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Gating System Design and Material Analysis for the Sand Casting of a Sprocket

Vishwas Mehta[1], Atharva Kulkarni[2], Rohan Mahale[3]

[1]Department of Mechanical Engineering, Vellore Institute of Technology, Vellore, Tamil Nadu, India
[2,3]Department of Automotive Engineering, Vellore Institute of Technology, Vellore, Tamil Nadu, India

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Abstract - *The process of metal casting in the casting industry involves a pouring process in which molten metal is poured into a mold by various different means and in various different conditions. The inherent dangers of the casting process coupled with dozens of factors such as pouring temperature, mould- characteristics, pouring speed etc. lead to a high degree of uncertainty in the finished product's quality. In order to obtain the best possible combination of initial factors, we have designed an analytical experiment by simulating the casting process for a set of varying parameters.*

***Key Words*: ProCAST, Gating design, Sand Casting, Visual cast Simulation, Sprocket**

1. INTRODUCTION

Traditional casting trade has a long history and until now it has been the basis of the entire mechanical industry. The growing requirement for casting with preferred properties, directional or controlled solidification has turned out to be the call for in today's scenario. Many of the casting products like Automotive, Structural and industrial applications have failed when they are subjected to complex conditions due to poor set of properties. In the present days, numerical modeling of the solidification is of significance. As a normal mathematical methodology, the limited component strategy has been utilized effectively in displaying the shape filling cycle of traditional castings.

1.1 Green Sand Casting

Greensand casting is a time-tested and highly versatile metal casting process. Various foundries utilize various strategies and materials, however greensand casting consistently includes making molds by compacting soggy, naturally reinforced sand around designs. Though shell shaping uses heat-reinforced sand and no-prepare casting utilizes synthetically fortified sand to frame molds, greensand casting is exceptional in that sand is fortified through normally happening mixes as rule, holding operator is earth.

Greensand casting can either be directed physically, with administrators playing out the positions of compaction, pouring or shakeout, or utilizing a mechanized framework. With manual greensand casting, arrangement costs are regularly lower than other casting strategies. Tooling can be made from plastic or wood, rather than iron or steel, and the mold itself is made from easily reclaimed material. Be that as it may, with manual greensand casting, per-part expenses can be high a result of the quantity of administrators needed to create each casting. Robotized greensand frameworks, then again, can deliver high volumes at lower per-part cost, more practically identical in such manner to measures like lasting mold casting. However, drawbacks to automated greensand casting include high start-up costs for the foundry and the need to more precisely control the makeup of the sand. Another benefit of greensand casting is its flexibility in allowing a wide range of alloys to be poured.

Capabilities

1. Suitable for producing small and medium-sized castings that weigh mostly less than 50 kgs [2].
2. If the item is produced using automated molding lines during the process, green sand casting can also produce large castings up to 500 kgs [2].

Downsides

1. Because the casting process is dependent on the fact that it is carried out in a mold box, finished product sizes are constrained to the size of the box.
2. Molds that have been green sand casted exhibit decreased surface strength compared to molds that have undergone more traditional processes [2].

1.2 Resin bonded casting

There are many different binder systems for sand moulds. They bond the sand grains together well enough to allow metal to be poured into the mold and have the mold cavity hold its shape until the metal solidifies. The simplest is a clay-water bond known as greensand. Other "bakeable" folios use molasses or flour. No-heat fasteners with synthetic tars are additionally used. For the most part, sand castings require an example on which sand blended in with folio is slammed and painstakingly eliminated. The example must, subsequently, be draftable without undermines which will keep the shape from being pulled from the example.

Epoxy resin is useful for larger pieces since it can be formed with fiberglass, cloth or mat over Styrofoam, wood, and/or metal armature. Nice surface can be obtained. Detail is difficult. Some plastic patterns may react with rubber molding compound, and leave it sticky or discoloured. It is always a good practice to do test samples. Reassembling resin models which have to be cut up to make a rubber or sand molds maybe difficult or impossible.

Capabilities

1. It produces accurate results that are superior to other sand-casting methods. This process also results in increased surface strength when compared to other sand-casting options [2].
2. The nature of resin sand casting can help reduce defects such as sand holes, air holes, and shrinkage. More flexibility with sizing & can produce large iron castings [2].

Downsides

1. Resin sand casting is a more expensive casting method. This type of casting calls for specialized molding equipment [2].

1.3 Materials

Stainless Steel Sprockets

Hardened steel or bronze might be utilized for consumption opposition; and formica, nylon, or other reasonable plastic materials might be utilized for unique applications. Stainless sprockets are either investment cast from 18-8 stainless or fully machined from T-304 SS or T-316 SS. Machined tooth (-MT) sprockets made from various stainless steels are also available.

Cast Iron Sprockets

The most common and economical material for flat wire belt sprockets is Cast Iron. Cast iron is commonly used in large sprockets, especially in drives with large speed ratios. It is adequate because the teeth of the larger sprockets are subject to fewer chain engagements in a given time. For serious assistance, projected steel or steel plate is liked.

Steel Sprockets

The more modest sprockets of a drive are generally made of steel. With this material, the body of the sprocket can be heat-treated to create durability for stun opposition, and the tooth surfaces can be solidified to oppose wear.

Though relevant simulation solvers are available, a series of researches remain to be done to achieve a simulation of the relevant physical field variable of an actual casting [1]. As known, the boundary conditions have to be provided before simulating the temperature field with the help of the available software [1].

Owing to the complexity of physical field in the casting process, the boundary conditions include: convection coefficient, and interface heat transfer coefficient between the cast and its mould; these parameters are difficult to define and require a trial-error approach to accumulate experiences for their determination [1].

2. LITERATURE REVIEW

Numerical investigation on solidification in casting using PROCAST [3]: In this paper, the researchers made 4 different types of design and solidification time and shrinkage porosity were observed. It was concluded that casting simulation was quiet very effective in determining the location of defects and eliminating them by visualizing mould filling, solidification and cooling. Modifications in riser & the gating system design by changing dimensions & geometry, eliminates shrinkage porosity defects from the cast part. After importing the 3D model to PROCAST, the parameters such as solidification time, shrinkage porosity and percentage solidification were observed.

Design and Analysis of Gating System for Casting of Sprocket [4]: In this paper, Mass flow rate, pouring & fill time, HTC interface & riser - open were the parameters. After the detailed observation in ANSYS software on how the heat varies inside the casting it was found that temperature field was largely influenced by the flow field. Hotspot defects mostly occurred at the thick sections of the mould and they can eliminate that by providing riser in that area so hotspot can be transferred to the riser. They observed the changes in solidification direction and can then direct the solidification process by changing or precisely modifying gating and riser system or altering another process parameter.

Solidification Analysis and Optimization Using Pro-Cast [5]: They observed the effect of riser height on shrinkage porosity, runner height on shrinkage porosity. They ran a simulation on basic sand casting because of 90 percent of defects in casting are because of wrong riser and runner heights researchers found out that using software like PROCAST they can simulate the defects beforehand and can make sure they choose the best on in application. In this paper the authors change the height of runner and riser 3 time and made an observation on how that effects shrinkage porosity. It was found that when riser height increased from 130 to 160 shrinkage porosity also increased.

3. EXPERIMENTAL DETAILS

The purpose of this Project is to simulate the mechanism of the solidification of Sprocket and analyze the results to give some aspects of logical thoughts for component designation, and to optimize the casting parameters in order to achieve better properties of part castings.

CAD Software: Solidworks 2020
CAE Software: VisualCAST (Solver – ProCAST)

3.1 Geometry

SPROCKET: A sprocket is a profiled wheel shaped component having external teeth or cogs. The sprocket meshes with tracks, chains or indented and perforated components to transmit rotary motion between two shafts in situations where gears cannot be fixed or used. They may also be used to transmit power between shafts where slippage is unacceptable. Unlike gears, sprockets don't mesh with each other directly. Having various designs, sprockets typically don't have a flange but some have timing belts with flanges in order to keep the belt centered.

Fig -1: Casted Product

Fig -2: After Machining

3.2 Methodology

To carry out the experiment we have considered three drastically different alloys casted in two different settings using gravity casting. The alloys are casted at their melting point, in casting mold with two types of sand materials – Green sand and Resin Bonded Sand to find out which sand material has better cooling, less defects and lower solidification time.

Part Casted:

We have chosen to simulate gravity filling casting of a Sprocket.

1. Alloys (Gray Cast Iron, Stainless Steel & Medium Carbon Steel) – product material
2. Molds (Green Sand, Resin Bonded Sand) – sand material

Parameters tested:

1. Hot Spot Density (percentage surface area of hot spot w.r.t total surface area)
2. Shrinkage Porosity (percentage volume of shrinkage w.r.t total volume)
3. Solidification Time
4. Niyama Criterion

(NOTE: Defect density is highly exaggerated due to the geometry of simulated part)

In this simulation of casting filling process, multiphase flow (VOF), energy, turbulence and solidification options were chosen. Likewise, sensible mathematical recreation equation was picked. Casting, shape material properties and estimation limit conditions were applied. The entire figuring space state was instated. Stream field and temperature field were coupling recreated. The hour of 3D model of cell body got done with filling measure comprising with real creation of filling were gotten in the wake of utilizing the recreation.

About the product utilized: ProCAST programming is a serious and complete casting measures reproduction device which is the aftereffect of over 20 years of cooperation with major modern accomplices and scholastic foundations everywhere on the world. ProCAST programming, in light of amazing Limited Component Innovation, is appropriate to likewise anticipate twists and leftover burdens and can address more explicit cycles like semi-strong, center blowing, radial, lost froth and ceaseless casting.

3.3 Gating System Design – Calculations

Design Considerations of Gating System

It guarantees that there is satisfactory material accessible considering the volume of the apparent multitude of regions of projecting and fluid shrinkage. Expanding the superheat builds smoothness of the material for the projecting, which can help with its stream into the shape however Increasing the superheat has issues related with it, for example, expanded gas porosity, expanded oxide development, and shape entrance. Since the riser is the supply of liquid material for the projecting it must be last to cement.

As hardening proceeds with the thickness of this skin increments towards the focal point of the fluid mass. Finding areas of the projecting with low V/A proportions further away from the risers will safeguard a smooth hardening of the projecting. When castings solidify, columnar grain structures tend to develop, in the material, pointing towards the center. Because of this nature, sharp corners in the projecting may build up a plane of shortcoming. By adjusting the edges of sharp corners this can be forestalled [6].

Disturbance can be decreased by the plan of a gating framework that advances a more laminar progression of the fluid metal. By making the path short we can keep the metal in its fluid state longer since it will get more warmth move from both the riser and the projecting.

Table -1: Gating system parameters*

Sr.no	Parameter	Values
1	Gating Raito	1:2:1
2	Pouring time	3.27 sec
3	Sprue height	105 mm
4	Sprue Well depth	13.10 mm
5	Sprue Top Diameter	13.10 mm
6	Sprue Bottom Diameter	9.26 mm
7	Runner Width & Length	10.12 mm
8	Riser Diameter	37.35 mm
9	Riser height	46.694 mm
10	Mold height	40 mm
11	Mold Volume	251906.06 mm3
12	Mold Area	42494.54 mm2
13	Filling time	23.7 sec

**Dimensions taken after giving Machining & Shrinkage allowances*

Terms:

W - Weight of Casting,
δ - Density of Metal,
t - Metal Pouring Time,
g - gravity acceleration = 9.81 m/s,
c - efficiency co-efficient for bottom gating
h - total height of casting cavity and riser
C - height of casting cavity
A_c – Choke Area
A_m - mold area
A_g - gate area
h_t - sprue height
h_m - mold height
t_f – Filling time

1. **Pouring Time of Molten metal: - {Steel}**

Pouring Time (T_{p}) = 2.4335 − 0.3953× log W × $(W)^{0.5}$
= 2.4335 − 0.3953× log 2 × $(2)^{0.5}$
= 3.27 sec

2. **Sprue:**

Sprue height h = 105 mm
Height of casting cavity, C = 40 mm
Effective height = h – C/2 = 85 mm
Gating Ratio = 1:2:1

i. Choke area $A_c = W/(dtc\sqrt{2gH})$
= 2.5/(7800*3.27*0.9*√2*9.81*0.085)
= 67.46 mm2

ii. Sprue bottom diameter (Πd'2/4) = A_c
Πd'2/4 = 67.46 mm2
d' = 9.26 mm

iii. Sprue Top diameter = 2*sprue bottom area
Πd'2/4 = 2*67.46 mm2
d'' = 13.1 mm

iv. Sprue Well Calculation:
Sprue Well Area = 2×Chock Area
πd2/4 = 2×67.46 mm2
πd2/4 = 134.92 mm2
d = 13.10 mm
Sprue base well Height (H) = 13.10 mm

3. **Pouring Basin:**

Pouring Basin Height = 105 – 85 mm
= 20 mm

4. **Riser:**

Mold constant c = 0.04 min/mm2 for steels
Casting volume V = 251906.06 mm3
Casting area A = 42494.54 mm2

i. Casting TTS = c(V/A)^2
= 0.04(5.927)2
= *1.4056 min*

ii. Riser TTS = 1.30(1.40)
= *1.82 minSS*

iii. Riser volume V = πD2H/4
= 0.25πD2(1.25D)
= *0.3125πD3*

iv. Riser area A = 2πD2/4 + πDH
= 0.5πD2 + 1.25πD2
= *1.75πD2*

V/A = 0.3125πD3/1.75πD2 = 0.1786D

v. Riser TTS = 0.04(0.1786D)2
= 0.04(0.03189)D2
= 0.5102D2
= 1.82 min

D2 = 1.82/1.2756*10^3
= 4.3316
D = 37.35 mm (Riser Diameter)
H = 1.25(37.35)
H = 46.694 mm (Riser Height)

5. Runner:

Gating Ratio = 1:2:1
$A_r = 2*A_c = 2*67.4 = 134.8$

i. Runner Width = $\sqrt{A_r}$
= 11.06 mm
ii. Runner Length = $\sqrt{A_r}$
= 11.06 mm

6. Filling time:

A_m = 42494.54 mm2 (mold area)
A_g = 524.7 mm2 (gate area)
h_t = 0.105 m (sprue height)
h_m = 0.040 m (mold height)

i.

$$t_f = \frac{A_m}{A_g}\frac{1}{\sqrt{2g}}2(\sqrt{h_t} - \sqrt{h_t - h_m})$$

$t_f = 42494.54*2*[(0.105)^{0.5} - (65)^{0.5}]/[524.7*(2*9.81)^{0.5}]$
= 23.7 sec

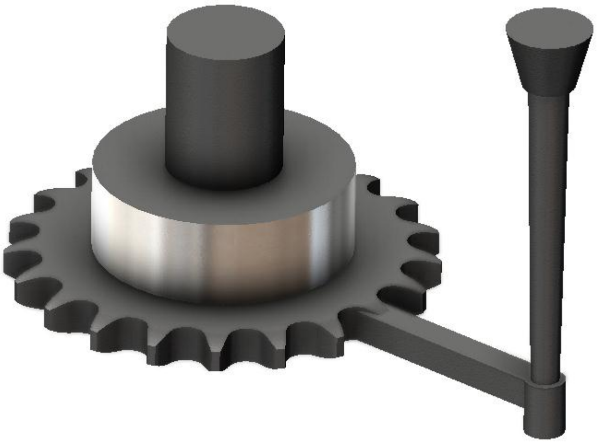
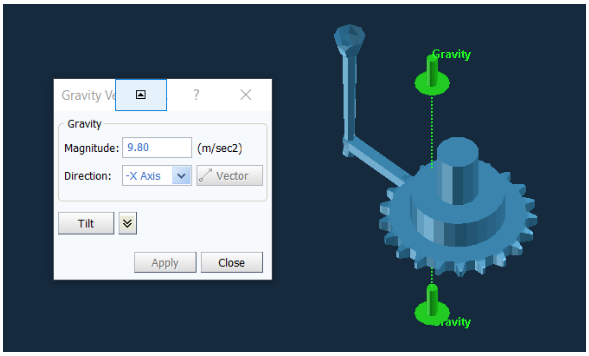


Fig -3: Final Casting (with gating system)

3.4 Steps for Simulation

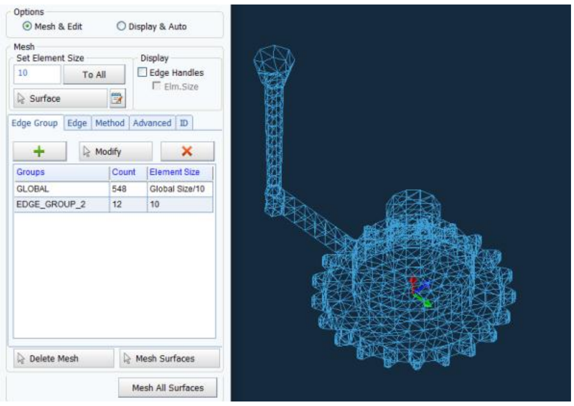
Meshing – Preprocessing



Magnitude: 9.80 (m/sec2)
Direction: -X Axis

Fig -4: Gravity setting (- Xaxis)

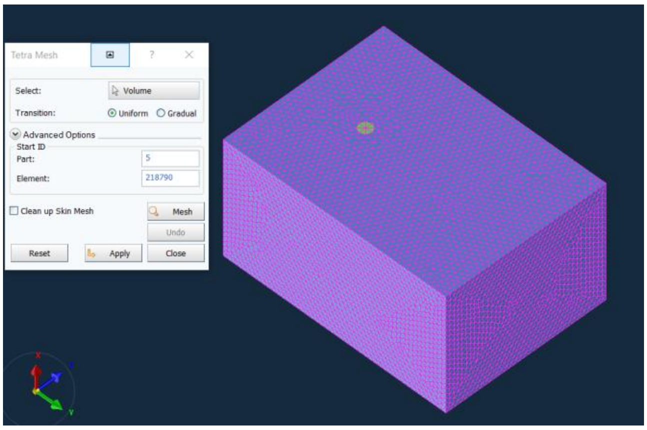
Firstly, Gravity is defined with 9.81 ms-2 in –X axis for liquid metal flow in the mold cavity. Then, a 2D Mesh is given to all surfaces including casting mold cavity and sand mold with element size of10 mm. At last, final Uniform 3D Mesh is given to whole part (mold and Cavity) for further processing.



● Mesh & Edit
Set Element Size: 10 To All
☐ Edge Handles

Groups	Count	Element Size
GLOBAL	548	Global Size/10
EDGE_GROUP_2	12	10

Fig -5: 2D Mesh Settings



Select: Volume
Transition: ● Uniform ○ Gradual
Start ID
Part: 5
Element: 218790
☐ Clean up Skin Mesh

Fig -6: 3D Mesh Settings

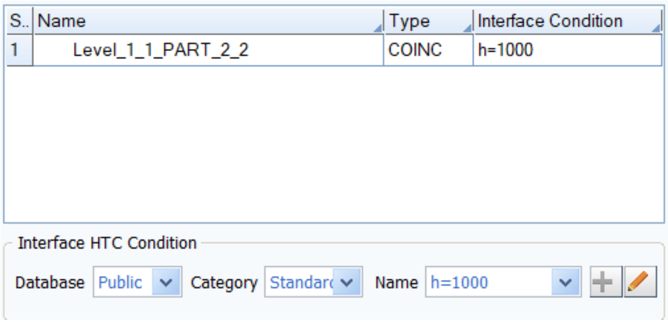
Simulation – Processing

The casting molding process includes the casting filling process and the casting solidification process. The filling process is a process in which a high-temperature fluid gradually fills a casting cavity through a gate, and the solidification process of the casting is essentially a heat exchange process between heats. Heat exchange mainly includes three processes, heat conduction, heat convection and heat radiation.

The simulation of the solidification process includes the heat transfer of the casting and the flask, the thermal convection of the casting and the air, and the thermal radiation of the liquid in the casting.

Gravity filling Boundaries:

1. In HTC Interface Manager - HTC (h=1000) – Coincident between sand (Green sand and Resin bonded sand) and casting material (Medium carbon steel, Stainless Steel and Gray Cast Iron)



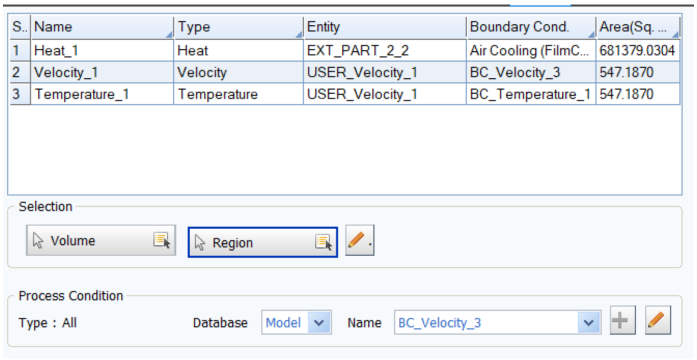
S..	Name	Type	Interface Condition
1	Level_1_1_PART_2_2	COINC	h=1000

Interface HTC Condition

Database: Public
Category: Standard
Name: h=1000

Fig -7: HTC Interface Manager

2. In Process Condition Manager – (i) Temperature of liquid casting material at the inlet surface of the sprue (ii) Velocity at the inlet surface of the sprue – according to fill time (iii) Heat radiation on the mold at air cooling.



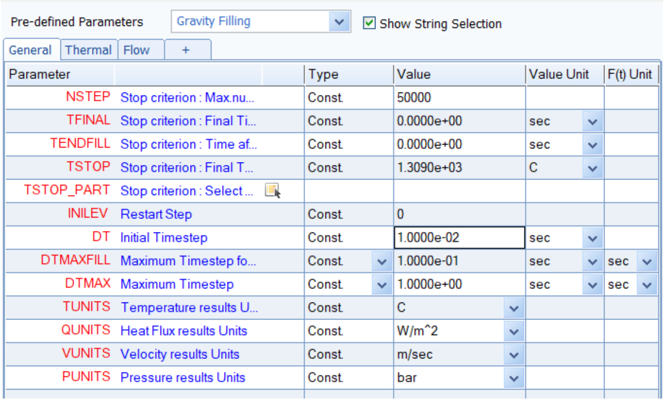
S..	Name	Type	Entity	Boundary Cond.	Area(Sq. ...
1	Heat_1	Heat	EXT_PART_2_2	Air Cooling (FilmC...	681379.0304
2	Velocity_1	Velocity	USER_Velocity_1	BC_Velocity_3	547.1870
3	Temperature_1	Temperature	USER_Velocity_1	BC_Temperature_1	547.1870

Process Condition

Type : All
Database: Model
Name: BC_Velocity_3

Fig -8: Process Condition Manager

3. Simulation Parameters – Gravity filling



Pre-defined Parameters: Gravity Filling
☑ Show String Selection

Parameter		Type	Value	Value Unit	F(t) Unit
NSTEP	Stop criterion : Max.nu...	Const.	50000		
TFINAL	Stop criterion : Final Ti...	Const.	0.0000e+00	sec	
TENDFILL	Stop criterion : Time af...	Const.	0.0000e+00	sec	
TSTOP	Stop criterion : Final T...	Const.	1.3090e+03	C	
TSTOP_PART	Stop criterion : Select ...				
INILEV	Restart Step	Const.	0		
DT	Initial Timestep	Const.	1.0000e-02	sec	
DTMAXFILL	Maximum Timestep fo...	Const.	1.0000e-01	sec	sec
DTMAX	Maximum Timestep	Const.	1.0000e+00	sec	sec
TUNITS	Temperature results U...	Const.	C		
QUNITS	Heat Flux results Units	Const.	W/m^2		
VUNITS	Velocity results Units	Const.	m/sec		
PUNITS	Pressure results Units	Const.	bar		

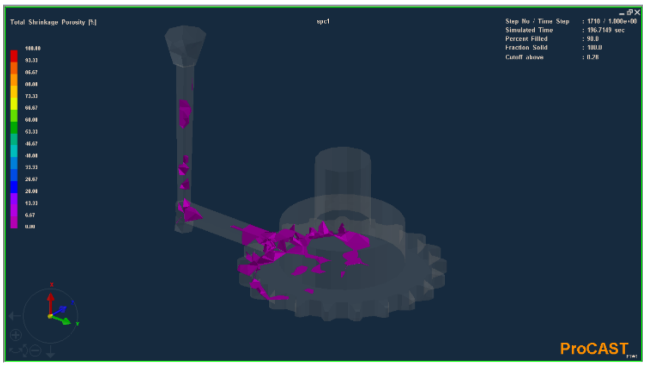
Fig -9: Gravity filling Parameters

4. RESULTS AND DISCUSSION

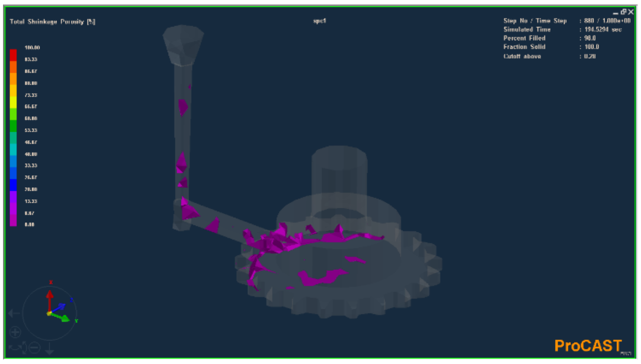
Using aforementioned methodology, the casting is designed and simulation process is used to reduce trials and rejections in the process prior to real life implementation.

4.1 Shrinkage Porosity:

Gray Cast Iron:



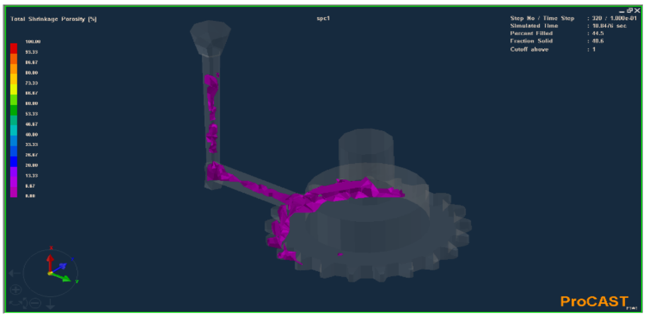
(a)Green Sand Mold



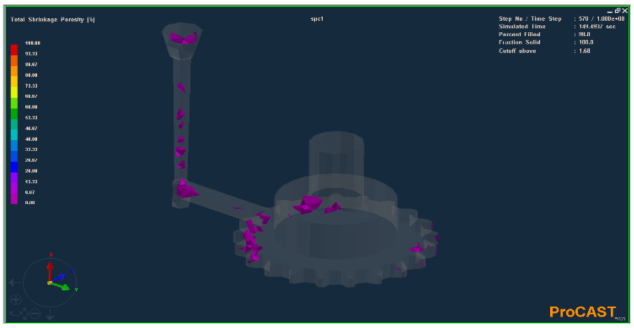
(b)Resin Bonded Sand Mold

Fig -10: Shrinkage Volume in Gray Cast Iron

Medium Carbon Steel:



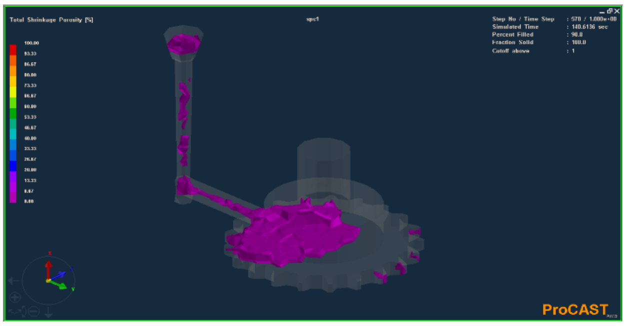
(a)Green Sand Mold



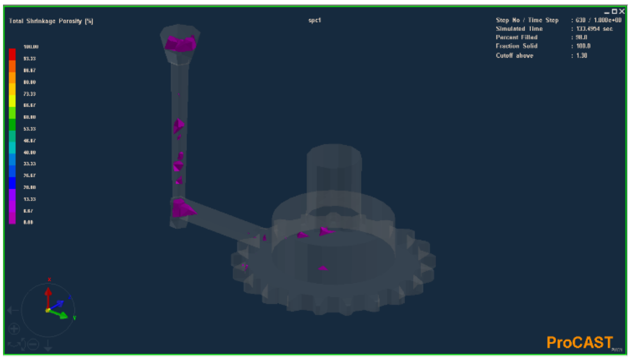
(b)Resin Bonded Sand Mold

Fig -11: Shrinkage Volume in Medium Carbon Steel

Stainless Steel:



(a)Green Sand Mold



(b)Resin Bonded Sand Mold

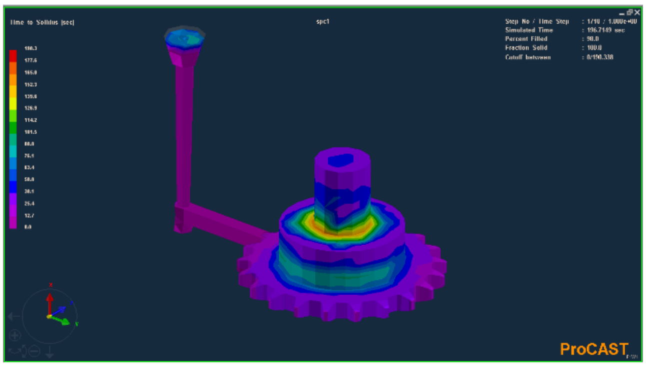
Fig -12: Shrinkage Volume in Stainless Steel

Shrinkage Porosity greatly influences the final quality of the casting. It refers to the dimensional reduction of a metal as it changes from molten to solid state and arises mainly due to insufficient feeding ability. Below pictures show us the percentage of Total Shrinkage Porosity that develop at 98% fill for different mold sands. Solidification shrinkage primarily occurs as the liquid alloy solidifies in a non-uniform pattern and leads to internal porosities. We can observe low percentage of shrinkage in the narrow or tapered sprue which is a result of 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. One more notable observation is that the cast using resin bonded sand as the molding material shows significantly lower level of shrinkage porosity when compared to the same casting setup using Green sand. This is attributed to the smoother and harder surface formed by resin bonded sand that has provides lesser friction to the flow of liquid alloy thus allowing efficient and continuous filling.

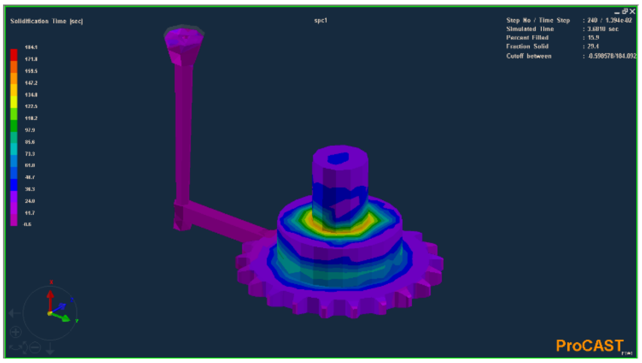
4.2 Solidification Time:

The total solidification time is the time required for the casting to solidify after pouring. It significantly affects the microstructure and thus the mechanical and thermal properties of the cast product to a greater degree.

Gray Cast Iron:



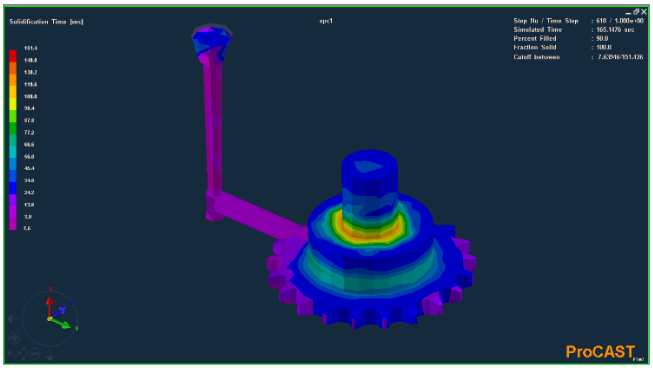
(a)Green Sand Mold



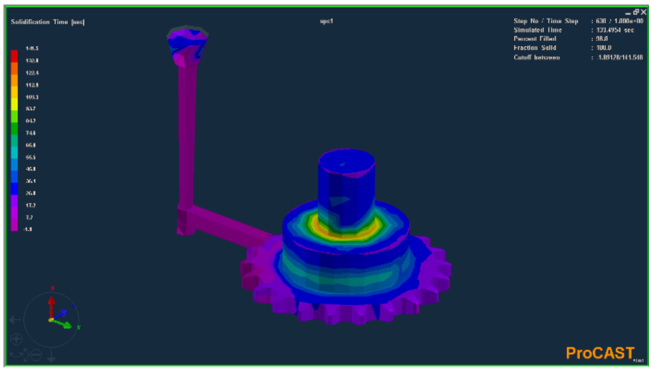
(b)Resin Bonded Sand Mold

Fig -13: Solidification time in Gray Cast Iron

Medium Carbon Steel:



(a)Green Sand Mold

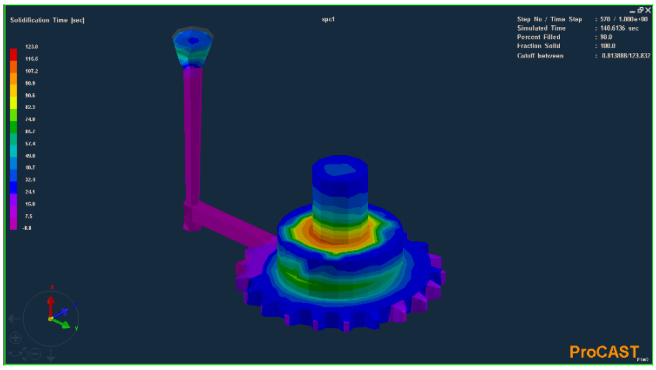


(b)Resin Bonded Sand Mold

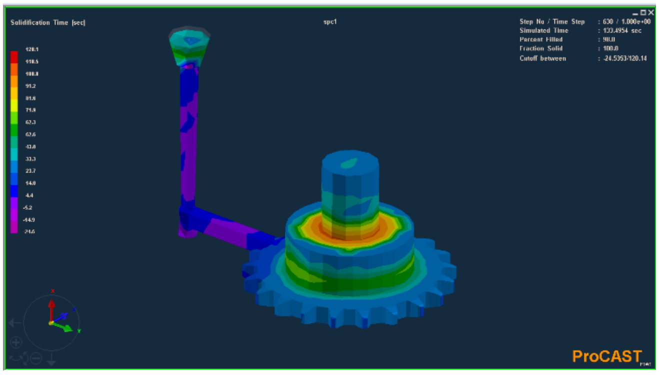
Fig -14: Solidification time in Medium Carbon Steel

It is observed that with an increase in solidification time the pore density goes down and vice versa. Longer the solidification time are detrimental in mass production as they reduced the overall yield per unit time. The parameters that affect the total solidification time include mould wall temperature, heat transfer coefficient at the metal-mould interface, mould wall thickness, material of the mould and so on. This implies that the type of mold sand used in the casting indirectly affects this.

Stainless Steel;



(a)Green Sand Mold



(b)Resin Bonded Sand Mold

Fig -15: Solidification time in Stainless Steel

When compared to a green sand, a resin sand casting mold takes relatively lesser time as it provides better overall heat transfer during casting owing to its better heat dissipation properties. Below shown are contour plots of total solidification time helps the end-user to calculate the cooling characteristics of the mold as well as predict the possible mushy regions during the filling process.

4.3 Niyama Criterion:

Gray Cast Iron:

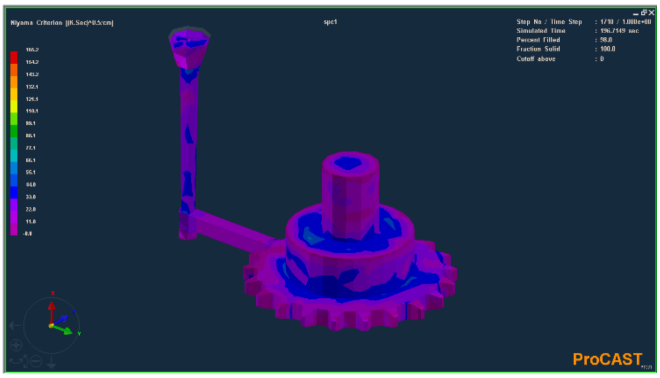


Fig -16: Niyama Criterion in Stainless Steel

Medium Carbon Steel:

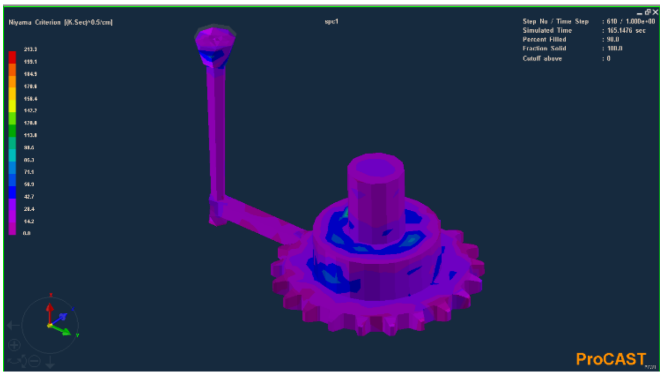


Fig -17: Niyama Criterion in Stainless Steel

Stainless Steel:

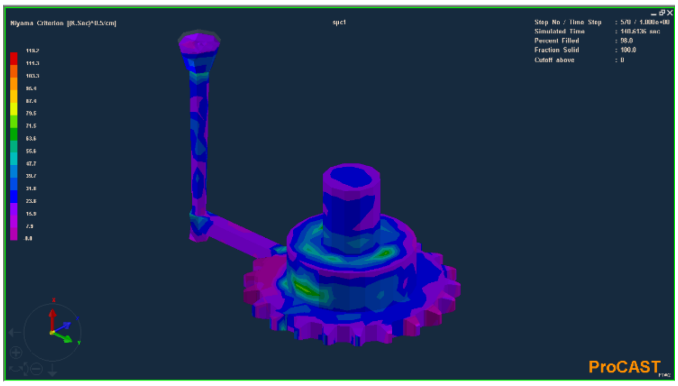


Fig -18: Niyama Criterion in Stainless Steel

The Niyama criterion (Ny), is one of the output parameters that helps identify solidification shrinkage in castings. It is defined as the local thermal gradient divided by the square root of the cooling rate. This parameter is analogically similar to Reynold's number from Fluid Mechanics. However, when the Ny value decreases below a critical value, Ny_{micro}, small amounts of micro-shrinkage start forming. As the value decreases further, a transition occurs at a second critical value, Ny_{macro} at which point macro- porosities start showing. These critical values are material specific in nature and differ with alloy composition. Above shown, are the contour plots of Ny for various materials which helps us validate the mold design and ensure that the shrinkage occurring in the casting is minimum.

4.4 Hotspots:

The solidification of liquid metal in the mould cavity starts immediately after entering into the cavity and does not occur at a uniform rate. Hot spots are sections of casting which have cooled down more rapidly than the surrounding material.

Gray Cast Iron:

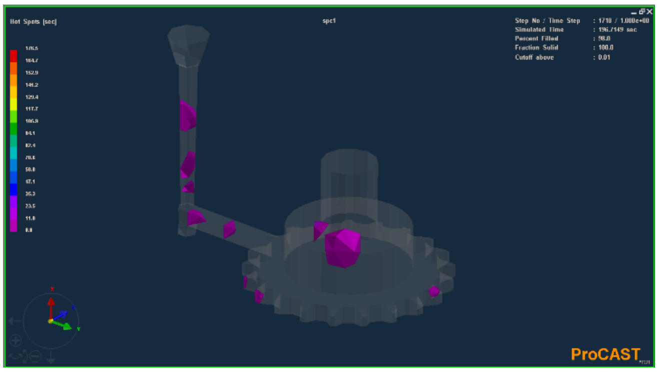


Fig -19: Hotspots in Stainless Steel

Medium Carbon Steel:

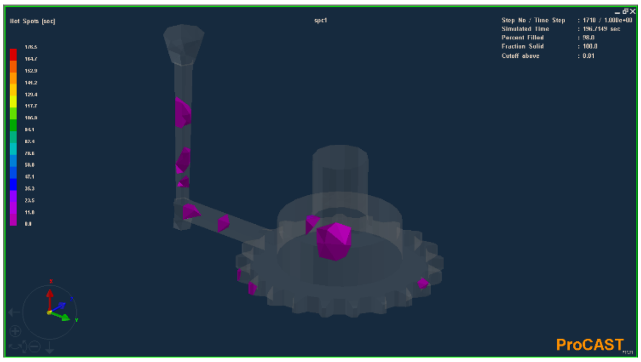


Fig -20: Hotspots in Stainless Steel

Stainless Steel:

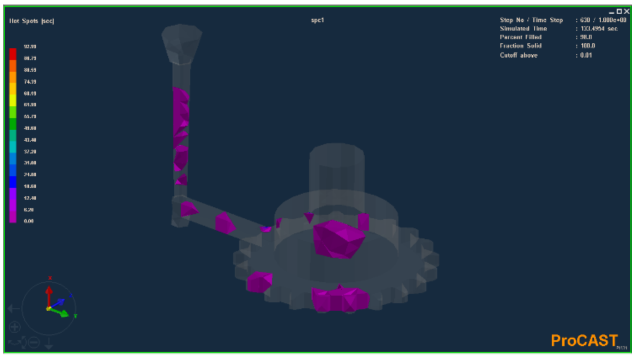


Fig -21: Hotspots in Stainless Steel

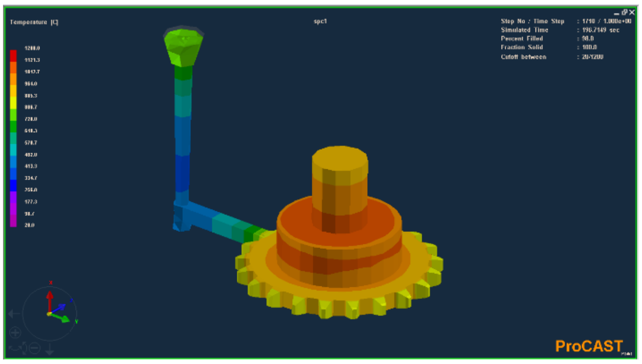
This leads to formation of relatively harder spots in places having low surface to volume ratio in the geometry. These hard spots interfere during machining and increases tool wear. It is mainly influenced by chemical composition of the material as well as effective cooling level of the cast. With the help of VisualCAST, we can see predict and visualize the locations of such hard spots, helping the end-user in determining the most suitable set of machining operations to be selected.

4.5 Temperature:

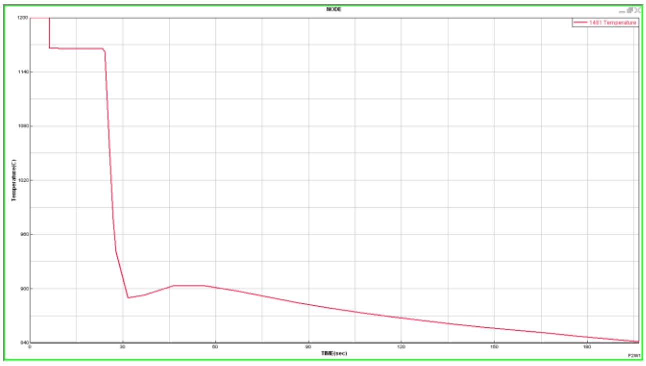
When the flow of metal into the mould cavity becomes steady, the temperature transition becomes steady. This simulation result conforms to actual situation because the fluid is the carrier of temperature and the change of temperature field is decided by the change of flow field.

The phase changes from liquid state to solid state gradually with the decrease of temperature, in which a lot of physical and surrounding parameter play an important role for the casting quality. Temperature distribution of sprocket component with respect to time is shown in figure.

Gray Cast Iron:



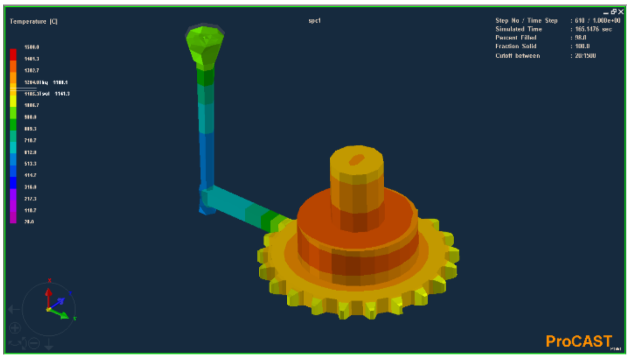
(a) Temperature contour



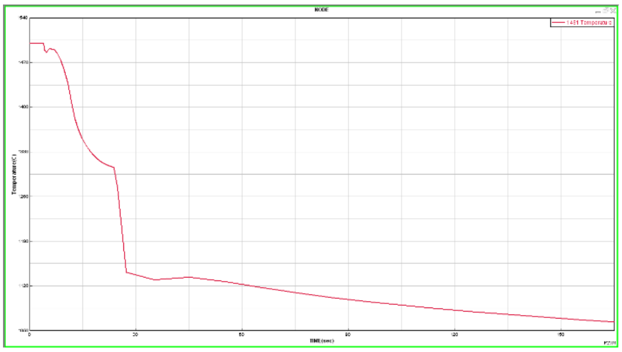
(b) Temperature vs Time graph
Fig -22: Temperature in Stainless Steel

It can be found that, after liquid metal has entered the bottom of cavity, the transfer direction of temperature is in keeping with flow direction of liquid metal and they are all transferred placidly from center to all around. The warming rate at the intersection of two walls is faster than other locations of model. When observed comprehensively, the temperature changes intensively in during the seconds of the whole filling process, with the filling process gradually becoming stable. Temperature changes will also become stable.

Medium Carbon Steel:

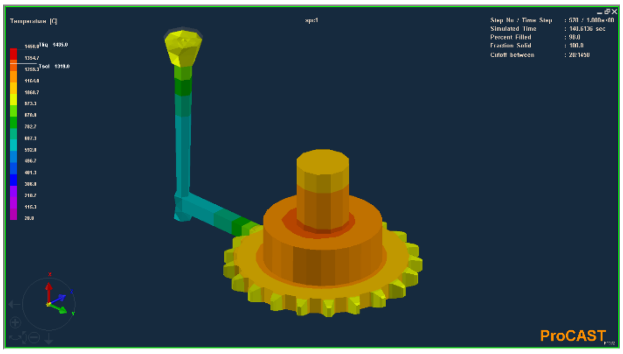


(a) Temperature contour

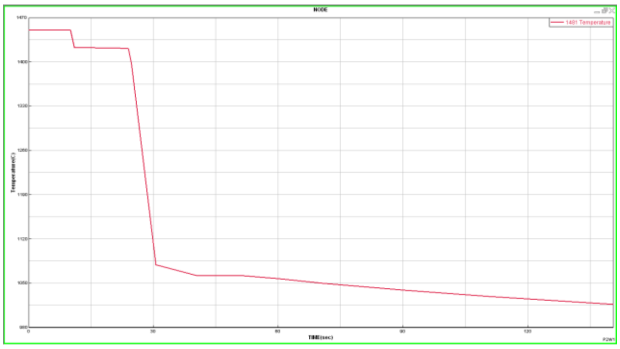


(b) Temperature vs Time graph
Fig -23: Temperature in Stainless Steel

Stainless Steel:



(a) Temperature contour



(b) Temperature vs Time graph
Fig -24: Temperature in Stainless Steel

5. SUMMARY AND CONCLUSION

According to the Sprocket Simulation for flow field and temperature field of 3D model in casting filling process, visual simulation of casting process can be made well, especially for the accuracy and the visibility of the change of liquid metal free surface by using ProCAST software. Due to the fluid is the carrier of temperature, the change of temperature field is decided by the change of flow field. The results of ProCAST simulation show that, solidification process and flow distribution identification of velocity vector in the early stage of filling process, the liquid level is volatile, especially when Liquid metal first contact with the wall of mold.

After filling enters the stable stage, the speed slows down and liquid level rises reposefully. The probability of defects caused by strong turbulent is decreased. Utilization of Resin bonded Sand brings about expanded surface quality when contrasted with other sand-casting choice sand the idea of sap sand casting can help lessen imperfections, for example, sand openings, air gaps, and shrinkage.

Table -2: Simulation Results

Sr. No	**Mold Material**	**Casting Material**	**Total Solidification Time (sec)**	**Shrinkage Porosity (%)**	**Niyama Criterion *(k.sec)^0.5/cm***	**Hotspots (%)**
1.	Green Sand	Gray Cast Iron	188.5	6.67	11-22	~11
2.		Carbon Steel	151.4	8	14.2-28.4	~3.7
3.		Stainless Steel	141.5	13.3	7.9-15.9	~3.5
4.	Resin Bonded Sand	Gray Cast Iron	184.1	5.6	11-22	~9.5
5.		Carbon Steel	120.1	6.67	14.2-28.4	~3.1
6.		Stainless Steel	123.8	8	7.9-15.9	~2.5

For Gray cast Iron, Resin bonded sand has 2.39 % less Solidification time than that of Green sand. Similarly, for Carbon Steel and Stainless Steel, Resin bonded Sand has 20.67 % and 12.50 % more cooling than that of green sand respectively.

It is observed that Resin bonded sand has more cooling than that of green sand with the same heat transfer coefficient. Also, there are less % locations of hotspots in resin bonded sand according to niyama criterion contours which results in lower shrinkage porosity. The best suitable materials for sprocket are Carbon Steel and Stainless Steel. It offers improved weldability and usefulness at high temperatures and metallurgical adaptability.

6. FUTURE SCOPE

Any simulation performed for any engineering application is just a colorful diagram without concrete experimental evidence. We had also planned through rapid prototyping, to create a pattern and make an entire cast of a Sprocket with all its accessories. This is the reason we designed a sand casting mould, so we could compare the theoretical data obtained from simulations with concrete experimental data obtained through real-time casting, hence establishing a relation between simulation model and physical real-world field variables and thereby examining their accuracy.

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