Design and Fabrication of a Wind Mill Hub

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Abstract
For centuries, windmills and watermills were the only source of motive power for a number of mechanical applications, some of which are even still used today. From time to time many materials were used to construct these structures. In the late 20th century the use of ductile iron(sg iron) found very effective for wind mills due to its high strength Ductile iron is not a single material but is part of a group of materials which can be produced to have a wide range of properties through control of the microstructure. This paper deals with the design and fabrication of a wind mill hub using SG iron.

Keywords
SG Iron, Wind Mill Hub

I. Introduction

Casting is one of the oldest manufacturing process which dates back to approximately 400BC. Earlier castings were probably made out of copper, silver, gold, bronze, etc. Perhaps the earlier casting of cast iron were those of cannon shot and grave slabs. The first foundry center came into existence in the days of the Shang dynasty (1766-1122BC) in china. A number of foundries using cast iron as a structural material came into being after Industrial Revolution (in Britain).

The collapse of the Toy Bridge in 1879 forced people to go beyond the rudimentary judgment of the then molders and to study the pounding variables and their effect on the properties of structures The middle part of twentieth century. Saw marked development in founding .Newer techniques came in to existence. Engineering institutes started teaching metal casting as an independent subject

II. Material Used

Ductile iron is a family of alloys which combine the principal advantages of graycast iron with steel. Ductile iron consists of graphite spheroids dispersed in matrix similar to that of steel .; the matrices can be similar. The ease with which ductile iron can be processed and cast into is very dependent on the carbon content.

Properties

- High castability
- Higher machninability compared to steel .
- Improved corrosion resistance
- Good vibration damping capabilities
- Ductility
- Low melting point.
- High strength and toughness

Table 1: Chemical Coposition SG Iron

Element	% Composition
C	3.6-4.2
S	.5 - 1
Si	1.25-2.0
Mn	0.35
P	0.08
Ni	0.0-1.0
Mg	0.05-0.08

III. Drawings

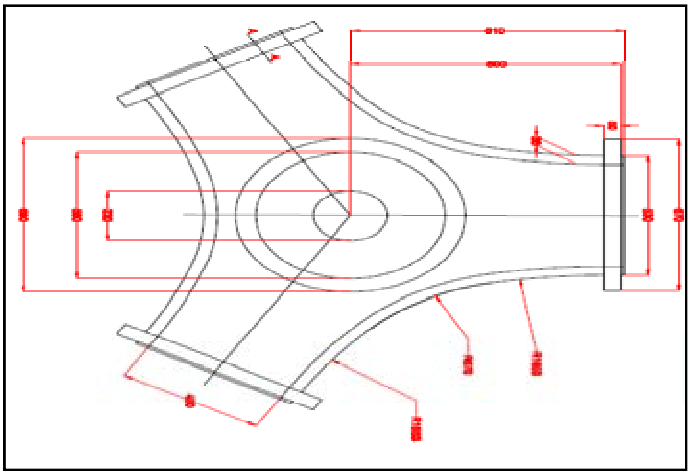

Fig. 1: Top View of HUB (All In MM)

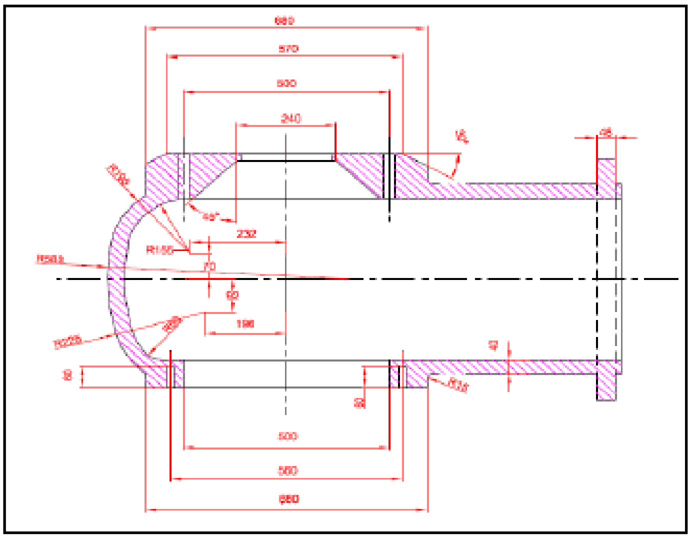

Fig. 2: Cross Sectional View (All In MM)

IV. Casting Design

Castings are born on designer's drawing board, but the final shapes is often altered during the course of its development. As machine elements tools or other objects, their functional purpose is given, first and fore-most attention by the designer. Ultimately after testing the design possible modifications are made. The next step is manufacturing.The following factors should be considered when designing a casting.

- Design for minimum casting stress. External corners should be rounded. Replace sharp angles and corners with suitable radi.
- Design for direction solidification. Bring minimum number of sections together.
- Design for metal flow: For SG iron the minimum casting thickness should be not be less than 8 mm.
- Design for minimum costing

V. Design of the Gates

Steps in Design
Weight of the casting = 2410kg
From normal foundry practice it is found that the yield for S.G

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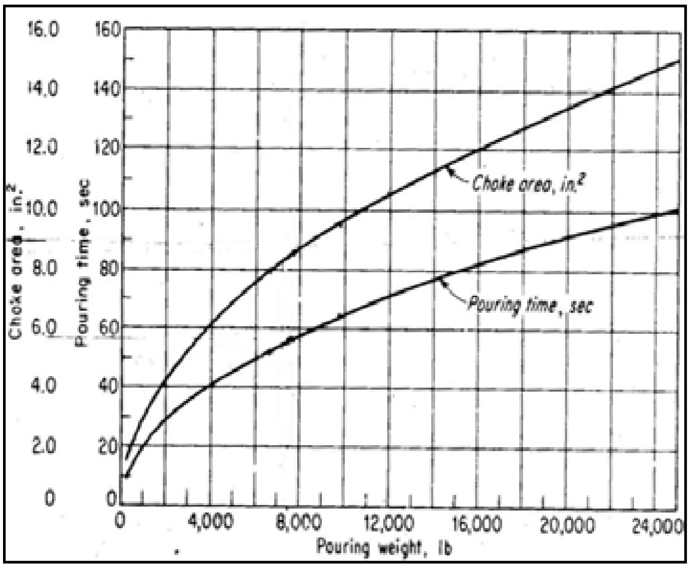
iron is 70-75%. That means if 100kg of molten metal is poured only 70-75% will be used by the casting remaining 25 to 30% is used for the gating system.
Taking yield 70%
Weight of the molten metal to be used = 3442.85
=(2410/70)*100 = 3442.85kg



Graph :1 Pouring Weight (lb) Vs Choke Area (in^2)

Values obtained from graph
Choke area = 8.6 in^2
Pouring time ≈57sec
Choke area means the lowest cross sectional area anywhere in a gating system
Choke area = 8.6in^2
Selecting number of gates
From the sprue the gate should start only after a 150mm length
The distance between two gates should be greater than 90mm
Heavy thickness should be provided with a gate
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There for a total of six gates needed hub
Total choke area = 4.6 in^2
Choke area of each gate = 8.6in^2/6 = 1.433 in^2
The cross section of a gate is shown in the figure
The ratio between the length and the height is 4:1
Therefore Area of the gate = 4t^2
4t^2 = 1.433in2
t^2 = .3583t
t = √(.3583)
= 0.598in
=15.2mm
= 15mm
Length = 4x15 = 60mm

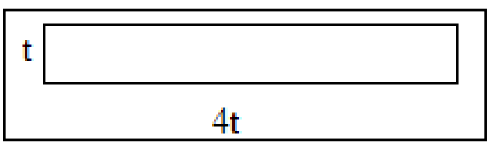

Fig. 3: Cross Section of in Gate

To introduce a taper 1.5mm is added to one side and subtracted from the other side.

VI. Design of RISER

For the casting of the wind mill hub, conventional risering using open risers is used.
Normally risers are placed at regions of heavy thickness
For the hub casting the regions of heavy thickness are
1. At the 3 flanges
2. Top central portion

Riser on flanges
Riser diameter = modulus of riser x 4
Modulus of riser= modulus of casting x 1.21
Cross sectional area at flanges is Rectangular
Width = 225mm (a)
Length = 50mm (b)
Modulus of Casting = a*b/2*(a+b) = area/perimeter
= 225*50/(2*275)= 20.45mm
Therefore modulus of riser=20.45*1.21
=24.75mm
Riser diameter =24.75*4
=99mm
≈100mm
Height of the riser = 100*1.5
Since the diameter to height ratio of riser is normally taken 1:1.5
Neck of the riser
Neck diameter is given ½ of the riser diameter
= 100mm/2 = 50mm
Riser's at central top part
The top central part is almost like a cylindrical part. In cylindrical parts a riser can properly feed only up to a maximum of 1200(600 on each side). So a minimum of 3 risers are necessary.
Modulus of casting = (a*b)/2(a+b)
a = 225mm
b = 85mm
= 225*85/2(225+85)
= 30.84mm
Modulus of riser = 30.84*1.21
= 37.324mm
Diameter of riser = modulus of riser*4
= 37.324*4
= 149.2983mm
≈ 150mm
Height of the riser = 150*1.5 = 225mm
Since the diameter to height ratio is 1.5
Neck of the riser is ½ riser diameter = 150/2
=75mm
In normal practice riser patterns are not manufactured for each casting. Some standard sizes are available. They are φ75, φ100, φ150, φ200 and φ225.

Design of the Runner and SPRUE

The gating ratio normally selected for SG iron is 4:8:3. (spure:runner:ingate)
Steps in design of runner
Total runner area of pressurized system = (8/3)* choke area = (8/3)* 8.6 in^2 =22.93 in^2
Area of runner = 2a^2
2a^2 = 8.6 in^2
a = 2.076 in
a = 5.080cm
= 50.80mm
≈ 51mm
Height = 2*a = 102mm

Design of sprue (pressurized)
The shape of sprue is generally tapering downwards
Sprue area at bottom = (4/3)*8.6 in^2
= 11.46 in^2
πr^2 = 11.46 in^2
r^2 = 3.649 in^2
r = 1.910inch
r = 46.80mm
Nearest sprue size available is 50mm

VII. Molding Box Selection

Most suitable size available is of the following specification (One half)
Cross section = $200mm^2$
Height = 550mm
Volume of molding box = 200*2000*550
= (area * height)
= $22*10^8$ mm^3
Total weight of casting = 3442.85kg
Density of SG iron = .225 pound/in^3
Mass / volume of casting = density
Volume of casting = mass/density (pound/(pound/in^3))
= 7655/.255
Casting volume = 30020 in^3 in both boxes Density of compacted sand (co_2) needed for large castings = 1.6 pound/in^3
Total volume of the box = 2.2m3*2
= $4.4m^3$
= 30299.02kg
= ≈ 30.3 ton

Fig. 4: Core Assembly

Fig. 5: Core Bottom Half

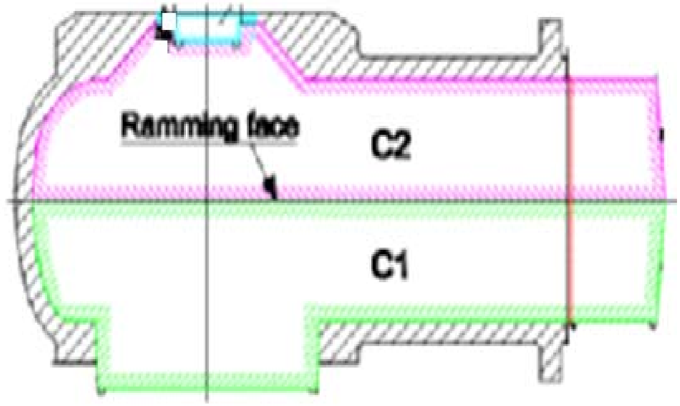

Fig. 6: Core Assembly

Table 1: Standard Sand Mixing Proportions

CHEMICALS	AMOUNT (Kgs)
Sand	500
Sodium silicate	22.5
Iron oxide	2.5
Yellow dextrin	2.5

VIII. Metal Melting

A. Induction Furnace Melting

The induction furnace used is the low - frequency, 60 - cycle type. The capacity of the furnace is 6 ton's. These furnaces can be operated either for cold melting or for duplexing. Very close control must be exercised over raw materials in these furnaces since the rust on scrap and other slag forming ingredients rapidly. Extremely close control of composition of metal temperature is possible in those furnaces, so quality S.G. iron can be produced.
A Y-block is used to produce tensile bar specimen for customer-acceptance test-and for conducting distractive tests on the metal. There is a standard Y-block pattern of heavy casting, this pattern is placed in the molding box and connected with the gating system. So that the part of the pouring metal will be filling the Y-block cavity. And solidifies to form the solid Y-block for conducting tests

B. Graphite Shape and Size

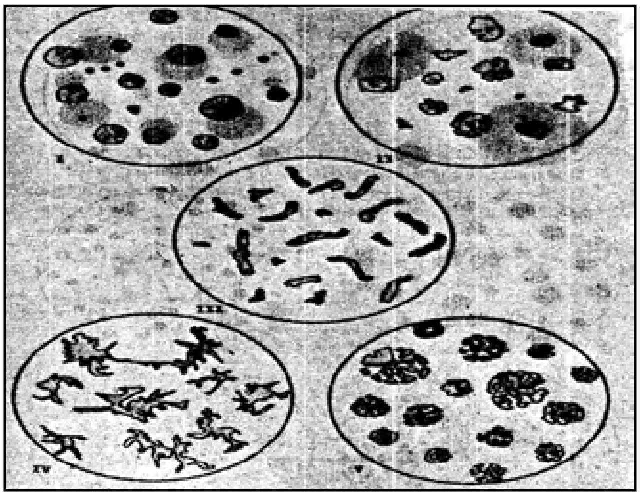

Fig. 7: Graphite Shapes in Ductile Iron

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Quality ductile iron is produced so that graphite is developed as spheroids. A number of other graphite may develop, however if the process is not carried out property. The chart classifying these graphite shapes have been proposed and presented in the figure. Type 1 graphite is the accepted graphite from of S.G. iron although presence of type II graphite will have little effect on properties. Up to 10% type and the remaining type III graphite will have no notice able effect on properties. Increases amount of type III is not desirable. Type IV and V are undesirable and have significantly low mechanical properties.

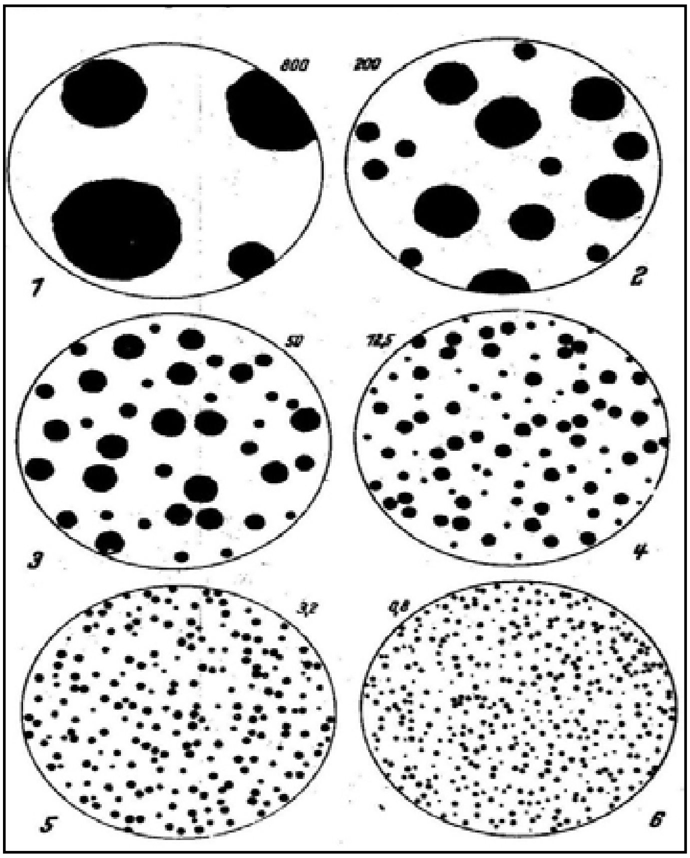

Fig. 8: Graphite Size in Ductile Iron

The graphite shapes developed in S.G. iron mainly dependents on pouring temperature, casting section size, amount of effective magnesium added and inoculants. In general the poor graphite shapes are developed low pouring temperature, heavy section sizes, insufficient magnesium added and low carbon - equivalent. Six sizes of graphite spheroids have been proposed. Among them 5 and 6 are the most desirable sizes. This mainly depends on pouring temperature and thickness of the section.

IX. Casting

A. Practical Considerations

1. Over gassing will produce white patches on the surface of the mould and core due to the presence of sodium bicarbonate. Optimum range 10 – 20 (lbs/in^2 – min)
2. A co_2 cores are to be painted with alcohol based refractory washes (zircon) and graphite.
   This is for getting better surface finish and to avoid sticking of pattern to the mould.
3. Preheating of ladle is done with help of firewood. (up to 500^{o}C)
4. Re-inforcement bars and hooks are placed inside the core for better handling and better strength
5. A splash-core is provided at the bottom of the sprue
6. Air-vents should be properly made for the escape of gases.
7. Chills of size 70*70*50 are placed at the heavy thickness regions of the casting to promote directional-solidification

X. Solidification Proces

The fundamentals of heating and cooling are shown in the graph given below

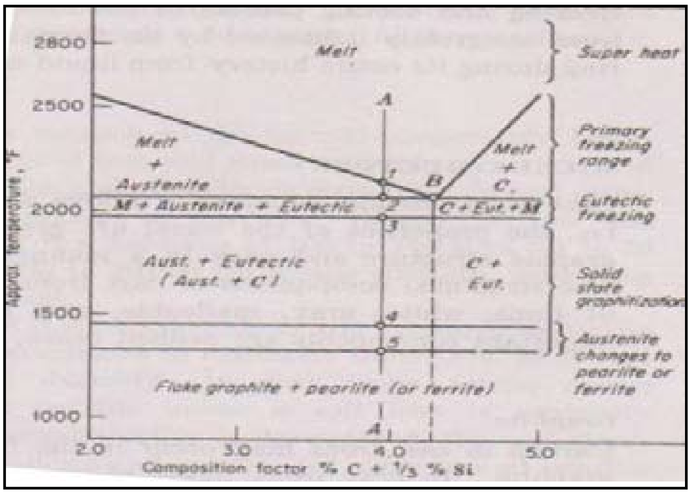

Fig. 9: Temperature Range of Solidification

1. Liquid metal cools until freezing begins at point 1. At this temperature solid austenite dendrites begins to form and grow until the temperature at point 2 is reached.
2. Eutectic freezing begins as the point 2 is reached. The eutectic solid which formed is a mixture of austenite and graphite. As the temperature has dropped to point 3, freezing is completed.
3. At the end of freezing, the structure consist of the solid developed during step A and B. (austenite and graphite)
4. Further cooling between points 4 and 5 results in the precipitation of carbon from the austenite present since austenite may contain as much as 2% carbon, but only (.60-.80) % as the temperature decreases to point 4. The excess carbon is precipitated as graphite in nodular iron.
5. Between points 4 and 5, the final change occurs in the solid during cooling. Austenite transforms over the temperature range 4 to 5. With the most favorable graphitizing condition, only ferrite is formed. With less severe graphitizing condition ferrite and peralite are formed. In nodular cast iron, mixed structure of ferrite and pearlite forms a "bulls eyes" of ferrite around graphite spheroids.

XI. Fettling

Fettling is the name given to cover all those operations which helps in giving the casting a good appearance after the casting has been taken out from the mould.

XII. Inspection and Testing

Inspections has to do with the observation of the process and products of manufacture to ensure the presence of desired qualities. Testing ,on the other hand ,specifically refers to the physical performance of operations to determine quantitative measure of certain properties such as mechanical , chemical.

Inspection procedures and test may be classified as follows

1. Visual inspection for defects
2. Geometric checking for shape and dimensions

3. Chemical tests
4. Microscopic test
5. Testing for mechanical properties
6. Non- destructive tests

XIII. Conclusion

The wind mill hub is manufactured and it passed all the quality tests.

XIV. Acknowledgement

I would like to thank Mr. T D S Kartha (Engineer in Charge of Mechanical Department) and all the staff members of AutoKast Cherthala, Kerala for helping me to complete this work successfully.

Referance

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