Design and Optimization of Gating System for TVS SATELITE

B. S. Shingate[1], Dr. S.V. Patil[2], Mr. N. B. Chaurasiya[3]

[1] Research Scholar ME student, Department of Mechanical Engineering, STES's RMD Sinhgad School of Engineering, Pune, Maharashtra, India
[2] Professor, Department of Mechanical Engineering, STES's RMD Sinhgad School of Engineering, Pune, Maharashtra, India
[3] Design and Development Department, Mutha Engineering Pvt. Ltd. Satara.

ABSTRACT

Abandon free Casting is the fundamental go for foundry industry. To accomplish this; foundry does numbers of shop trials to kill deformity. This takes part of time to plan legitimate framework. For better throwing; gating framework assumes an imperative part. The principle capacity of gating framework is to give nonstop stream of liquid metal upto the kick the bucket pits. Throwing recreation programming's have facilitated the outlining of legitimate gating framework. In throwing process different number of shapes and sizes of various segments are threw for that a legitimate planning of gating framework is essential. This incorporates outlining of runners, risers, doors, sprue, and so on. In this work AUTOCAST-X programming has been utilized which is a simple to utilize program, in view of vector component strategy for recreation to foresee shrinkages and gas porosity effortlessly. An all-around outlined runner and gating framework is critical to deliver great quality kick the bucket castings by giving a homogenous mold filling design. Stream investigation of the part is done keeping in mind the end goal to unmistakably break down the pit filling process. In this study, a TVS SATELITE, item was picked. The target of this work is to speak to TVS SATELITE throwing outline and its reenactment utilizing AUTOCAST-X programming. At first when the segment was gave various absconds such a role as Cold close, Misrun, Shrinkage porosity and Gas porosity were found. This thus prompted dismissal of number of parts. Keeping in mind the end goal to enhance the nature of the castings created, the gating framework outline was transformed from the current door to changed entryway. The segment was planned utilizing AUTOCAST-X Software. The procedure parameters like metal temperature, fill speed and filling time are considered for improving the procedure. The throwing got after cementing will be acknowledged and went before to creation. Since we outline and streamline the gating framework for TVS SATELITE.

Keywords *- TVS SATELITE, AUTOCAST-X Software, Shrinkage, Simulation, Gating System, Casting Defects..*

1. INTRODUCTION

In throwing process, gating framework assumes a critical part to create a superb throwing. An inadequately planned gating framework results in throwing deformities. A gating framework controls mold filling process. The fundamental capacity of gating framework is to lead clean liquid metal from spoon to the throwing hole guaranteeing smooth, uniform and finish filling. Henceforth to plan a decent gating framework one must know the conduct of liquid stream amid mold filling process. In vehicles commercial enterprises numerous parts utilized are of various shapes and they are hard to fabricate so the throwing procedure is constantly utilized as a part of the assembling of the car items. Throwing is an extremely flexible procedure and equipped for being utilized as a part of large scale manufacturing. Foundry is mother industry. In throwing process bunches of examination has been done in foundry innovation, however yet experimentation technique utilized for planning the gating framework, it is tedious and immoderate procedure, so the material use, vitality use, and different assets use is exceptionally troublesome in foundry commercial enterprises. Numerous basic shapes are made in foundry by throwing process, on account of basic shapes present numerous imperfections emerge in throwing while directional cementing. Indeed, even in a totally controlled procedure, deformities are discovered. So for the great directional hardening appropriate outlining of gating framework is essential to give metal in fluid structure to the throwing depression. The gating

NOMENCLATURE

G: Liquid metal per mould (kg)
T: Pouring time (sec)
ξ: Velocity Factor
hst: Ferrostatic Head (cm)
σ: Density of liquid metal (kg / $cm^{3)}$
hsp: Height of sprue above ingate (cm)
b: Height of casting above ingate (cm)
c: Total height of casting(cm)

framework ought to be outlined appropriately in light of the fact that larger than usual gating framework prompts lower yield of the throwing. Mold filling is an unpredictable wonder, affecting both inner and outside quality. The stream of liquid metal in the wake of being poured is a transient wonders joined by turbulence, detachment of the stream from the limits, isolating and consolidated stream at the intersection, synchronous warmth exchange amid the stream and onset of hardening. Additionally dissolve properties like thickness, consistency and surface pressure are ceaselessly changing amid the stream. This together makes the filling investigation entirely mind boggling. An upgraded gating plan fulfilling this whole prerequisite is acquired by experimentation through experimentation techniques for a given throwing geometry. Be that as it may, this technique takes quite a while to get the idseal measurements of the gating channels furthermore adds expense to the organization. Another methodology is to shape the scientific model that speaks to the real form filling process, with the goal that we can anticipate the outcomes ahead of time before delivering genuine throwing. This numerical model is then executed in an appropriate streamlining calculation which improves the procedure parameters alongside fulfilling all the procedure requirements. Consequently physical trial is supplanted by numerical examination by this strategy. This procedure spares time by applying an exact and exact numerical streamlining system. Research work distributed on improvement of gating framework suggests augmenting the yield, minimizing the ingate speed of liquid metal, advancing the ingate area and minimizing warpage. Be that as it may, nobody seems to have concentrated on amplifying the filling rate of liquid metal. So to deliver a throwing that is free from the pouring related surrenders and has ideal gating measurements in view of filling rate, there is a need to build up a technique that streamlines the gating measurements considering the limitations of pouring related imperfections.

2. LITERATURE REVIEW

Following literature review is carried out for the basic study regarding gating system design before doing actual gating design for a product TVS SATELITE.

C. M. Choudhari , B. E. Narkhede, S. K. Mahajan, [1] In this study, they showingcomponenthaving shrinkage porosity defect leading to failure. Also due to sudden variation in thickness it was subjected to incomplete filling. Then they redesign and redevelop the component by providing sufficient draft and radius at the junction of Component geometry. Their work has been made to carry out the entire methoding, simulation and optimization in AutoCAST X software which is based on Vector Gradient Method (VGM). Then it is observed thatentire shrinkage porosity should get shifted in the feeder by setting all the design parameters in numerical simulation software. This gives significant improvement in the quality of casting. When they compared their workwith the experimental trial simulation, the results were found in good agreement.

B. VijayaRamnatha, C.Elanchezhiana, Vishal Chandrasekhar, A. Arun Kumar, S. Mohamed Asif, G. Riyaz Mohamed, D. VinodhRaj ,C .Suresh Kumar, [2] In this study, a Commutator End (CE) bracket, a cold chamber die casted product was chosen. Initially when the component was casted they analyzed various defects such as Cold shuts, Misrun, Shrinkage porosity and Gas porosity. The results of their design give rejection of number of components. Then they changed the gating system from the existing flat gate to modified spoon fed gate in order to improve the quality of the castings produced. They designed component using Pro- Engineer and flow analysis was carried out using Rotork Flow 3D Software. They consider process parameters like metal temperature; fill velocity and filling time for optimizing the process. Quality assessment for the die casting parts was made by microstructure analysis.

C. M. Choudhari, B. E. Narkhede, S. K. Mahajan, [3] In this paper, theyredesign and develop a casting free from defects, in particular, shrinkage defect. Theytakencomponent for simulation study was subjected to shrinkage defects. And which was the major cause for the rejection in the foundry. The component under their study consists of square shaped (at top) plate having three perforations with diminishing height (at bottom) and subjected to multiple hot spot. When they carried out various simulation trialsoptimum location of feeder has been identified. Proper feeding has helped in shifting the hot spot completely inside the feeder. And hence improvement of the

feedability index which represents yield of feeders and quality of casting. Then they compare simulationresults with the experimental trial and the comparison was found to be correct.

Uday A. Dabade and Rahul C. Bhedasgaonkar, [4] In this paper they combined design of experiments and computer assisted casting simulation techniques. That combination was made to analyze the sand related defects in green sand casting. They selected ductile iron cast component and an attempt has been made to obtain the optimal settings of the molding sand and mould related process parameters of green sand casting process. They considered green sand related process parameters like moisture content, compression strength, and permeability of molding sand and mould hardness. In first part of this paper Taguchi based L18 orthogonal array was used for the experimental purpose and analysis was carried out using Minitab software for analysis of variance (ANOVA) and analysis of mean (AOM) plot. ANOVA results indicate that the selected process parameters significantly affect the casting defects and rejection percentage. Then in the second part, they performed shrinkage porosity analysis using casting simulation technique by introduction of a new gating system designed, solid model developed for four cavities mould. Then they take number of iterations using casting simulation software for mould filling and solidification analysis to reduce the level and intensities of shrinkage porosities in cast component. The result shows reduction in shrinkage porosity (about 15%) and improvement in yield (about 5%) with new gating and feeding system design.

Utkarsh S. Khadeand Suresh M. Sawan, [5] In this paper they analyzed and studied casting of brake disc. This work has been made to solve the problem of lower casting yield due to over designed gating system components. To overcome this problem they redesigned gating system. They made various 3D CAD models of that designs and designed gating systems for the casting and simulated using simulation program Autocast-X flow plus. After analyzing the simulation results, they get results which are not agreed, then they made changes in that design and 3D CAD model and simulated again, they repeated that procedure until the desired results are obtained so as it will give the sound quality casting with the higher casting yield, profit and productivity.

Swaroop S. Magdum, Baliram R. Jadhav, [6] In this work they shows the development of the casting processes simulation techniques used in the AutoCAST simulation software. In the simulation technique they designed gating systemnumerically and by that dimensions theydrawn 3D model of the gating and cavity, that model is used for virtual casting in that process by that simulation technique trial and error method, the optimized gating system was finalized. After that they implementedfinalized designed gating system on the pattern for simulation process and taken the sample casting to validate the result of the simulation technique. So they overcome wastage caused due to trail and error by using this technique and optimization of quality implies lower production cost and higher yield.

M. Di Foggiaa, D.M. D'Addona, [7] This paper is focused on the description of investment casting process and its key parameters in order to give a quite detailed knowledge of the main indicators of this manufacture method, for its nature prone to have high costs of rework or scrap. It provides a brief description of EuropeaMicrofusioniAerospaziali and a simple, schematic flow of the main processes; afterwards the main processes are discussed in more detailed manner with their manufacturing methods and product specifications. These are indispensable preconditions to introduce the discussion on the critical parameters for investment castin g process.

Literature study helps in designing the proper gating system. All the papers give information related to gating design and various trends and innovations in foundry industry.

3. GATING DESIGN

1. **Design of Gating System**

   Casting can create intricate shapes with both external and internal shapes Casting process consists of following steps:

   a) Mold preparation
   b) Melt metal
   c) Solidification
   d) Finishing

   Design of gating system includes following parameters:

   a) Type of gating system used (top, parting, vertical, bottom)
   b) Position of gates and runner.

c) Design of riser and sprue and there position.
d) Gating ratio.
e) Pouring time, pouring temperature, pouring rate selection.
f) Layout of gating channel.

Goals of gating system

a) To avoid trapping gasses in to the mold.
b) To avoid shrinkage.
c) System to trap nonmetallic inclusions.
d) To provide enough metal to mold cavity before solidification starts.

The main objective of gating system is to allow clean, uniform flow of metal through mold without any turbulence.

Gates Important points:

a) Discharge level is highest in gates farther to sprue and reduces around nearer gates. [Johnson]
b) Ratio of flow rates depend upon gate to runner area ratios and discharge coefficient ratios. This implies that flow ratios are independent of distance between gates, length of runner between the gates. [Berger and Locke]
c) For correct location and cross sectional area of each flow through each gate should be predicted properly.[Dr. B. Ravi]

Function of gating system

1. Economy of size
2. The filling of mould at the required speed for most castings, this roughly equals 0.5m/s
3. The delivery of only liquid metal into the mould cavity no other phases such as slag, oxide, sand, air or other gases
4. The elimination of surface turbulence
5. Establish proper temperature gradient
6. Ease of removal

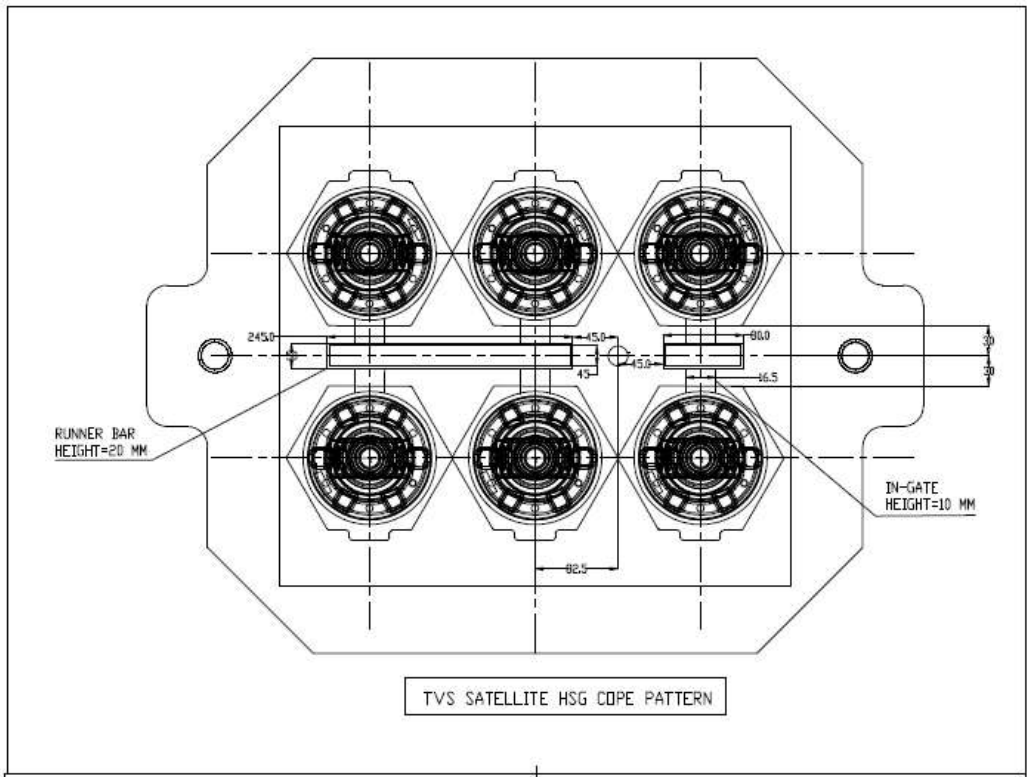

Fig. 1 TVS SATELITE Cope Pattern

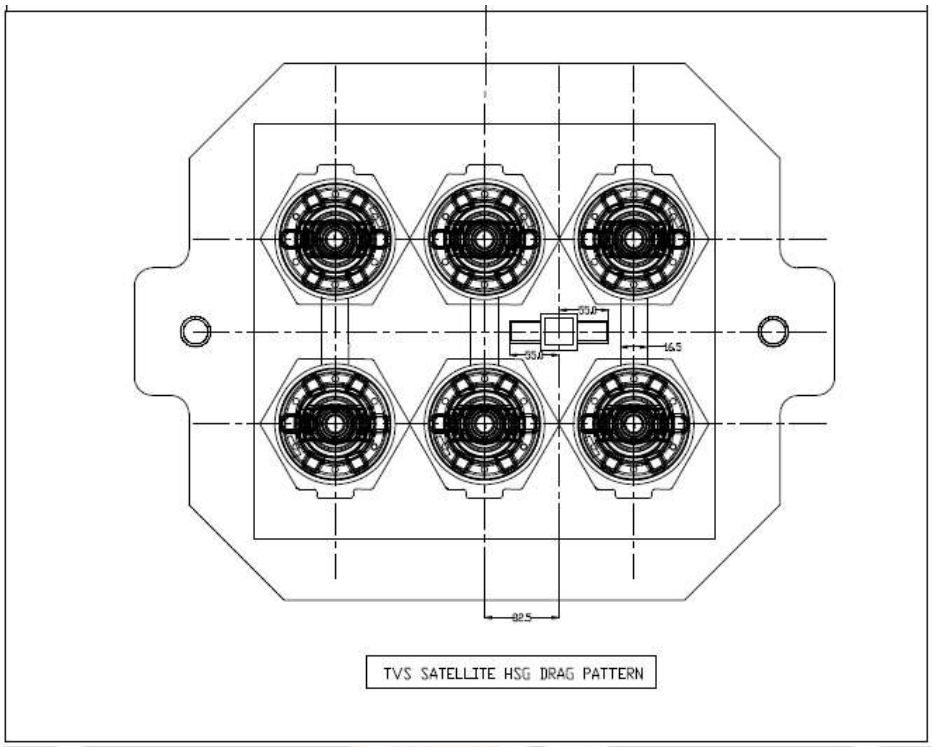

Fig. 2 TVS SATELITE Drag Pattern

Figurw 1 and 2 shows 2D drawing of TVS SATELITE cope and drag pattern this was primary need of casting simulation software. A 2D drawing is saved in stl. format and implanted in AUTOCAST-X flow plus software to perform simulation analysis.

2. Design Calculatios

Design of gating system includes design of sprue, runner and ingate mainly. There are total 12 die cavities in one mould box. Main purpose of gating system is to lead clean molten metal without turbulence upto the die cavities.
Casting: TVS SATELITE. It is sand casting process having cast material as cast iron – CI 4.0 CE.
Weight of casting = 1.2 kg / pc , No. of castings / mould = 12, Total weight of casting = 1.2 × 12 = 14.40 kg, Liquid metal / Mould = 21.60 kg, Velocity factor = 0.40
Gating Design:-
Liquid metal per mould (G) = 1.5 × Total casting weight
= 21.60 kg
Pouring time (t) = $0.9 \times \sqrt{2} \times G = 5.92$ Sec Say 6 Sec.
Velocity Factor (ξ) = 0.40 assumed

Ferrostatic Head $hst = hsp - \frac{b^2}{2c}$
Where,
hsp = height of sprue above ingate = 17.78cm
b = height of casting above ingate = 7.30 cm
c = Total height of casting = 7.30 cm
hst =14.13cm
Density of liquid metal (σ) = 6.8 kg / cm^3
Total ingate area =

$$\frac{22.6 \times G}{\sigma \times t \times \xi \times \sqrt{hst}}$$

= 80.712 cm^2

Down sprue area = 807.12 mm^2
Taking Gating Ratio = 1:1.2:2 we get,
807.12:968.54:1614.24
Down sprue area = 807.12 mm^2
Runner Area = 968.54 mm^2
Ingate Area = 1614.24 mm^2
The above design calculations gives solidified casting with shrinkage defect. In initial design there is a presence of risers and ingate having rectangular cross-sectional area.

Table -1: Comparison between designs of the Existing and modified gating system

Design Parameters	**Existing Design**	**Modified Design**
Height of sprue above ingate	17.18 cm	12.70 cm
Height of casting above ingate	7.30 cm	7.30 cm
Total height of casting	7.30 cm	7.30 cm
HST	14.13 mm	9.05 cm
Down sprue area	807.12 mm^2	1008.52 mm^2
Down sprue radius	16.03 mm	17.92 mm
down sprue dia.	32.07 mm	35.84 mm
Runner Area	968.54 mm^2	1008.52 mm^2
Ingate Area	1614.24 mm^2	2017.04 mm^2
Ingate height	5.00 mm	5.00 mm
Ingate Width	26.90 mm	33.62 mm

Table-2 Comparison between various parameters

Gating	Gating Ratio	Bunch Weight (kg)	
Existing	1:1:2:2	26.20	INACCURATE
Modified	1:1:2	21.44	ACCEPTABLE

Hence by changing height of sprue above ingate as shown in table-1 from 17.18cm to 12.70cm we can increase the total ingate area from 1614.24mm^2 to 2027.04mm^2

Fig. 3 Initial Gating Design

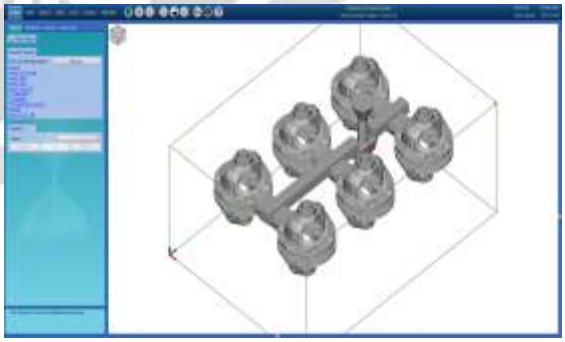

Fig. 4 Modified Gating Design

As per the foundry requirement the mould box is of dimensions 388 mm X 540 mm X 274.2 mm. Green sand has been used as a mold material. The casting process used is sand casting. There are XII numbers of cavities present in the mold box. And hence gating is designed in such a way to fill all mold cavities continuously without any delay in the filling.

2. SIMULATION ANALYSIS

Flow simulation of modified gating system

By performing simulation analysis on software AUTOCAST-X flow plus the obtained results are shown by following figures. This shows flow of molten metal upto the cavities without turbulence.

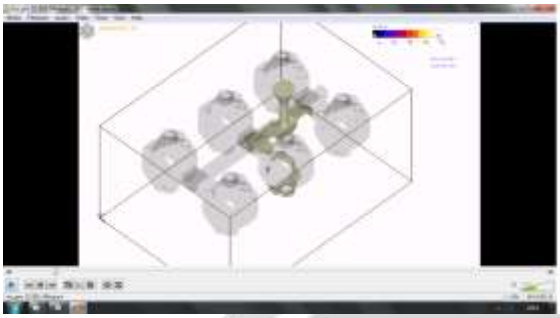

Fig. 5 5% Filling of Casting Cavity

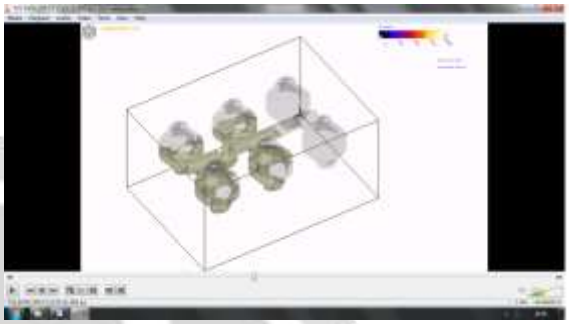

Fig. 6 25% Filling of Casting Cavity

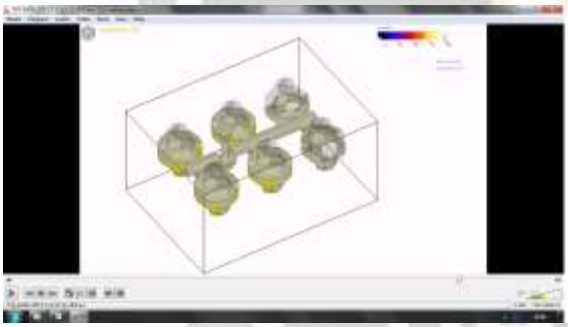

Fig. 7 98% Filling of Casting Cavity

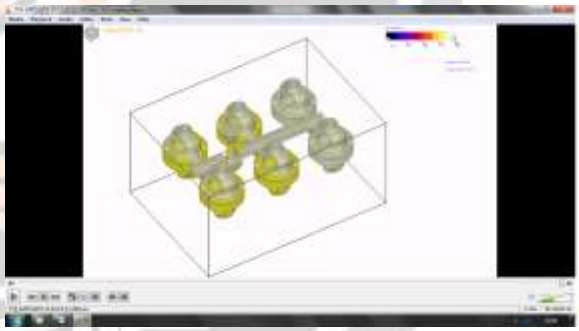

Fig. 8 100% Filling of Casting Cavity

Optimization done by using simulation software AUTOCAST-X flow plus by implanting modified design of gating system.

Main results obtained by using simulation software are total solidification, air fraction, liquid fraction, and flow of molten metal through the cavities.

After getting simulation results right the actual production was done to represent casting of TVS SATELITE. Results of air fraction and liquid fraction are shown in following figures from 9 to 15.

The figure 15 shows images final solidified defect free casting of TVS SATELITE. Hence we design and optimized the gating system for TVS SATELITE.

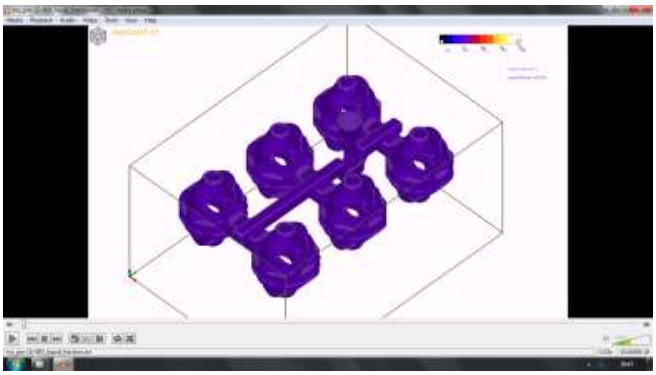

Fig. 9 97.87% of Liquid Fraction

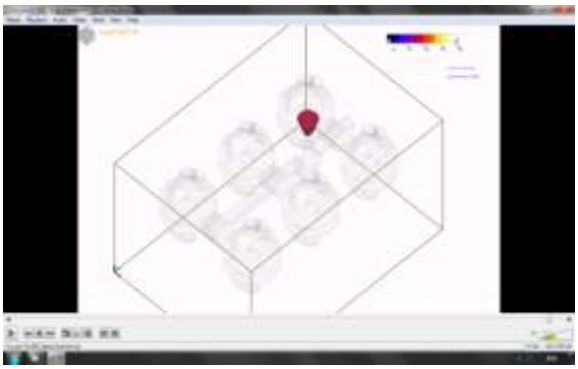

Fig. 10 0.95% of liquid fraction

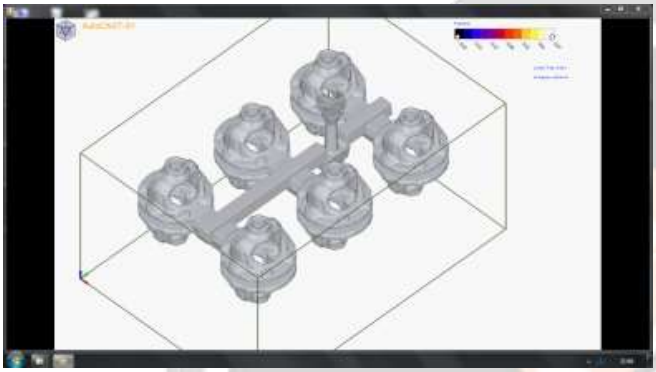

Fig. 11 99% of Air Fraction

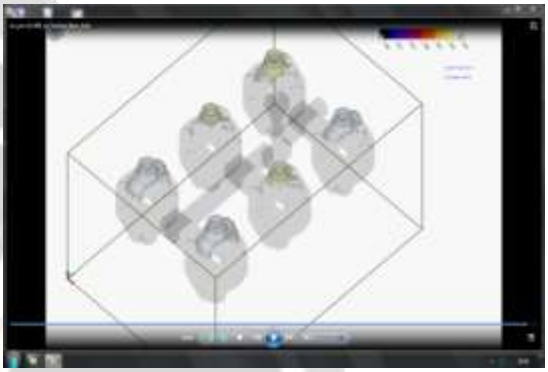

Fig. 12 5% of Air Fraction

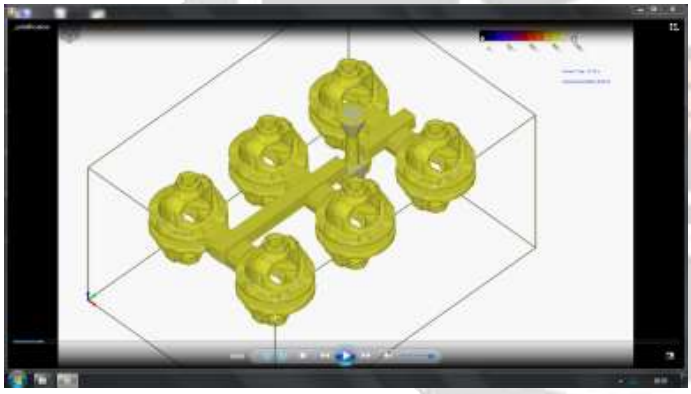

Fig. 13 5% of Solidification

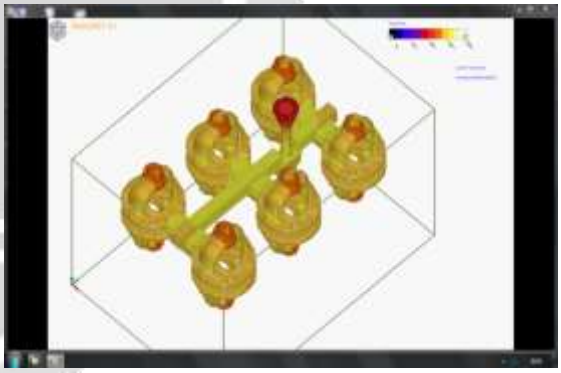

Fig. 14 99% of Solidification

Fig. 15 Final Accepted Defect Free Casting of TVSSATELITE

5. CONCLUSIONS

The work managed recreation and outline of gating framework because of which different throwing deformities are diminished and that was our goal. At first part TVS Satelite was chosen. At the point when segment was tried shrinkage imperfections was examined. This was because of dishonorable gating framework. It prompted uneven and turbulent filling in the bite the dust depressions. Also, this outcomes in diminishment in quality and expansion in dismissal rates. Another gating was planned and by supplanting introductory gating with changed gating the liquid metal streams into the bite the dust pit with uniform filling and inside less time. Thus it results in less time working with minimizing all throwing deformities with expansion underway with no loss of material, machine and labor. The proposed yield in existing configuration of gating framework is around 45%. What's more, with changed gating framework yield gets to be 60 to 70%.

I. Hence casting of TVS SATELITE was obtained by proper designing of gating system.
II. This results in decrease in rejection and improvement in production.
III. A proper gating system design with the help of casting simulation software helps to eliminate defects at large.

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