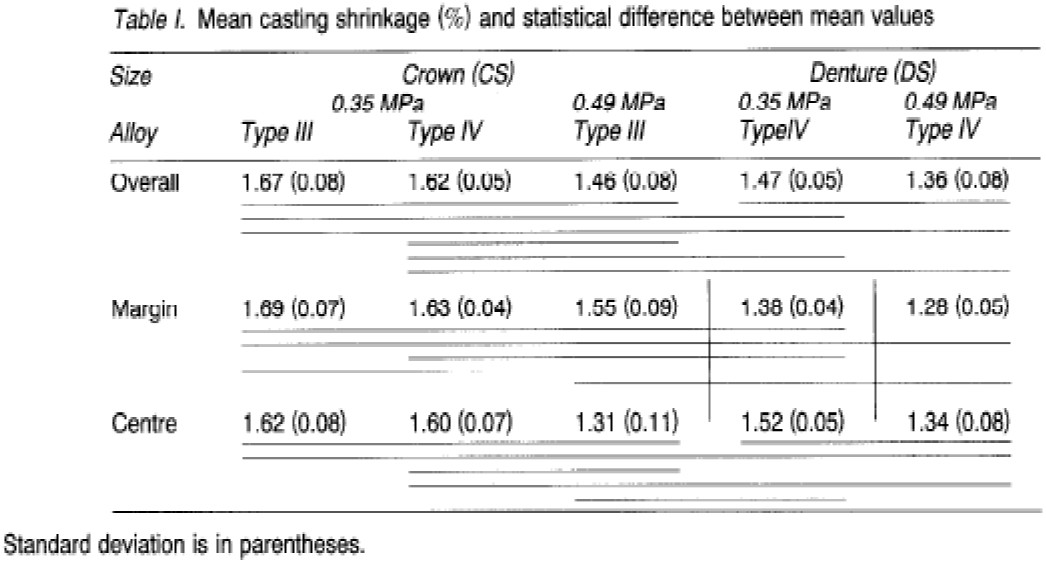


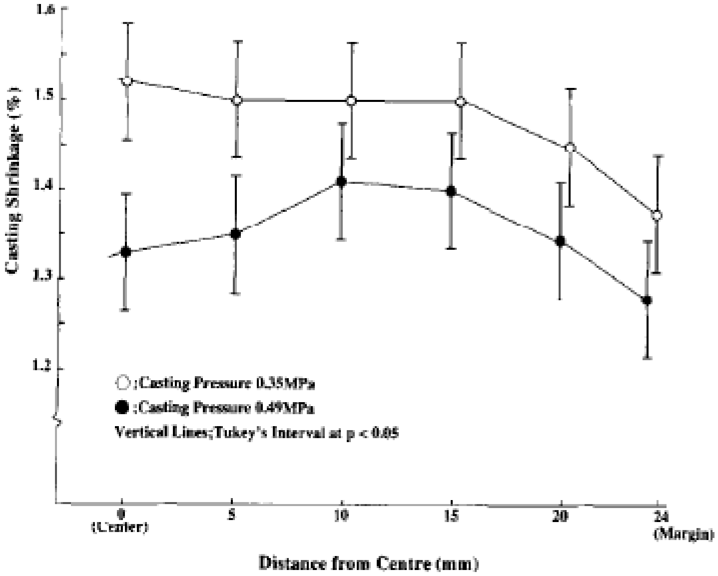
Table I. Mean casting shrinkage (%) and statistical difference between mean values

Size	Crown (CS)			Denture (DS)	
	0.35 MPa		0.49 MPa	0.35 MPa	0.49 MPa
Alloy	Type III	Type IV	Type III	TypeIV	Type IV
Overall	1.67 (0.08)	1.62 (0.05)	1.46 (0.08)	1.47 (0.05)	1.36 (0.08)
Margin	1.69 (0.07)	1.63 (0.04)	1.55 (0.09)	1.38 (0.04)	1.28 (0.05)
Centre	1.62 (0.08)	1.60 (0.07)	1.31 (0.11)	1.52 (0.05)	1.34 (0.08)

Standard deviation is in parentheses.

In this table they have taken two different types of pressure. The mean shrinkage ranged from 1.28% to 1.69% when the size, location and casting pressure changed.

Now in the second fig they have specified it with the help of graph, how these pressures are acting and how the changes in (mm) are occurs in shrinkage in percentage.

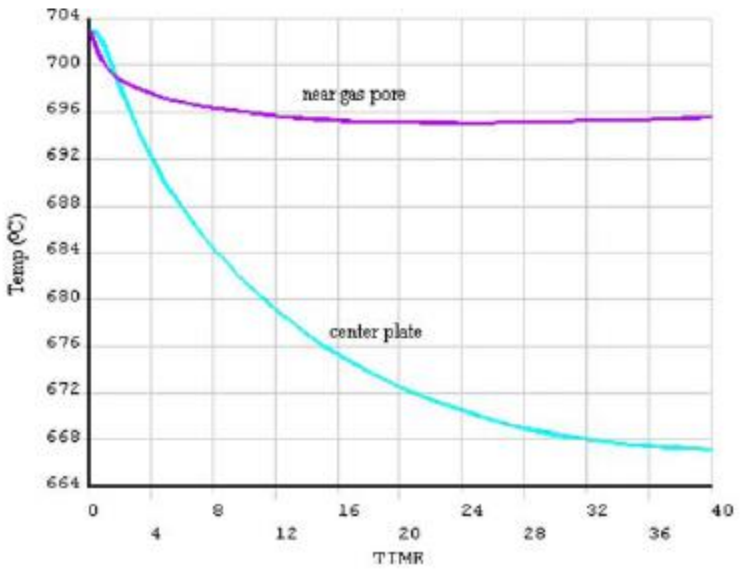


At low casting pressure the shrinkage in not changing much from the center (0 mm) to 15mm and then suddenly decrease as we go to margin 24mm.

And at high casting pressure the no significant change was found between the two points, center and margin.

And all these factors will really effect the casting of a crankshaft, and the quality and precision can be improved by changing of these two main factors to some desirable ratio and how we want and for what type of engine do we cast a crankshaft. In another type of paper they have studied the shrinkage of a die cast crankshafts on the basis of metallurgical and chemical study and from mechanical properties and the depth of quenched layer and the distance between the web. Subsurface shrinkage of the unquenched layer was induced by improper casting process of the crankshaft. The fact that Vickers hardness of the quenched layer was smaller than technical requirements is induced by abnormal microstructure which contained many adverse unsoluted pearlite and ferrite. The abnormal microstructure of the quenched layer may be induced by the abnormal chemical compositions or improper quenched process or both of them. The smaller yield strength and impact strength measure of distance between the web. **[6]**

In the other studies they have talked about the shrinkage porosity in high pressure die casting. They have analyzed that the gas pores in the die casting process is acting like an efficient heat insulator that retards the heat transfer and therefore slowing the heat transfer process as compared to regions without porosity which is leading to a lower solidification rate and causing shrinkage.



In this graph the have shown that there is a temperature difference in the different regions of the crankshaft casting process that is the gas pores the temperature is much higher than the center of the crankshaft because the air bubbles acting like an insulating medium and take much longer to become a solid state then the rest of it, which leads to the formation of shrinkage porosity. And it has some distinctive dependencies on several factors essentially affecting the heat transfer and local solidification rate during the casting, such as component thickness, alloy compositions, and process conditions. **[7]**

In other studies they have studied the causes of shrinkage and how to avoid it they have seen a small holes round in structure but basically they are irregular in shape and tend to form branching internal fracture. Thin multi-angled edge is most susceptible to this type of shrinkage which occurs when the metal cools.

Castings can cool up to 100 degrees per minute once the pouring is done after melting so shrinkage can be caused while solidification is under way, it is important to have equipment prepared to treat the job piece before it solidifies. The common cause of shrinkage is due to casting sprue which is the pouring of molten metal into mould, in some areas the metal takes longer to solidify and contract which reduces material availability and likely to cause shrinkage.

We can avoid this problem by taking the sprue taperd rather than a flat or squared it will spray the molten metal to the cavity rather than just pouring it, through this certain areas of the workpiece will began to solidify before the mould is entirely filled. And the flow to the mould should be as uniform as possible and a large central or multiple sprue arrangement can help achieve that.[8] New methodologies need to be evolved to minimize the shrinkages in castings and to enhance the process of direction solidification so that sound castings can be made. Existing foundry practices employed to achieve these objectives are based on the subjective judgement of the foundry experts. Present state-of-art processes followed to achieve these objectives are based on trial-and-error production, which are intolerably subjective and do not guarantee a satisfactory result. To this end, an intelligent shrinkage minimization module is required which can learn the real behavior of the solidification process so that it can perform the task of casting design feature modification in real time and intensify the process of directional solidification for a given casting. In this research, synthesis of two NN models, such as K-SOM network and BPN, are adopted to tackle the underlying problem. In the test problem considered, the NN-based model was able to minimize the shrinkages by accurately modifying the casting design features and augmenting the process of directional solidification. The proposed methodology simplifies the task of foundry designers to perform casting design modifications in a more flexible and intelligent manner[9]. Shrinkage characteristic of US 413 cast aluminium alloy has been discussed in the current study. The decrease in specific volume leads to shrinkage in castings and it can be envisaged as a defect. The shrinkage porosity has been studied using finite difference based casting process simulation software. The shrinkage characteristic has been quantified using arithmetical formula. A three dimensional solid model of the shrinkage defect has been constructed using CAD. Shrinkage characteristic has also been quantified through experimental validation studies and compared well with casting process simulation. Influence of casting shape on the shrinkage characteristic has been studied in this paper[10]. The general technique for eliminating shrinkage porosity is to ensure that liquid metal under pressure continues to flow into the voids as they form[11].

PROPOSE SOLUTION ON HOW TO MINIMIZE SHRINKAGE DEFECT IN CRANKSHAFT CASTING:

The most common causes of shrinkage are related to the **casting sprue**, which is the passage through which molten metal is poured into a mold. In some areas, such as the heavy sections of the mold, the metal takes longer to contract and solidify, which reduces feed material availability and increases the likelihood of shrinkage, especially if the sprue is too small for the volume of flow. A properly sized sprue attached directly to the heavy section can fill the cavity and provide the feed material necessary to counteract shrinkage as cooling occurs. In addition, using a rounded, rather than a flat or square gate on the sprue can further reduce the risk of forming shrinkage defects in crankshaft casting.

Using a narrow or tapered sprue can result in the molten metal being sprayed rather than poured into the cavity. When this happens, certain sections of the workpiece begin to solidify before the entire mold is filled. Molten flow into the cavity should be as uniform as possible, and a larger central sprue or a multiple-sprue arrangement can help achieve the even supply of material.

- Circular Gate Advantage
    - They can be small
    - Well suited for heat-sensitive materials
    - Less expensive to produce
    - Easier to operate than other open gates

CONCLUSIONS:

After careful study of different literature review regarding the shrinkage in casting and moulding, several crucial factors have been included to explain the main defects that occurs while moulding. Few of those factors are concluded here. One of them is temperature gradient. As during the moulding, temperature of molten metal changed markedly over short period of time when it is poured in moulding material. Another factor is time difference in alloy solidification. Moreover, defects in casting also depends on the volume of supplied molten metal. The more the amount of molten metal changes, the more different casting would be. The opening of the mould could be another main factor defecting the casting process. As most of the cases it keeps tapered which is metallurgical imperfect. By changing its opening from tapered to square this problem could be solved.

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