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Casting simulation of valve body using ADSTEFAN simulation software

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***Abstract:**In this current scenario of globalization, foundries play a key role for manufacturing industries as they are the major source of castings. More than 90% of all manufactured goods & capital equipment use casting for their manufacture. This paper aims to reduce/eliminate the casting defects in valve body by design optimization of gating and risering system by replacing existing trial and error casting method with the help of CAD modeling and simulation software. In this paper modeling of valve body was done in NX CAD V9 (UG) and ADSTEFAN used as a simulation software.*

***Keywords –**Casting Simulation; Gating Design Optimization; Shrinkage; Fluid flow and Solidification and Valve body.*

I. Introduction

Casting is a manufacturing process by which a liquid material is usually poured into a mould, which contains a hollow cavity of the desired shape, and then allowed to solidify. The solidified part is also known as a casting, which is ejected or broken out of the mould to complete the process. Metal casting is probably the method of shaping metals. The art of foundry is as ancient as the dawn of the civilization. Manufacturing of sound casting is the main aim for foundry men. To achieve this number of trial casting has carried out on the shop floor and one repetition can take up a week or more, which affects the regular production. Casting rejections are of a major concern in the foundry industry. Great saving of materials, energy and time can be achieved, if casting design can be corrected prior to moulding on the basis of defects prediction [1,2].Many researchers reported that about 90% of the defects in castings are due to wrong design of gating and risering system and only 10% due to manufacturing problems. Casting defects result in increased unit cost and lower morale of shop floor personnel. The defects need to be diagnosed correctly for appropriate remedial measures; otherwise new defects may be introduced. Casting simulation process can able to overcome these problems. One of the common defects which occur in casting is shrinkage porosity. It cannot be avoided but can be controlled. As practice last solidifying are generally removed following the directional solidification. These parts, which are removed, can be feeder and gating system. Hence it becomes necessary to find their optimum shape and size so the casting should be free from the shrinkage defects. Applying the conventional iterative approach of carrying out casting trials is time consuming and expensive whereas simulation based approach is most effective in this scenario.

Foundry industry suffers from poor quality and productivity due to the large number of process parameters, combined with lowerpenetration of manufacturing automation and shortage of skilled workers compared to other industries. Global buyers demanddefect-free castings and strict delivery schedule, which foundries are finding it very difficult to meet. Casting defects

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result inincreased unit cost and lower morale of shop floor personnel. The defects need to be diagnosed correctly for appropriate remedialmeasures; otherwise new defects may be introduced. Unfortunately, this is not an easy task, since casting process involves complexinteractions among various parameters and operations related to metal composition, methods design, molding, melting, pouring, shake-out, fettling and machining. For example, if shrinkage porosity is identified as gas porosity, and the pouring temperature islowered to reduce the same, it may lead to another defect, namely cold shut [3].

From realistic considerations the experimental results are always better for design and development of mould and for arriving at the optimum process parameters.However it is costly, time consuming and may be impossible in some cases. Therefore casting simulation process is a convenient way of proper design of risering system and analyzing the effect of various parameters. There are number of casting simulation software are developed and are used in foundry worldwide. The application of casting simulation software's are also increasing day to day in Indian foundry as it essentially replaces or minimizes the shop floor trials to achieve the desired internal quality at the highest possible time. The shop floor iterations can be significantly reduced and will be primarily used for concept validation. Many dedicated casting simulation software's are available today- MAGMASOFT, ProCAST, SolidCAST, and AutoCAST.

II. LITERATURE REVIEW

There were lot of research work had been done on casting simulation by using different casting simulation software

ManjunathSwamy H M [4] investigated on conventional gating design casting defects such as shrinkage and gas porosities were found in front axle housing a critical automotive component. This component is generally made out of spheroid graphite iron. A flawed gating system was found to be the reason for improper fluid flow and melt solidification which in turn produced casting defects

Ravi B. [5] worked on computer-aided casting design and simulation. This paper describes a much better and faster insight for optimizing the feeder and gating design of castings

Naveenkumar [6] developed a simulation tool and its application to a pump casing that wasmanufactured by using a sand casting route. A simulation software called ADSTEFAN was used to designoptimization of riser system by fluid flow and solidification for pump housing through several simulationiteration, it was concluded that defect free casting could be obtained by modifying the initial riser system i.e.bylocation of riser from outer circumference to inner side which is prone to formation of shrinkage porosity andlead to elimination of shrinkage porosity.

Naveen hebsur [7] work on simulation of sand casting of a flywheel using ADSTEFAN software. Several iterations has been done to obtain a defect free component. Four ingates are provided at the first iteration, after the completion of first iteration the shrinkage defect is occurred. In order to obtain sound cast the model has to be modified in such a way that two ingates are provided at the thicker section of inner rib of flywheel and on which the risers are provided to achieve the directional solidification and hence a defect free component is obtained.

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III. MATERIAL AND METHODOLOGY

Valve bodies are cast or forged in a variety of forms and each component have a specific function and constructed in a material suitable for that function.

- For small valves are usually brass, bronze, or forged steel.
- For larger valves, cast iron, cast ductile iron or cast steel as required for the pressure and service.

Table 1: Chemical composition of carbon steel (ASTM A216 WCB)

Element	Iron (Fe)	Carbon (c)	Manganese (Mn)	Silicon(Si)	Sulfur(s)	Phosphorous (P)	Residuals
Weight	97-100%	0- 0.3%	0- 10%	0-0.6%	0- 0.045%	0-0.04%	0-1.0%

Methodology

Figure 1 shows drawing of a typical valve body and Table 1 shows its specifications. The valve body casting model with essential elements of the gating system like In-gate, runner, sprue and risering system weregenerated in NXCAD V9.0 (UG) modeling software as shown in figure 2. In first iteration bottom gating system without chill is used which results in shrinkage defects near the body. Thus in order to obtain the sound cast chills are provided in second iteration which results in sound cast.

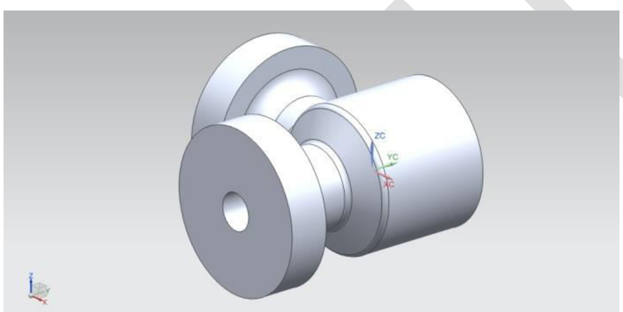

Figure 1

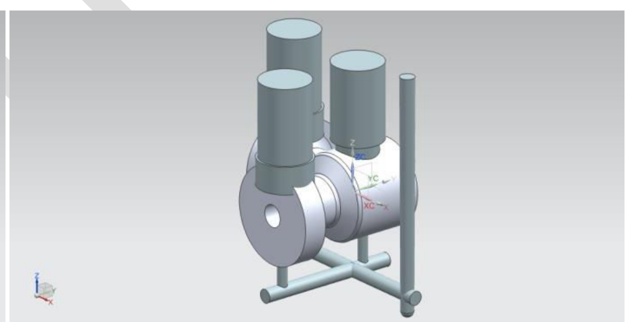

figure 2

Summary of parameters and dimension of gating system

Parameter	Value/Type/Dimension
Gating system	Pressurized gating system
Runner type	Circular
Sprue type	Circular cross section
Pouring time	35 seconds
Gating ration for steel	1:2:1.5
Sprue area	3180.86 mm^2
Runner area	1590.48 mm^2
Ingate area	795.215 mm^2

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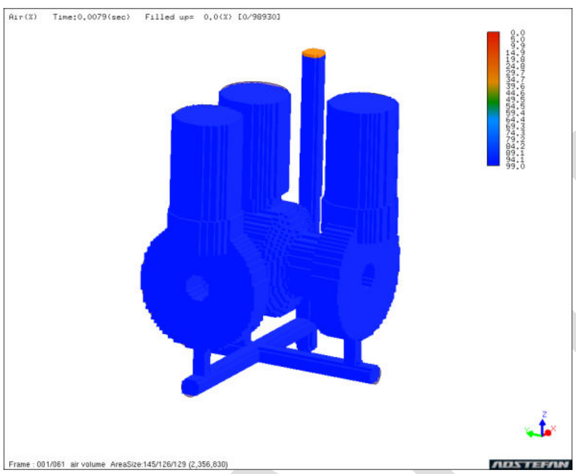
IV. Results and discussion

Iteration 1

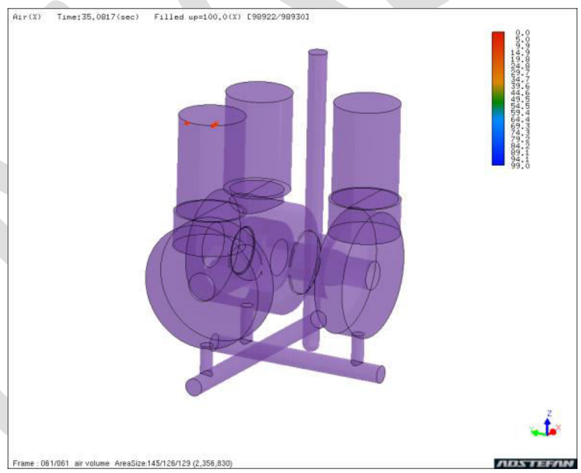
A. Air entrapment

Figure 4 shows the simulation results of iteration 1 where chills are not provided. In figure 4 (a) blue colour indicates the cavity is completely filled with air before the flow of molten metal. In Figure (b) grey colour represents the cavity is completely filled with molten metal. Thus from the simulation results it is clear that there is no air entrapment zone in the casting component. The air is completely escapes from the top of the riser resulting in no air entrapment in the casting component.

c



3 (a)

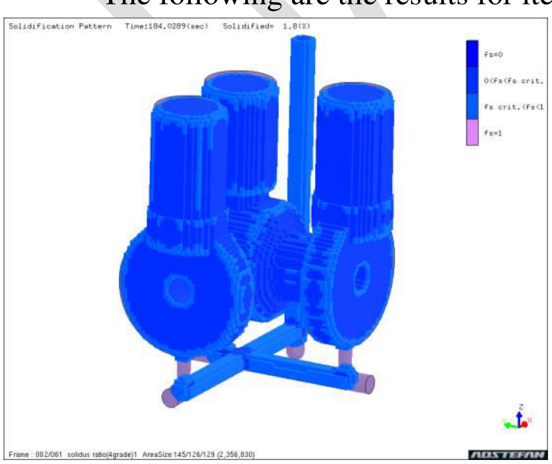


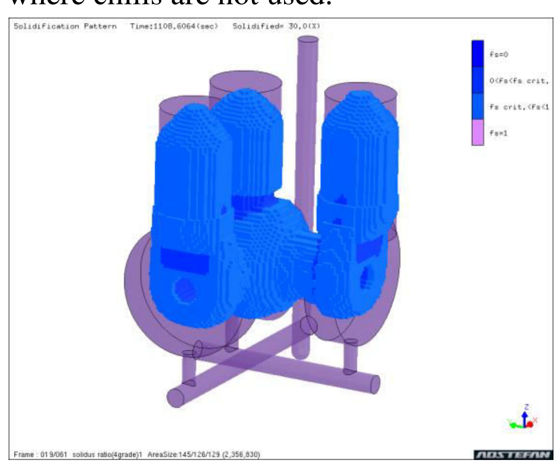
3 (b)

Fig: 3 Air Entrapment

B. Solidification pattern

The following are the results for iteration 1 where chills are not used.





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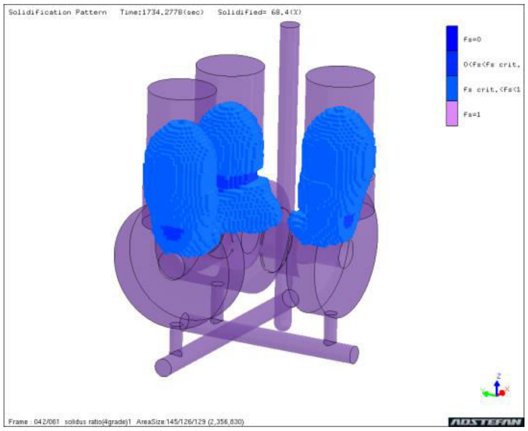
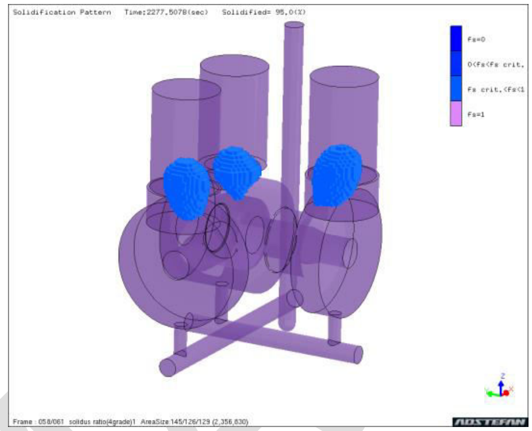
4 (a) **4 (b)**





4 (c) **4 (d)**

Fig: 4 Solidification Pattern

The solidification pattern of the iteration 1 is as shown above. It can be observed that the valve body along with gates and risers are in molten condition at the beginning. As the solidification progresses it can be observed that the solidification starts at the end and works its way towards the riser. Thus it can be concluded that the solidification pattern for iteration 1 is satisfying the directional solidification.

C. Soundness of degree

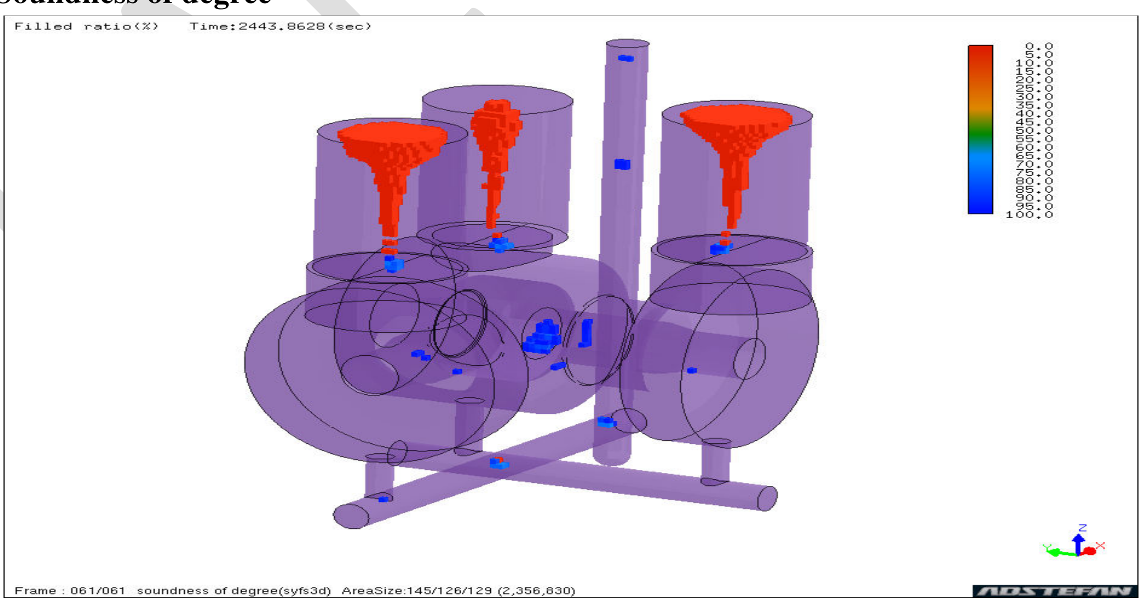


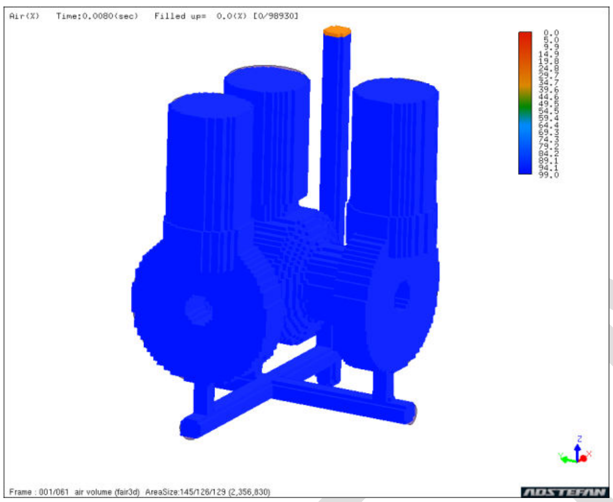
Fig: 5 Soundness of Degree

Soundness of degree specifies that our casting is how much defect free. From the above figure it can observed that there is shrinkage occurring in the valve body. Thus the next iteration is done with the aid of chills to eliminate the shrinkage defect from the valve body.

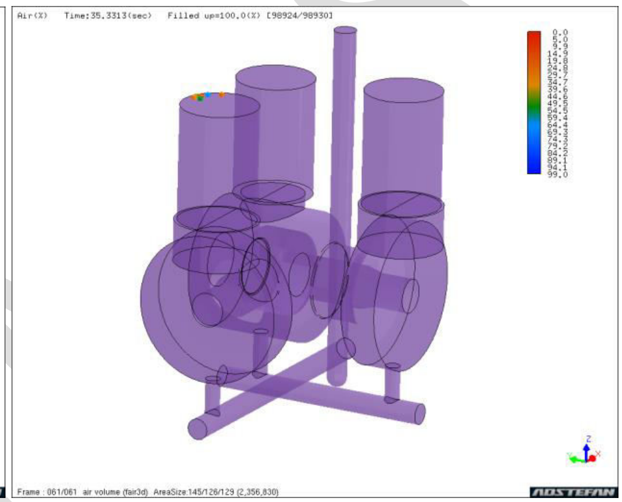
Iteration 2

In this iteration the same gating system was used as used in iteration 1 along with aid of chills. The following observations are noted down.

A. Air entrapment



6 (a)

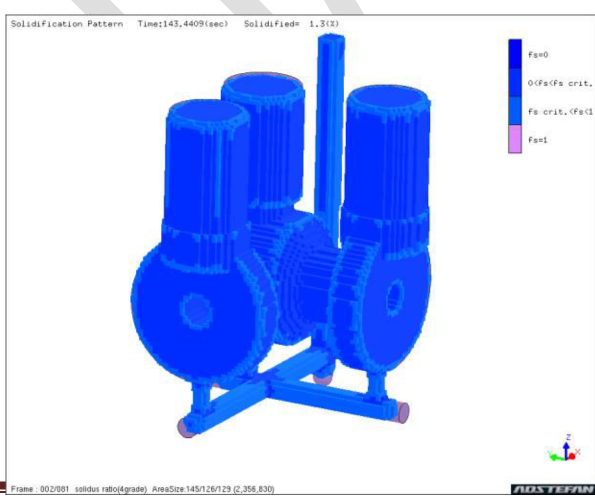


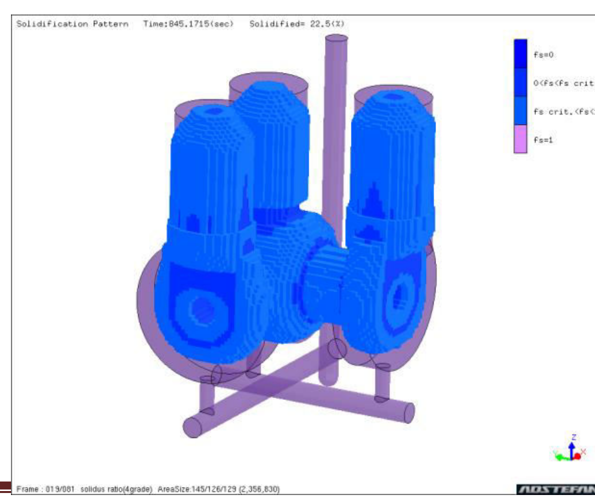
6 (b)

Fig: 6 Air Entrapment

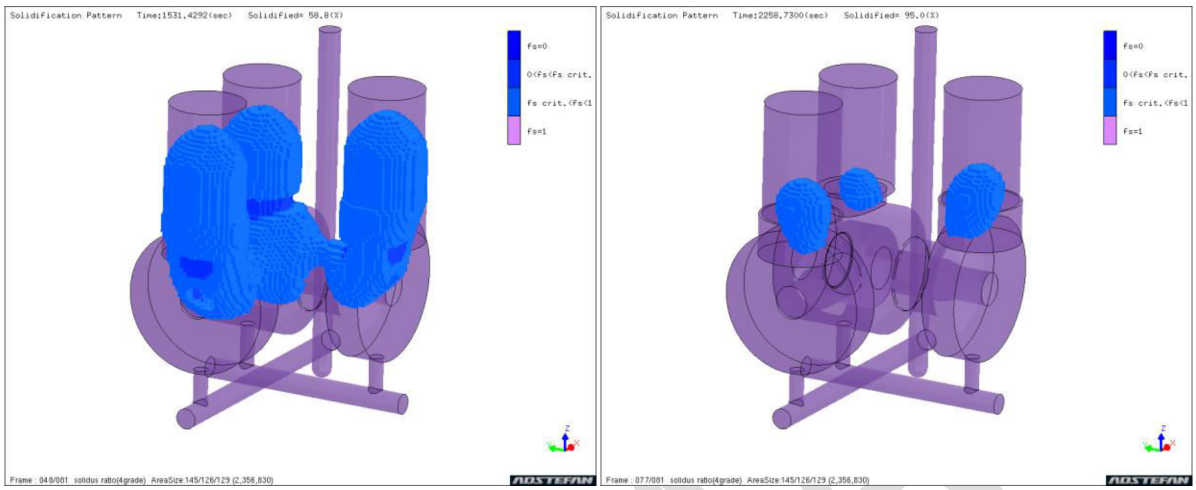
Figure 6 shows the simulation results of iteration 2 where chills are used. It is clear from 6 (a) and 6 (b) that there is no entrapment zone in iteration 2 also.

B. Solidification pattern





7 (a) 7 (b)



7 (c) 7 (d)

Fig: 7 Solidification Pattern

The results of solidification pattern for iteration 2 is as shown above. From the above observations it can be noted that the last region to solidify is riser hence it can compensate for the shrinkage. Thus it can be concluded that the solidification is directional i.e starts from the end and works its way towards the riser.

C. Soundness of degree

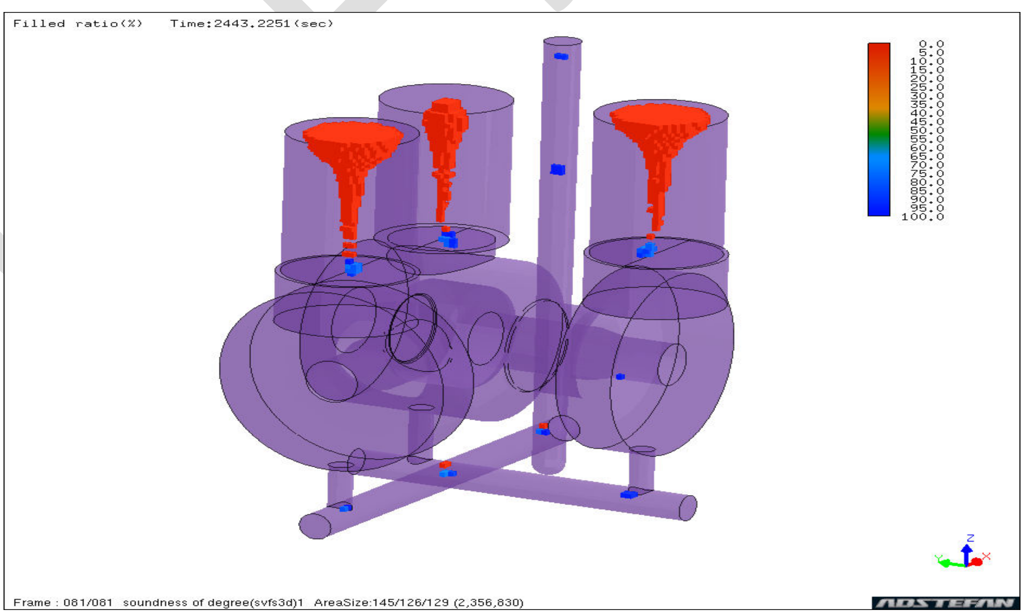


Fig: 8 Soundness of Degree

The results obtained from iteration 2 shows that there is no shrinkage occurring in the valve body. Thus it can be concluded that the results obtained from iteration 2 i.e. bottom gate with the aid of chills produces defect free casting. Thus there is no need of next iteration.

CONCLUSION

(1) Casting simulation technology has sufficiently matured and has become an essential tool for casting defect troubleshooting and method optimization. It enables quality assurance and high yield without shop-floor trials, and considerably reduces the lead-time for the first good sample cast.
(2) By moving the trial and error process into the virtual world and determine the cost of different design and process options. By minimizing real world trial and error (and surprises) making castings right the first time.
(3) From the above thesis work, we found that when the chills are not used in iteration 1 there is shrinkage occurring in the valve body. Thus we have used chills in iteration 2 which results in sound casting by eliminating shrinkage completely from the valve body.

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