A REVIEW ON WELDING OF CAST IRON MATERIAL

Saurabh Mangate
Department Of Mechanical Engineering
Students of 4rd Year
JD College Of Engineering and Management, Nagpur

Sangharkshak Manwatkar
Department Of Mechanical Engineering
Students of 4rd Year
JD College Of Engineering and Management, Nagpur

Bhushan Nehare
Department Of Mechanical Engineering
Students of 4rd Year
JD College Of Engineering and Management, Nagpur

Nikhil Borkar
Department Of Mechanical Engineering
Students of 4rd Year
JD College Of Engineering and Management, Nagpur

Abstract :

The difficulty with welding characteristics of the cast iron generated majorly from the high carbon placid of the material. Due to welding and cooling, the carbon makes formation of various undesired micro-structures possible, reducing the weldability, a great deal in all regions related to welding. For welding the cast iron material by using warming welding process according to the preheating temperatures extent. the lower preheating temperatures are not sufficient for lowering the cooling rate to the desired values and hence formation of brittle phases as martensitic and carbides are encountered.

Ni based electrodes are generally used for such cases. Ni based fillers are lame than steel alloys and yields higher ductility. Increased ductility modify crack formation especially in case of martensitic transformation and additionally Nickel bonds with Carbon preventing formation of iron carbide. Upon these superior properties, Ni electrodes provide relatively let down mechanical properties with respect to steel.

KEYWORDS: weldability , welding processes , micro-structure , cast iron material.

Introduction:-

Welding is a permanent joining process used to connection different materials like metals, alloys or plastics, together at their contacting surfaces by application of heat and or pressure. During welding, the work-pieces to be joined are melted at the interface and after solidification a permanent joint can be achieved. Sometimes a filler material is added to form a weld pool of molten material which after solidification gives a strong bond between the materials. Weldability of a material is depends on different factors like the metallurgical changes that occur during welding, Due to rapid solidification changes in hardness in weld zone, presence of oxidation due to reaction of materials with atmospheric oxygen and tendency of crack formation in the joint position.

Weldability of cast iron has been found to be very poor due to the heterogeneity of matrix phase and non-wettability of the graphite phase. These phases undergo a series of microstructural changes in the heat affected zone (HAZ) during weld repairing by fusion welding the project discusses the nature of these changes occurring in the vicinity of the weld zone as well as method of controlling these to get passable weldment.

Preheating must be sustained for a time sufficient to avoid martensite formation and to prevent secondary graphite from developing in the matrix upon annealing or multi pass welding. The effect of preheat is to reduce residual stresses, distortion, prevent cold cracking and reduce the hardness in the HAZ. In this study, the HAZ structures and mechanical properties of grey cast iron welds have been examined in the as-cast and fully fertilizing annealing conditions under preheat temperatures.

Ductile cast iron is an important cast material to the designer which reaper the advantages of cast iron, such as cut rate, effortless of machining, low melting temperature, good fluidity, good wear resistance properties, high damping capacity, excellent heat resistance properties and those of steel, such as high strength, ductility, toughness, hot workability and hardenability.

In the case of cast iron filler metal, it is reported that the weld cracking due to formation of brittle phase in fusion zone (FZ) is highly probable when preheat temperature is lower than 300°C. Nickel based electrodes offer the highest crack resistance weld mainly because of their desirable mechanical properties and their ability to precipitates the carbon picked up from the base in its free form as graphite.

Table 1: Chemical composition of cast iron according to its types.

IRON TYPE	PERCENT(%)				
	C	Si	Mn	S	Ph
GRAY	2.5-4.0	1.0-3.0	0.2-1.0	0.02-0.25	0.02-1.0
DUCTILE	3.0-4.0	1.8-2.8	0.1-1.0	0.01-0.03	0.01-0.1
COMPATCED GRAPHITE	2.5-4.0	1.0-3.0	0.2-1.0	0.01-0.03	0.01-0.1
MELLEABLE(CAST WHITE)	2.0-2.9	0.9-1.9	0.15-1.2	0.02-0.2	0.02-0.2
WHITE	1.8-3.6	0.5-1.9	0.25-0.8	0.06-0.2	0.06-0.2

Welding processes :-

1. Powder Welding :

Ghaini et al. [1] showed that residual stresses can control the crack generation during the welding process in ductile cast iron. “Powder welding process employes Oxyacetylene welding (OAW) torch in which welding alloy in the form of finely divided powder through matering devices”.They also used powder welding process to characterize the kind of crack formed in welding process. He claimed that the cracks in powder welding process are differing in morphology from the cold cracks in the case of arc welding of ductile cast irons.

2. Friction welding :

Winiczenko and Kaczorowski [2] used friction welding of ductile iron with stainless steel. They concluded that friction welding is accompanied by a transport of atoms in both directions across the ductile iron-stainless steel interface. They showed the maximum length of Cr and Ni diffusion in cast iron is 50ųm and the bainitic matrix improves this transition.

3. Shielded metal arc welding (SMAW) :

A common method for repair welding of cast iron is shielded metal arc welding (SMAW). This method is rather cheap and easy. In this method, usually carbon steel fillers are used to repair the damaged areas. Shielded metal arc welding (SMAW) using 98.2% Ni and Fe-Cr-Ni alloy filler materials respectively. They have concluded that welding ductile cast iron with or without preheat is possible but preheating almost always increases weld quality and ductility. OAW results very poor weld metal properties whereas SMAW yields and amount of ductility in the weld metal.

Material – Cast Iron:-

Cast irons are the ferrous alloys having iron, silicon and carbon content generally greater than 2.1 wt% and solidifying with a eutectic structure. By the eutectic solidification characteristics, cast irons can be liquid between 1150-1300°C and shows good fluidity and casting characteristics, making melting and casting a preferable production technique. Applications of cast irons are housings, enclosures, brake drums, clutch plates and counter weights.

1. WHITE CAST IRON:

When the cooling is rapid, the carbon cannot form graphite instead remains as metastable iron carbide and large amounts of cementite is formed. Also graphitization may be inhibited by the alloy composition. The structure is very hard and brittle and un machinable but can be used as a wear resistive material.

2. MALLEABLE CAST IRON:

If suitable heat treatment is applied to the white cast iron, annealing at 800-900°C for prolonged times, the carbon in the cementite precipitates as graphite having irregular shapes. The structure of matrix is determined by annealing process as ferrite or pearlite. Malleable cast irons yield high strengths and appreciable ductility.

3. CHILLED CAST IRON:

When a localized area of a gray CI is cooled very rapidly from the melt, CI is formed at the place that has been cooled. This type of white CI is called chilled iron. A chilled iron casting can be produced by adjusting the carbon composition of the white CI, so that the normal cooling rate at the surface is just fast enough to produce white CI while the slower cooling rate below the surface will produce gray iron.

4. GRAY CAST IRON:

Gray cast iron is the most common type of cast iron. Generally it has about 1 - 3 wt. % Si. Presence of silicon in combination with the slow cooling promotes the formation of graphite instead of iron carbide. In this type, graphite is in the form of flakes. General microstructure of gray cast irons consists of flakes distributed in pearlite matrix but addition of about 15% Ni to the composition may produce austenitic matrix. The graphite flakes behave like the cracks in the microstructure therefore gray cast irons show weak mechanical characteristics in tension whereas possess high strength in compression.

5. SPHEROIDAL GRAPHITE CAST IRON:

Sulfur in CIs is known to favor the formation of graphite flakes. The graphite can be induced to precipitate in a Spheroidal graphite CI, Fe, 3.2 C, 2.5 Si, and 0.05 Mg wt. %, containing graphite nodules in a matrix, which is pearlite. One of the nodules is surrounded by ferrite, simply because the region around the nodule is decarburized as carbon deposits onto the graphite spheroidal shape by removing the sulfur from the melt using a small quantity of calcium carbide (CaC2).

6. NODULAR CAST IRON:

Nodular cast irons are produced adding magnesium or cerium to the gray iron composition. These elements act as nodulizers and change the flake like morphology of graphite into nodules, therefore the crack behavior of the graphite gets eliminated and the mechanical properties, especially in tension become improved. Mechanically nodular cast irons may have characteristics similar to steels. Thus, they combine the advantageous properties of steels and cast irons. Graphite nodules dispersed into pearlite and/or ferrite matrix constructs the characteristic microstructure of nodular cast iron.

Literature Review:-

Pascual et al. [3] have studied welding nodular cast iron with oxyacetylene (OAW) and shielded metal arc welding (SMAW) using 98.2% Ni and Fe-Cr-Ni alloy filler materials respectively. They have concluded that welding ductile cast iron with or without preheat is possible but preheating almost always increases weld quality and ductility. OAW results very poor weld metal properties whereas SMAW yields an amount of ductility in the weld metal. Furthermore, using Ni electrodes is another factor increasing the ductility which hinders the carbide formation.

El-Banna. [4] has studied welding ductile cast iron in as-cast and fully ferritized states using SMAW process with ENiFeCI filler material. He has worked on different preheating temperatures and again concluded that ductile cast iron can successfully be welded with or without preheating using Ni based electrodes but in order to achieve certain mechanical properties a preheating temperature of 200-300°C is required. Additionally he stated that R m values required from the base materials can only be met in ferritized components. In as welded specimens ledeburitic carbide structures and local melting around the graphite nodules are observed. With application of preheating various pearlite and martensite ratios instead of carbide were formed.

Pouranvari.[5] carried out a study on welding cast iron using SMAW with Ni based electrodes. He also applied PWHT to the welded pieces. Due to possibility of increasing amount and continuity of carbides preheating is not used and formation of cracks was not reported. Material was fully annealed and a nearly uniform hardness profile is achieved. Again nickel based filler is used to prevent ledeburitic carbide formation in the structure of the weld piece but due to dilution very high carbon contents are come across which cannot be compensated with Ni. This excess amount precipitated as graphite in fusion zone. In PMZ ledeburitic and martensitic structure formation occurs, constructing a hard and brittle network among fusion line.

Voigt et al. [6] have studied general HAZ structures of ductile cast irons. SMAW with ENi-CI filler material used with about 300°C of preheating. Sub-critical annealing and full annealing is applied to the specimens. In as weld specimens carbides are formed surrounding the graphite nodules and in intercellular regions between nodules. It is concluded that this formation cannot be effectively prevented in PMZ. Martensite, observed in HAZ, cannot be overcome if the preheating temperature is sustained for sufficient times after welding. By application of subcritical annealing martensite was decomposed to ferrite and secondary graphite.

Sr. No.	Paper ID	Author	Material	Welding	Input Parameter	Output Parameter	Conclusion
1.	Material and design 31(2010)3253-3258	M. Pouranvari	Grey cast iron	SMAW	PWHT 870 degree Celsius	Tensitein HAZ & graphitization inthis zone	Grey cast iron with nickel based filler metal and applying PWHT can serve as a solution for cast iron welding problems.
2.	62(2008)1359-1362	M.Paacual, M.Pascual Martinez spain	Ductile cast iron	SMAW	Electrode were dried at 90 degree celsius	Preheat, microstructure, electrode	Total strain,assuring non-fragile behaviour of joint.
3.	SSRG - IJME(4) 1-6	Rajneesh kumar , rahul bhatnakar , Vaibhav Trivedi	Grey cast iron	SMAW	Shilded metal arc Welding tensile test , IZOD test	Graphitaisation in this zone	The effect of Pre-hit reduce residual stresses , distortion

Result :-

The SMAW welding is sufficient to weld the cast iron material and more preferable to weld cast iron material.

Conclusion:-

In this review we study different welding processes are suitable for cast iron material. The most common method for cast iron welding is shielded metal arc welding (SMAW) / manual metal arc welding (MMAW). Also study of different types of cast iron and the weldability of cast iron material. Preheating is the most important factor on cast iron. Preheating produces welding joints of higher strength and elongation but of lower hardness for FZ and HAZ at all cooling rates. Higher cooling rates produce joints of higher strength and hardness but lower elongation. Preheating increases the width of the FZ and HAZ. Preheating produces larger grain size in FZ and HAZ under all condition of cooling. In general preheating produces higher quality index for all cooling rates.

References:-

1. Malek Ghaini F, Ebrahimnia M, Gholizade SH. Characteristics of cracks in heat affected zone of ductile cast iron in powder welding process. Eng Fail Anal 2011;18:47-s–51-s.
2. Winiczenkoa R, Kaczorowski M. Friction welding of ductile iron with stainless steel. J Mater Process Technol2013;213:453–62.
3. Pascual M., et al., Analysis of the weldability of ductile iron. Materials Letters, 2008, Vol.62: p. 13591362.
4. El-Banna E. M., Effect of preheat on welding of ductile cast iron. Materials Letters, 1999, vol.41: p. 20-26.
5. Pouranvari M., on the weldability of grey cast iron using nickel based filler metal. Materials and Design, 2010, vol.31: p. 3253-3258.
6. Voigt R. C., et al., A study of heat-affected zone structures in ductile cast iron. Welding Journal, 1983, vol.42: p. 82-88.
7. Ebrahimnia M, Malek Ghaini F, Gholizade SH, Salari M. Effect of cooling rate and powder characteristics on the soundness of heat affected zone in powder welding of ductile cast iron. Mater Des 2012;33:551-s–6-s.
8. Mirhedayatian SM, Vahdat SE, Jafarian Jelodar M, FarzipoorSaen R. Welding process selection for repairing nodular cast iron engine block by integrated fuzzy data envelopment analysis and TOPSIS approaches. Mater Des2013;43:272-s–82-s.