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CFD Stream Flow Analysis of Amine Gas for Cold Box Core shooter process

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ABSTRACT: cold box core shooter process produced the core require for making the brake disc in sand casting. Brake disc is a very important and mandatory component in automobile vehicle industry. Brake disc sand core are very thin in size and disc surface area is too high compare to thickness. Maintain the quality of brake disc sand core with proper hardness and strength is critical and rejection rate increase during handling and require surface treatment to achieve desire casting finish surface quality. For curing the sand core amine gas have to pass from each and every sand particle in cold box. Air stream flow analysis provides freedom to observed not only air flow behaviour inside in cold box with pressure and velocity but also percentage of volume cover by the air to predict position of air inlet and outlet air vent cross section and locations. Analysis will provide guideline for manufacturing cold box to control core rejection, cost of core manufacturing, and cost of production and maintenance.

KEYWORDS: Cold Box Sand Core, CFD, Core Shooter, Brake Disc, Stream Flow Analysis, air vent.

I. INTRODUCTION

Foundry industry is one of the major industries material suppliers where automobile casting component are produced. 70% components of any automobile region are produced with casting process. To produce such intricate hollow shape casting components required sand cores which are produced by core shop. Cores are produced with different types of Cold box material and strategy and sand core ejection from die. Sand core shooter machine exist in current industries for brake disc sand core working with large rejection rate, required to stop amine gas spread around the machine, consumption of extra amine gas, hazards for operator's eyes, skin, lungs. Amine gas blow inside in core box and passing from each and every sand particle effect on sand core strength, porosity, density, hardness, surface quality. Cold box air went location plays important role for amine gas distribution in cold box with proper pressure and velocity that varies because of various core geometry and cross sections. Mould relief angle, draft, taper, loose piece and mould split with parting are the various part of cold box design. The splitting line at the parting face where amine gas opens from cold box is also important factor and has to consider as a output port at defining face labelling in boundary condition in air stream flow analysis system. Cold box made with metal, non metal, alloy, non alloy, polymers, wood, and the material withstand and maintain the shape when sand blowed inside with pressure. Entry point in cold box where sand first touch the surface that surface get wearied by sand after a define time of production. Each material of cold box material have a limited life of production cycle after that the intricate shape of cold box geometry disturb and not able to produce sand core at desired dimensions.

Sand core surface is normal to its sand blowing direction is observed in many foundry is successful and know as horizontal parting line cold box method. And distribution of sand and amine gas is axis symmetric and result for hardness is identical at each surface of sand core. In vertical parting line sand blow direction is parallel to the sand surface and strength is varies from core sand entry point to the core bottom point. Vertical parting cold box core create problem in casting process. Horizontal parting line cold box core large disc surface parallel to ground and easy to eject from cold box and quick sand core curing happened and easy to dressing the core.

Paper is organized as follows. Section II explains briefly about the development done in related cold box core shooter process and the analysis work in single phase two phase stream flow behaviour inside in cold box with properties study to cure the sand core. CFD air stream flow analysis provide precision result for amine gas air blow inside in cold box saved time and cost of cold box tool development given in Section III. Section IV presents experimental results showing results of images tested. Finally, Section V presents conclusion.

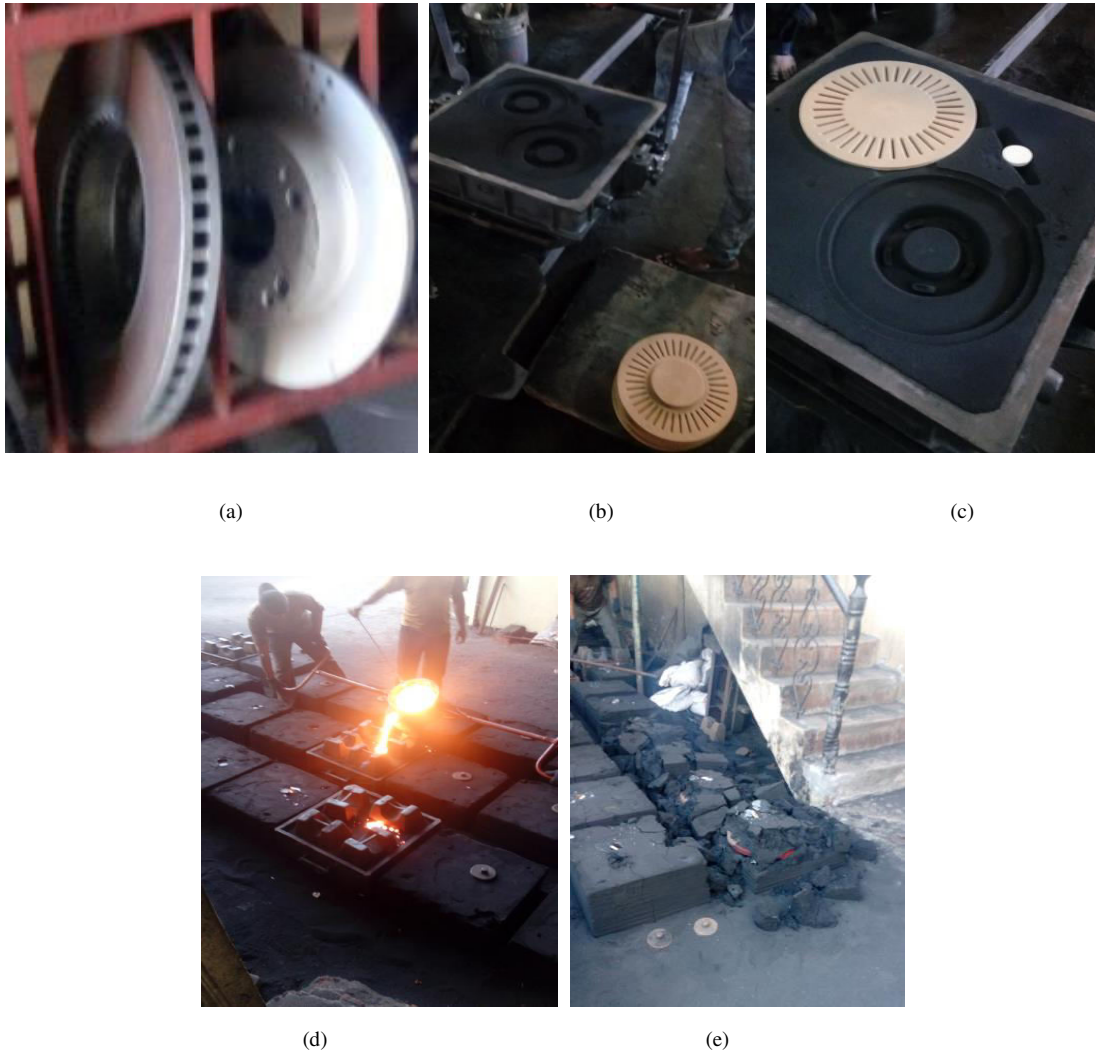


Fig. 1. Brake disc casting process (a) brake disc (b) Brake disc sand core with green sand moulding line (c) core position in sand moulding box (d) molten metal pouring line (e) brake disc casting solidification

The above Figures shows the brake disc component and its sand casting process and how molten metal poured in sand mould box to get the casting of brake disc by placing brake disc sand core sandwich between core and drag. Brake disc sand core is complex in shape, fine fins, low thickness; disc diameter to thickness ratio in high, the sand core is required to dressing for removing entry cylindrical projection. Cylindrical projection of sand core top is a not part of finished sand core but it is the essential part of cold box sand core shooter system. This conical cylindrical shape part maximum convert in core print area to get core yield and maintain as possible low manufacturing cost of sand core and reduced the require time to core dressing and parting line smoothing before sand core proceed to moulding line of brake disc casting manufacturer unit.

II. RELATED WORK

The manual process of sand core shooting process was extracting the multiple parameter and valuation observed by Amarjeet R et al. [1]. To maintain required hardness and strength the sand core the study of sand filling capacity and blowing range of sand inside in cold box is mandatory. J. Danko et al. [2] core sand is pre process before blow inside the cold box and this well processed sand mixture is chemically cure for hardened by chemical process by induced amine gas in it with proper air pressure and velocity, this paper focuses on the detail material used for making sand core with its binder, resin and hardener by A. Fedoryszyn et. al. [3], measuring techniques and procedures are used to acquire the characteristics of box filling and sand compaction using blowing and shooting methods. A device for

making complex and tiny sand core in hot-box and cold-box both processes, as well as CO₂ and hot air gassing blowing machine for determining core compaction settings, primarily in hot-box and cold-box operations, - a mechanism for blowing/shooting outfitted with a valve with a variable releasing stroke & bushings in the shape of cylindrical inserts holding core sand. The equipment is used to measure the influence of air pressure as well as its distribution inside the shooting tank just on major (sand flow rate, thrust force) as minor (sand-air flux density, speed) presented by M. Aslanowicz et al. [4]. The process of sand blowing model stepped in design, analysis, and development category with analysis methods by Mosim Attar et al. [5], in this paper Core sand inside in core box after sand shooting compaction is depend on the cross section of sand intake inside in core box, the extension of the hole axis where sand enter in core box study is affecting various parameter when all the boundary condition have to set in solid phase stream analysis flow where sand particle prevents the amine gas entry at the core sand intake point.

Some time if core not get proper hardness then core will degrade and deform and will lose its strength. Entry of sand core many time it is a waste and remove when core get hardened. For calculating yield and production cost neck height should be very low and diameter of neck have to large, this core intake extension always effect on the core hardness, compactness, and amine gas curing at complex shapes. R. Danko et. al. [6]

The work in this paper is divided in two stages. 1) Core box design and modelling 2) Core box amine gas stream flow analysis. 3D geometry of core box is not applicable for stream flow analysis, volume model have to extract from the core box both half with the help of CAD software known as Siemens NX and exported in suitable extension format Thereafter, import in Analysis software known as Ansys. Core box amine stream flow analysis done in CFD air stream flow analysis by follows the correct steps

III. METHODOLOGY

Exemplar based air stream flow analysis of cold box core shooter process is done with the help of analysis software required the data as a input, thereafter a boundary condition have to apply on geometry model after meshing stage and solver will solve the iteration in background to solve the CFD analysis mathematical work and provide the demanded result as define in solver to check the result are satisfactory or not. The following steps are compulsory for CFD air stream flow analysis.

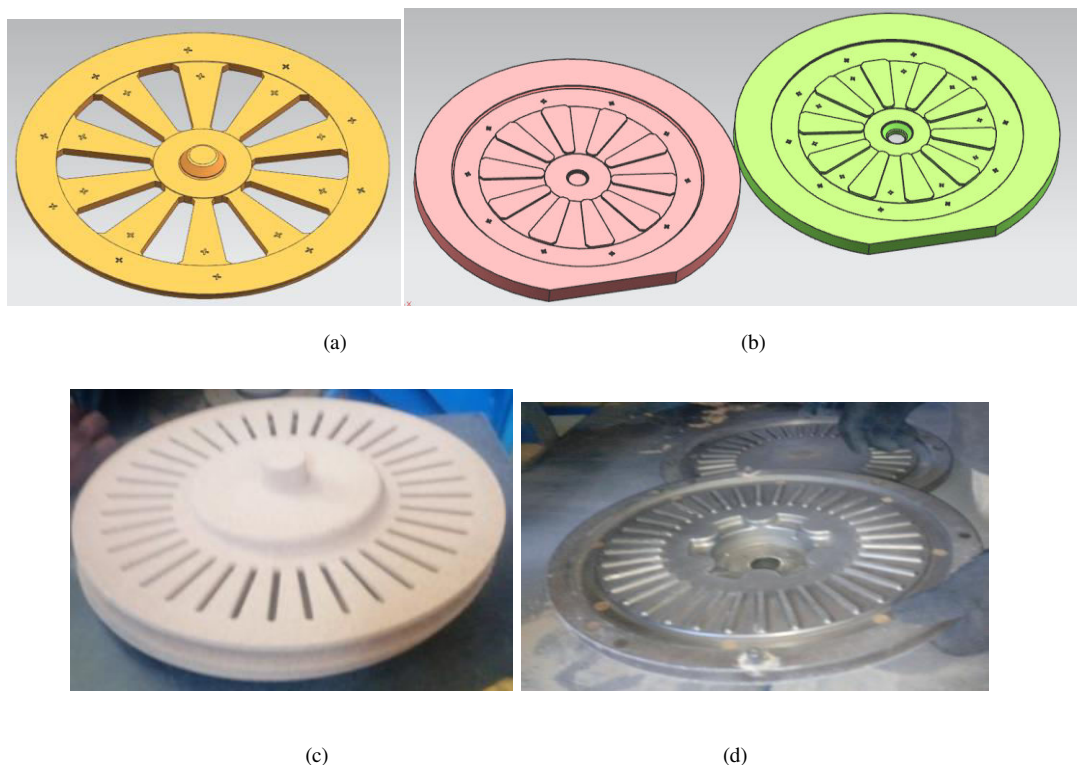


Fig. 2. Cold box and sand core for Brake Disc (a) 3D modelling in Siemens NX software for Brake disc sand core (b) 3D model of cold box in Siemens NXCAD software (c) sand core sample actual (d) actual metal cold box for brake disc core.

Fig 3(a), 3(b) is the following figures shows the steps required to complete air stream flow analysis of cold box core for single phase fluid behaviour with fluid characteristics by defining the input pressure, mass flow for desire output results. Process steps of CFD air stream flow analysis for cold box core shooter are as follows

1. Design of core box. 2. Design of volumetric model 3.define 3D volume model material in CFD software 4. Model meshing 5.boundary condition definition 6.solver demand for result types 7. Result study and comparing with legends.

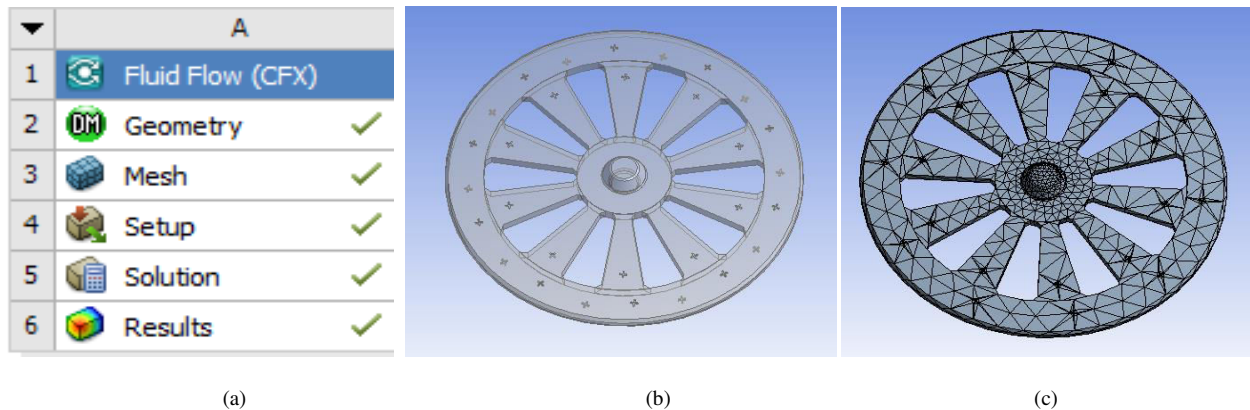


Fig. 3. CFD steps for sand core Amine gas fluid flow analysis (a) steps of CFD analysis in Ansys (b)3D modelling export from Siemens NX software and import in Ansys (c) Mesh generation for sand core 3D model, node = 3057, elements=11909,

This CFX Analysis standard process available in Ansys software, 3D model import from any software with suitable file extension in Geometry module and named selection defines the domain surface for air entry and air exit, this named selection helps in setup module definition. After Geometry module definition meshing have to done in Mesh Module with all standard process. By default it is triangular meshing for CFX analysis. Meshing provides statistics of node and elements number with notification about quality of mesh if bad meshing generates. Setup module allows defining the properties of air stream entry by inlet label with inlet pressure and unit of pressure with define quantity. And outlet label for finding the properties of output and proceed it for Solution by define the require numbers of iterations. Solution module operation proceeds to solves the iteration based on the unit of inlet and outlet properties. Once solver solves the solution result module is editable to check the stream line for velocity and counter for pressure. Global input for velocity and default parameter sets and for pressure 0 bar to 3 bar user defined unit and value sets. After all the operation total three case studies observed in the experimental results setup.

IV. EXPERIMENTAL RESULTS

. fig4 (a) in the boundary condition apply for inlet and out let parameter with geometrical selection. Inlet surface is defined in name selection and arrow towards the model similar to entry in model with 5 bar static pressure defines in Ansys software.fig4(b) is the velocity with legends indicates the colour code of specific velocity unit intensity to compare the velocity inside in core box by graphical method.

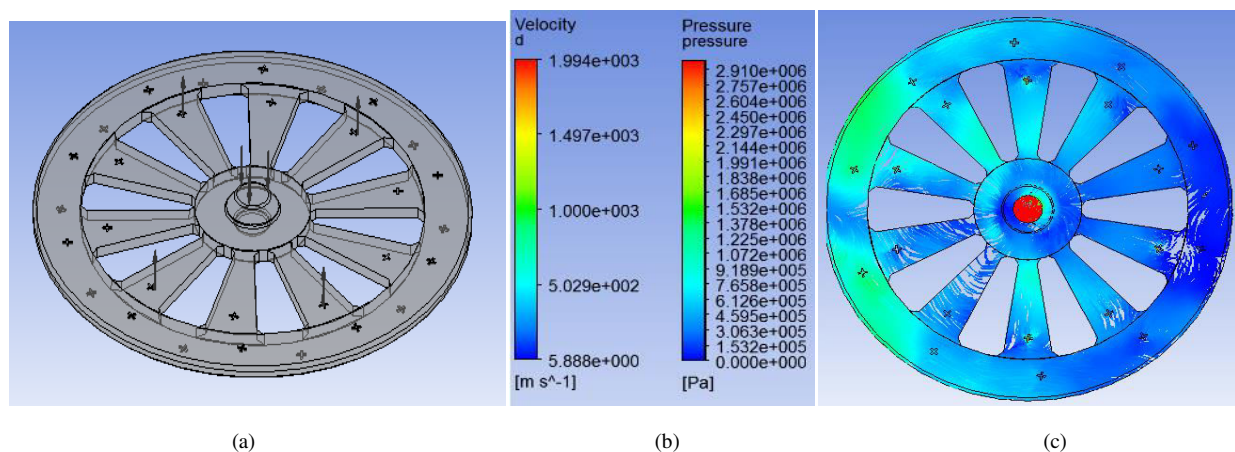


Fig. 4. CFD steps for sand core Amine gas fluid flow analysis (a)3D modelling export from Siemens NX software (b) steps in Ansys software for CFX (c) volume model in Ansys CAD module

Fig4(c) result declares the stream line flow for velocity and pressure that indicates that distribution of pressure and velocity from blowing inlet area to boundary surface is variable, and not gradually decrease so it will affect the core quality and its hardness and strength.

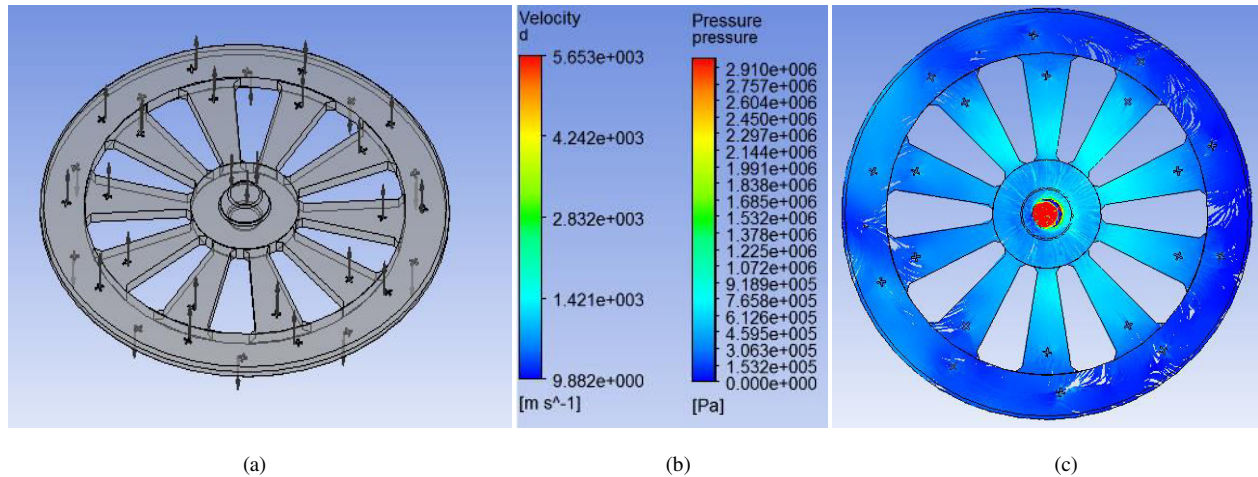


Fig. 5. CFD steps for sand core Amine gas fluid flow analysis (a) 3D modelling export from Siemens NX software (b) steps in Ansys software for CFX (c) volume model in Ansys CAD module

Fig 5(a) is second case were air vent means the air output area is increase and air vent location place from that location air will out and maintain the pressure and velocity. Fig 5(b)(c) result are better than the first case study but at couple of corner in cold box it shows the empty where stream intensity and density are not up to desire level, it will also effect on the core quality.

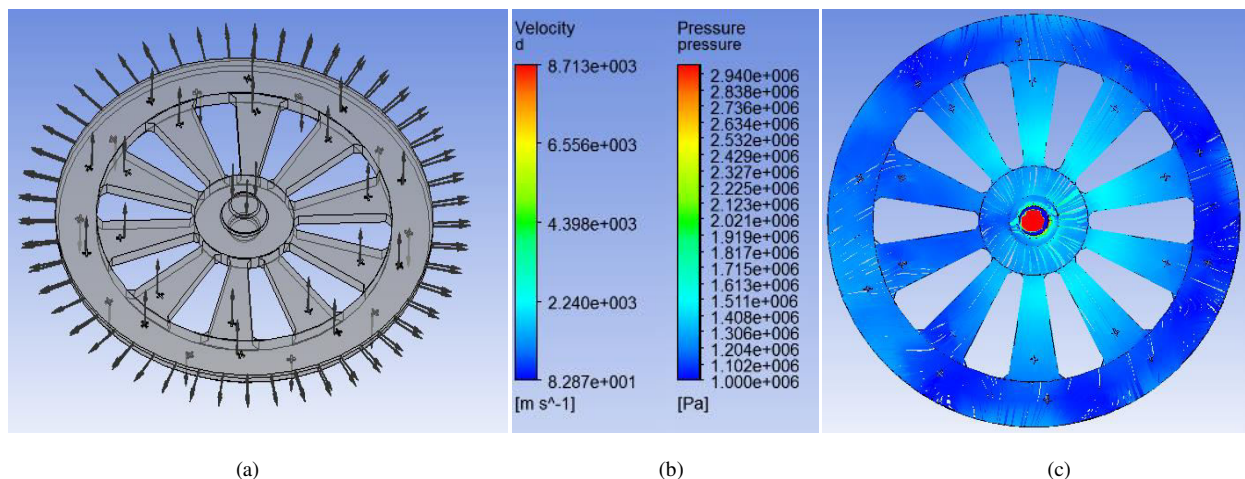


Fig. 6. CFD steps for sand core Amine gas fluid flow analysis (a) 3D modelling export from Siemens NX software (b) steps in Ansys software for CFX (c) volume model in Ansys CAD module

From the two case studies available in fig 4 and fig 5 observation guides to add more air vents to words the outer periphery of cold box, then only pressure will distribute in manner of axis symmetry format.

Again new case study in done in Fig 6 shows the inlet and outlet named selection has been modified and updated At the boundary periphery shown in fig 6 (a) where arrow direction is away from core box boundary, number of air vent same as previous case. Fig 6 (b) velocity legends units and pressure unit indicate that gradually pressure spread in cold box from blowing area to the core boundary and no empty are found that shows the absence of stream line in fig 6 (c) are the total observation from above result. For the Ansys software limitation with computer hardware core model has been modified in shape and reduced in size.

As per experiment result core box has been modified and air vents add by machining air vent provision and cold box sand core produced with low rejection rate with increasing the strength and hardness of brake disc sand core.

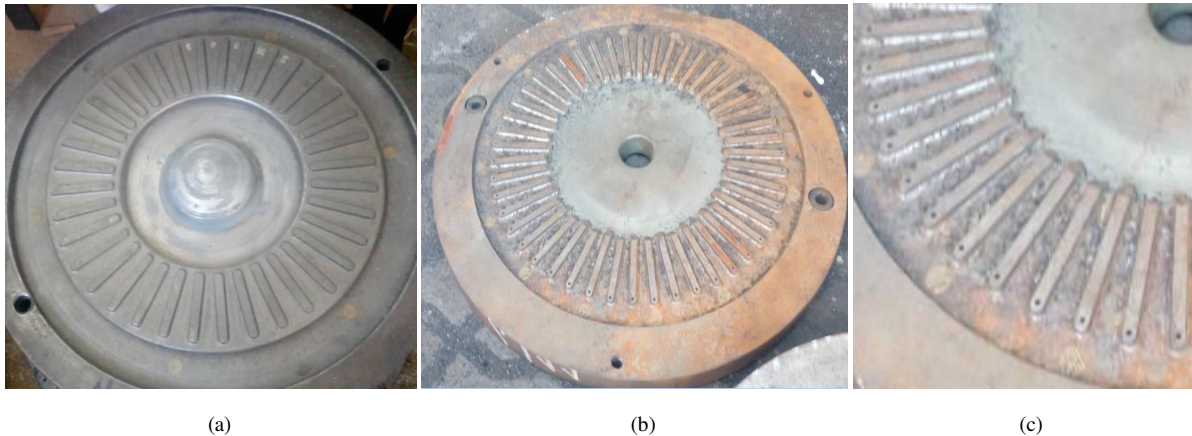


Fig. 7. CFD steps for sand core Amine gas fluid flow analysis (a) core box with nominal air vent (b) core box with proper air vent guide by softwares for machining location of air vents (c) focused view of air vent in cold box of fig(b) view

Fig. 7 (a) cold box is manufacture with standard practice and it is applicable for production also but for more yield and reduce extra consumption of amine gas and reduce cycle time, cold box re machined as per analysis experiment result for desire optimum performance in fig (b) and brass type air vent and cylindrical hole was generate inside in core box to eliminate amine gas trapping in core box in detail view fig(c.) yellow colour patches are the brass air vents.

V. CONCLUSION

We have analysed that amine gas air pass from cold box with proper velocity and pressure to cure the core for achieve desire proper hardness and strength is only possible by providing proper position of output air vent. Locating appropriate position of air vent in cold box addressed by compared multiple analysis result of air flow stream analysis with legends for velocity and pressure distribution from blowing area to periphery of boundary of core cavity in cold box. Practical method may vary and skilled experience assistance not predict surely in brake disc type sand core. Analysis software guides with precision and accurate result for brake disc sand core cold box manufacturing.

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