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A Review on Defect Minimization in Sand Casting

S.Dhanush[1], S.Balaganesh[2], V.Vijayakumar[3], C.Ashok kumar[4], R.Dinesh[5*], S.Elangovan[6]

[1-4]UG Students, Department of Production Engineering, PSG College of Technology, Coimbatore, India
[5]Assistant Professor, Department of Production Engineering, PSG College of Technology, Coimbatore, India
[6]Associate Professor, Department of Production Engineering, PSG College of Technology, Coimbatore, India
*rdh.prod@psgtech.ac.in

Abstract –

Foundry firms in emerging countries have low value and competitiveness as a result of the numerous progression variables involved. Casting defects are identified as the artifact system doesn't fluctuate in a fully precise progression. A better grasp of the causes of casting defects is really important to minimize them. Casting optimization techniques serve a significant role in decreasing casting defects and increasing casting yield, particularly in small and medium-scale foundries. Engineers can use casting simulation software to visually validate their design calculations, decreasing the number of prototype test runs needed to build the final component. This review paper discusses several research publications and draws conclusions from them.

Keywords: Casting defects, Casting optimization techniques, Trial reduction, Cost efficient.

I. INTRODUCTION

Metal casters use the term "casting" to describe the process of producing numerous components for the automotive, and aviation industries. Sand casting is a traditional manufacturing method that uses sand as a refractory medium which increases the quality of casting. The majority of flaws will appear during the casting process. Metal casters can use simulation to predict numerous flaws and generate trustworthy outcomes in a short amount of time. Many problems linked to the cast component can be predicted using casting simulation software such as Auto Cast, Procast, MAGMASOFT, Click2Cast, ADSTEFAN, among others [1].

It's extensively harder to cope with some key troubles with inside the design of the casting process, product category settings, and so on with simply CAD/CAM technology. On the other hand, computer-aided design technique fills this need by assisting engineers in creating, verifying, validating, and optimizing layout solutions prior to their implementation and practical realization [2]. Simulating a genuine phenomenon with a set of mathematical equations executed in computer software is known as simulation. In casting simulation, a finite element technique is utilized to evaluate mould filling and solidification using programs [3].Casting solidification is a complicated process that requires modelling in the industry before it can be carried out [4].To obtain the desired internal quality at the maximum feasible yield, casting simulation effectively replaces or minimizes shop floor testing. Today, a variety of casting simulation programs are accessible [5]. A visual representation of the mould pouring and solidification is included in the casting simulation. The study of solidification behavior began in the outside sector and progressed to the central region, depending on the temperature factors, before concluding with the discovery of defect [6]. After methoding, the layout is tested for defects in the usage of a simulation of casting solidification. A better starting design can save down on simulation cycles while also improving cast quality. Methoding relies heavily on feeder design [7]. In order to forecast cavities, the solidification time might be used [8]. The intake for the hot metal to flow into the mould is known as the gating system. The right gating mechanism can help prevent casting defects [9]. The amount and position of shrinkage porosity are greatly influenced by the diameter of the gating system [10]. The software has proved to be reliable in forecasting defects [11]. However, rather than depending on casting simulations completely, it is preferable to understand and foresee their trends [12]. Su-Ling Lu et al discussed the difference in coating thickness between the defect region and the temperature distribution acquired using ProCAST was investigated. At the depth of the WTCL defect zone, the difference in layer thickness has a significant impact [13]. The gating mechanism directs molten metal into the pattern cavity and feeds this during the shrinkage process that occurs during casting solidification. The gating system must be designed correctly in order to meet two crucial objectives. By minimizing premature solidification, short flow channels and quick metal flow eliminate casting misruns [14]. The finite element numerical method is used in the computer-based casting simulation, which results in superior findings that are comparable to experimental results. The riser size and placement can be optimized using computer-based numerical simulation methods in foundries to prevent defects caused by casting shrinkage [15].

II. CASTING AND DEFECT ANALYSIS

Warm molten material is poured into a mould box with a hollow part of the desired shape and allowed to set. Casting is the term for the solidified component. Casting is commonly used to create complicated forms that would be difficult or costly to create using other procedures. Casting is a technique for introducing the possibility of failure into all of the feat systems in the end product at some point [16].

Foundry industries are affected by bad quality and productivity. Large numbers of parameters of procedure are answerable for the price of poor quality. Global customers call for disorder free casting and maintains transport schedule, which foundries are finding very tough to meet [17]. In particular, at cutting-edge casting industries, quality control, low manufacturing, strength efficiency, high material input, and environmental manufacturing's influence are all common problems. The development of casting products in various applications is a major concern for the Indian casting industry. An appropriate process must be chosen from among a variety of options purely based on the product's requirements and the location of its use. Figure 1 indicates the detailed overall skeleton of the casting process [18].

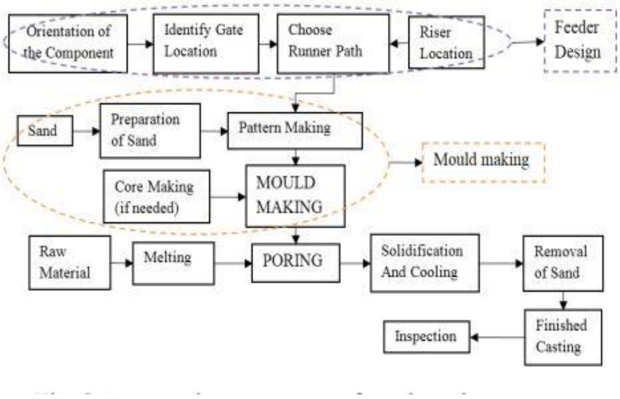

Fig.1 Steps and components of sand casting process [18]

Table.1 Brief classification of defects occurs in the casting process [18]

Casting Defects		
Surface defects	Internal defects	Visible defects
Blow	Blowholes	Wash
Pin holes	Porosity	Rat tail
Blister	Pinholes	Swell
Drop	Inclusion	Misrun
Scab	Dross	Cold shut
Penetration		Hot tear
Buckle		

III. DEFECT MINIMIZATION BY SIMULATION

Fig.1 displays a link between the real process, the simulation method, the naturally occurring phenomena to be reproduced, the governing equations that describe particular physical activity, and the output variables. Materials and material characteristics, as well as equipment and operational settings, are employed to reflect the physical behavior and phenomena of casting processes in real-world situations. The simulation findings, on the other hand, include physical details about the casting process as well as final microstructures, flaws, and casting quality. The simulation findings, on the other hand, include physical details about the casting process as well as eventual microstructures, flaws & quality.

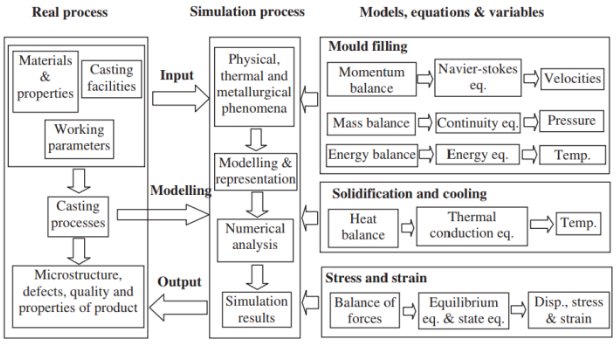

Fig.2 Modeling and simulation processes [2]

The cooling process from the external casting surface to the interior can be shown in Fig.2 and the position of shrinkage porosity can be detected. This analysis aids in the optimization and verification of riser design, resulting in increased casting yield and desired quality.

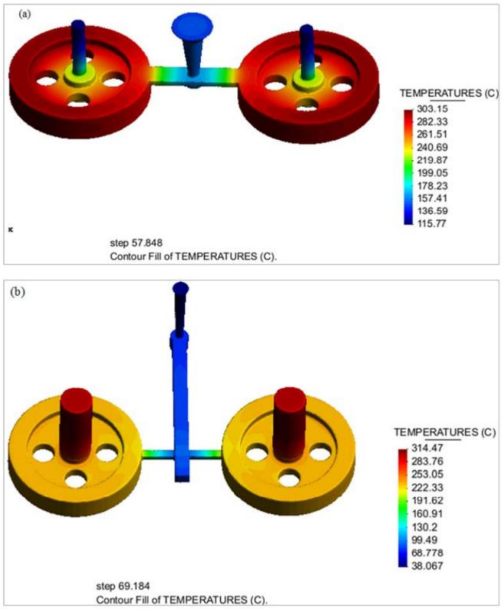

Fig.3(a) Conventional gating design (b) Proposed gating design [9]

Feeders and feed aids can be created and optimized in the feed module to obtain the required quality and productivity. Figure 4(a) depicts the Hotspot indicating the latest solidifying region, whereas Figure 4(b) depicts the software's suggested site for the feeder.

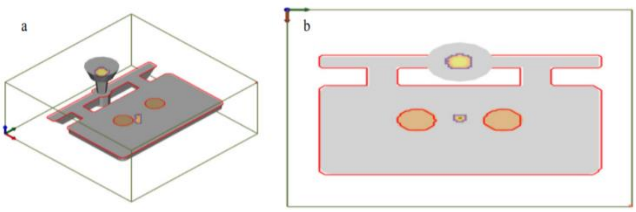

Fig.4(a) depicts the Hotspot indicating the latest solidifying region, whereas Fig.4(b) depicts the software's suggested site for the feeder [4]

Fig.5(a) & (b) depicts metal filling in the mould cavity, which ensures that liquid metal flows smoothly and that cold metal does not enter the cavity. The yellow color emphasizes the decline in temperature caused by the chill. However, this temperature reduction is on the safe side, as there is no risk of cold metal.

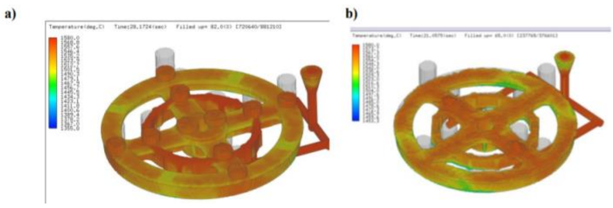

Fig.5 Fluid flow in the casting component [5]

The defect results reveal the occurrence of shrinkage defects exclusively in the centre feeder in every rectangular plate with variations in thickness after assessing the solidification behavior as shown in figure 6.

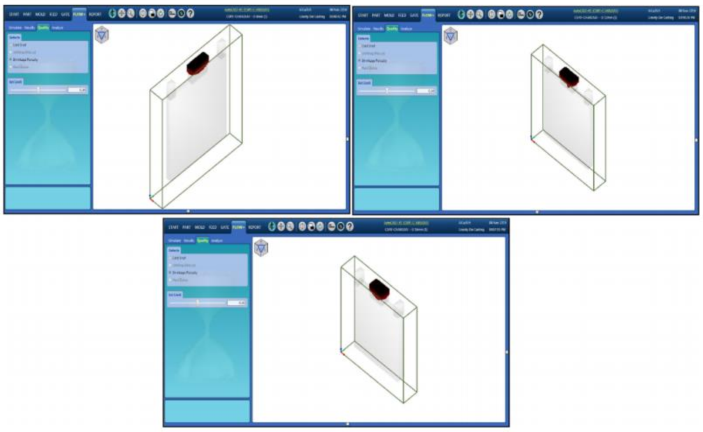

Fig.6 Defects in geometry varied plates [6]

AutoCast is a simulation programme that is mostly used by designers. Figure 7shows an example of how to do this. a-software imports the component, b-solidification, c- sectional view, d-design of feeder. The amount of time it takes for solidification to occur is a key consideration in gate design. The comparable tendency in solidification time is shown in Fig.8.

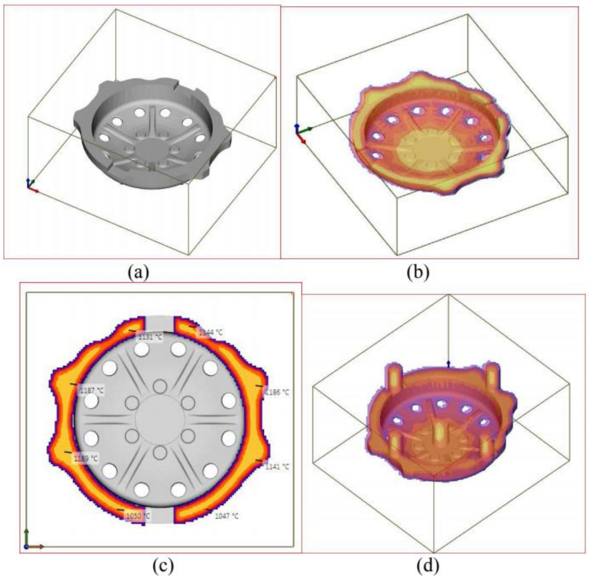

Fig.7 a-software imports the component b–solidification c-sectional view & d-design of feeder [7]

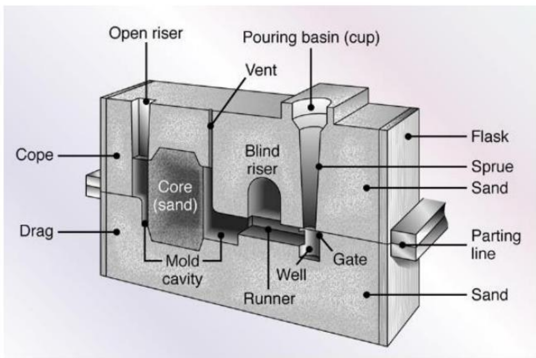

Fig.8 Gating system of Sand Casting [9]

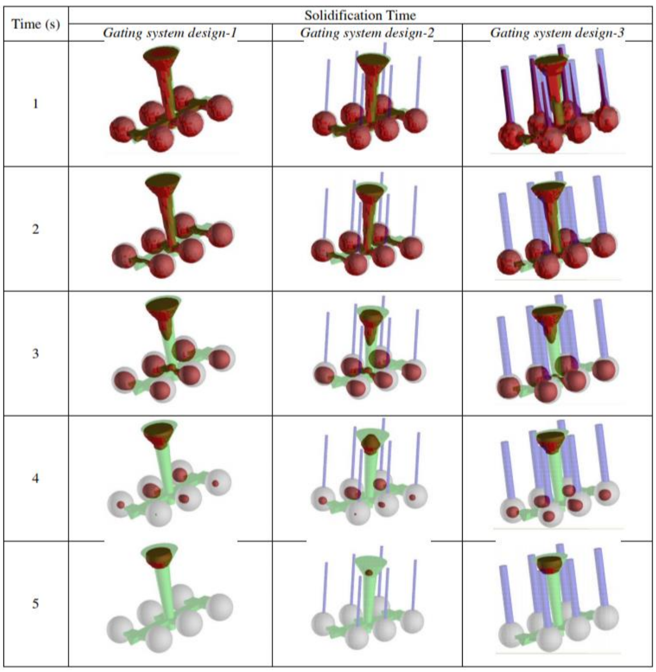

Fig.9 Similar tendency in Solidification time [9]

The use of an exothermic sleeve in conjunction with the riser produced an exceptional outcome, with all hot spots moving inside the riser and no hot spots remaining in the casting. The cooling part of the casting with the exothermic sleeve is shown in Fig.9.

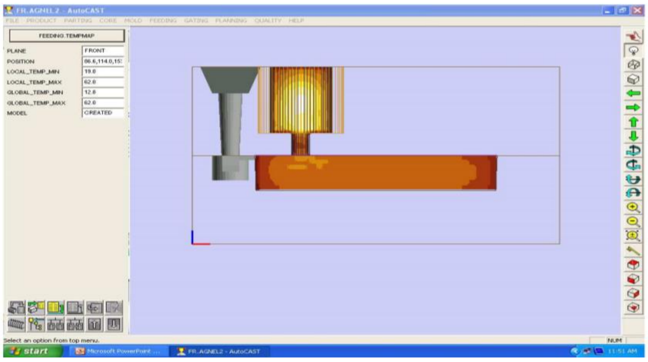

Fig.10 Cooling of Casting with Exothermic sleeve [11]

A.Sunanda et al. use Creo software to create a design for the pulley and gating system, as well as Procast to analyze solidification and mould filling. Sand was chosen as the mould material, and computer-aided simulation software was used to conduct the prediction study. Numerical simulation is being used to thoroughly investigate the specified model (pulley). Fig.11 shows the procedure to enhance the casting design [1]. Su-Ling Lu et al reported that with the help of ProCAST software, a horizontal centrifugal casting system for a tube was designed, focusing on the flow behavior of the metal melt during the horizontal centrifugal casting system. Fig.12 indicates the WTCL's centrifugal casting process is depicted schematically. On the wet-type cylinder liner inner surface, the formation of Macro segregation as well as shrinking holes and the performance of WTCL produced by centrifugal casting are both important factors. The ProCAST software tool was used to develop a model of centrifugal casting WTCL in this study, and the simulation output was used to help enhance the casting process. The results show that the ProCAST software package is suitable for WTCL horizontal centrifugal casting simulations [13].

With the support of captivating advancements in the casting field, R. Kumar et al. exhibit how to create a gating system for investment casting. Fig.13 shows the process sequence of investment casting. A rotary adapter is created using advanced methods in this study. Investment casting was chosen for producing the item because it has a complex curved profile and requires a high surface polish with tight dimensional tolerance. Different real time factors were used as inputs in this study, and the simulation was run. The simulation results were examined, and flaws were discovered. The changed gating mechanism was identified during this experimental investigation to aid in the regular manufacturing of sound casting using NX and Pro-cast software [14].

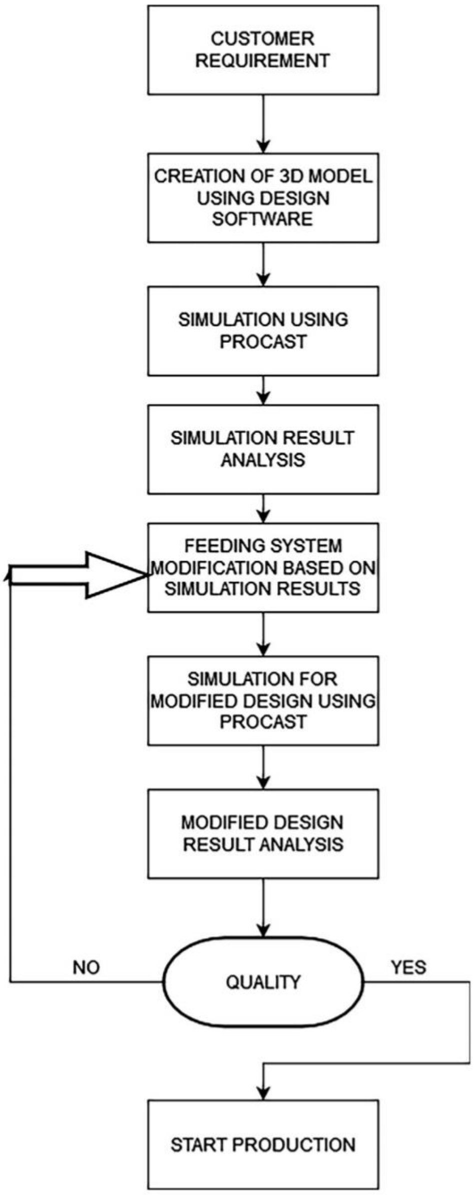

Fig.11 Procedure to enhance casting design [1]

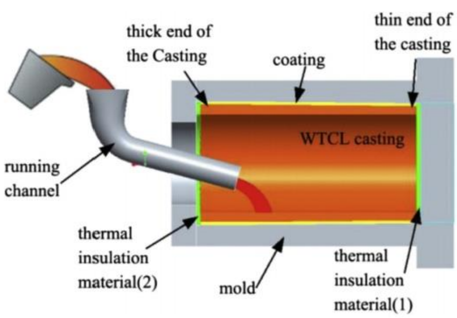

Fig.12 WTCL casting process [13]

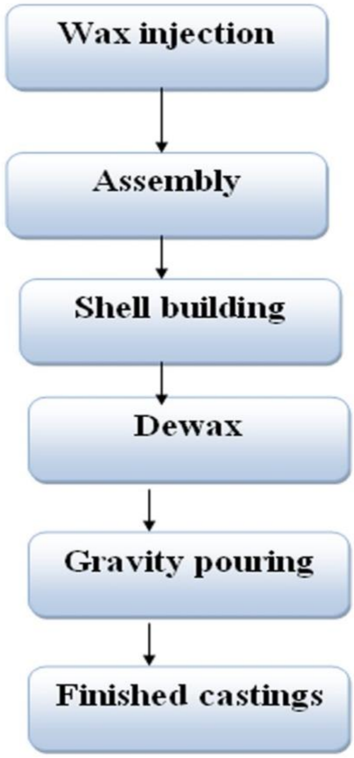

Fig.13 Process sequence of Investment casting [14]

S. Aravind et al, employed computer-based simulation software to run numerical simulations to reduce challenges including solidification shrinkage, cracks, voids, imperfection and riser level troubles. This study also contributes to the advancement of gravity casting in aluminum-based alloys. The MAGMASOFT programme was helped to simulate the solidification of a casting method in this study. The simulations were done with the aid of the MAGMAsoft software by changing the making design and core pins position adjustments to the casting part without changing its pattern objectives. In the production process, the introduction of computer-based numerical simulation tools will help to reduce the time it takes to produce castings. It also used to reduce the number of trial runs. By combining the modeling results with the design changes in the component, the defect minimization rate was lowered from 2,50,000 - 30,000 parts per million. As a result of the lower rejection rate, the manufacturer's output has grown, resulting in higher profits [15]. Within expanded region of casting, Dongyu Han et al. discovered that dendritic deformity produced by thermal constricting stress in the freckle pathways led freckles to evolve into slivers. ProCAST has been employed to simulate the geometry of the squishy region, which revealed freckles generated at the squishy region's total elevation. Finally, this study investigated the expansion and growth of sliver dendrites in Ni-based crystal superalloy, as well as the system of freckle formation into sliver [19].

Ryosuke Tasaki et al.[20] discussed about a new method for regulating the filling of metal in mould behavior of the casting process. Flow disruptions and air entrapment are prevalent when transitioning from a small to a large flow channel in the cavity. To increase the effectiveness of systems integration, a filling process design approach based on model predictive control is proposed. A filling process is developed using a model predictive control method. When liquid metal erupts from a confined path flow into a large flow path in the hollow, flow disruption and air entrainment can occur. A computational fluid dynamics study and a laboratory experiment of iron metal casting illustrate the efficacy of the operation control system design of pressed action with the fluid pressure of filled molten metal and the consistent flow without generated new. Malcolm Blair et al. [21] explained that casting design is becoming more dependable and efficient thanks to advances in computer modeling in design, manufacturing, and non-destructive testing. Finally, simulation must be able to generate bespoke standards that can ensure part performance. Explains recent research on predicting the occurrence and nature of casting faults, as well as their impact on performance. The current efforts to develop integrated design methodologies are examined in this article, as well as how different types of faults express themselves in casting. In the future years, Demand towards lightweight, greater castings is expected to grow in the coming decades.

Limin Jia et al. [22] studied the gas pore or shrinkage defects that occurred in the centrifugal casting of Ti-6Al-4V alloy. Numerical simulation and experimental study were used to investigate alloys generated in graphite moulds under various vertical centrifugal casting circumstances. 0 rpm, 110 rpm, and 210 rpm were the three rotation rates used in this experiment. The proportional amounts of micro pores as well as micro cracks diminish as the mold-rotating rate is boosted, whereas the fraction of inclusion grows rapidly. Using a vertically centrifugal casting process, according to this study, can significantly reduce the severity of casting defects. The defect-visible specimens reduces from 62.4% to 24.8%. When the mould rotation rate is raised from 0 to 210 rotation per minute, the fault specimens diminish from 62.4 percent to 24.8 percent. The categorization of flaws in castings made via electric driven arc smelting was researched by Skryabin M L et al.[23] The existence of a well-defined uniform floor on which the fracture occurs distinguishes a stone-like fracture. Inside the austenite phase, grain barriers composed of good character debris or films generated from molten eutectics are slightly soluble. It is indeed to mention stone-like cracks are most commonly encountered at grain barriers.

Benny Karunakar et al. [24] said that in an experiment to prevent casting errors, back propagation neural networks had been used. Using data from a metal foundry, the authors used back propagation neural networks to try and predict considerable casting defects inclusive of fractures, blow holes, compression strength, permeability, air locks, shrinkage, rate composition, and melting conditions were used as inputs, while the occurrence or absence of flaws was used as an output. The observation reveals that the 5 casting defects tested had been diagnosed previous to the pouring process. Also, back propagation neural networks supplied the important protections towards casting errors.

L.A. Dobrzański et al.[25] presents a methodology for automating the control and monitoring of the technological process of producing aluminium alloy elements. The developed methodologies will allow for the detection and classification of defects. It will be able to decrease or eliminate them - at least in part - with proper process control. The developed computer machine can detect and classify flaws in Al-Si alloy castings of the EN AC-AlSi7Cu3Mg kind automatically. It really has evolved into a means of assisting and automating the decision to deny castings which do not meet the quality standards.

IV. DEFECT MINIMIZATION USING OPTIMIZATION TECHNIQUES

Dr. S. Nallusamy [26] discussed that, in a recent competitive environment, it is necessary for the foundry industries to reduce the rejection percentage in order to have less cost of manufacturing. However many Foundries concentrate on production instead of controlling the rejection. While some foundries follow the trial and error methods to do so. In order to increase the productivity of the entire supply chain, strategic methods are to be followed. So in this paper, various defects in casting are analyzed and their remedies are proposed for comparison with actual industrial results. Cyrus F. Wood [27] because there is more to be lost by poor judgment now than ever before, there is a greater need for excellent judgment than ever before. Second, the appropriate performance rating function must be chosen, and an acceptable mathematical model to explain the system must be built. Finding the best design for a complicated system necessitates a significant amount of human judgment. It's not unheard of for the initial attempt at optimizing a model using a particular technique to have unsatisfactory results.

Steve Cockcroft [28] For over 5000 years, casting techniques have been exposed to continuous technical advancement, primarily through trial-and-error improvement. Casting operations are increasingly employing numerical optimization techniques. Many ingot casting and near-net-shape processes are numerically analyzed and optimized in the papers in the Special Issue "Optimization of Industrial Casting Processes." Michail Papanikolaou et al [29] and Konstantinos Salonitis This is one of the first attempts in counter-gravity casting to combine CFD simulations with multi-objective optimization approaches. Its goal is to figure out how feeder design affects shrinkage porosity so that a new type of casting process may enhance casting quality and yield (CRIMSON). A multi-objective problem was reduced to a single-objective problem using the weighted sum approach. Heat treatment can be used to enhance the cast product's mechanical characteristics and remove residual stresses. Mohd. et al [30] The gating system controls both the flow pattern and the mould filling. To address inclusion, cold shuts, gas porosity, shrinkage, Misruns, and Slag, various gating approaches can be used. Non-gravity casting employs the tap and collect method to carry water, whereas gravity casting allows for better flow. The flow rate and velocity trajectory with the water model are also quite close, according to simulation experiments.

Mohd. Muzammil et al [31]. A significant number of variables influence the various casting quality aspects of the product during the metal casting process. Some parameters, such noise factors, can be changed, but others cannot. Clay composition, moisture level, ramming, sand particle size, metal fluidity, and gating design are all factors to consider. Taguchi's Robust Design approach is used to optimize the gear blank casting process in this study. Nandagopal M et al [32] said that an adequate degree of those operating variables is empirically proved using in modern casting foundry. The quality of the mould is critical in the green sand casting method for producing high-quality castings. These properties are improved by improving method factors such as ramming phases, thickness of wall in mould, and weight percent of bentonite with the help of grey relational analysis done by Taguchi method. Because of improved mould quality, casting rejection related to mould in stress plate casting has lowered from 40 percent to percentage. The intriguing part is that improving the value of permeability from 80 - 120 increases the nominal mold hardness and decreases the thickness of the wall, which improves the mould quality. M Arulraj et al [33] Squeeze casting is a simple method for making composite materials with advantages including low material processing costs, convenience of material handling, size, design, and matrix structure stability. The composite was made of an LM24 aluminum alloy strengthened with silicon carbide as well as coconut shell ash. Taguchi optimization was employed to find the best casting condition.

Yong Kuk Park et.al. [34] can be used to find the best casting sequence that maximizes the average efficiency of particular molten alloys and masses. Furthermore, by including ingot M. L. Skryabin and Likhanov, "The study of casting defects in steel 35 HGSL,adjustment based on the reality of discrete ingot size, this LP scheduling can increase ingot use while also meeting deadlines. Sushilkumar et al.[35] In a green sand casting process, Taguchi optimization was used to determine the best operating variables for a cast-iron differential housing cover product. A cause and effect diagram is employed to define the main factors are identified using a cause and effect diagram. To identify the ideal levels matching to the process parameters and how many minimal experimental trials need to be done, signal-to-noise ratio, ANOVA, and orthogonal arrays are used. According to the findings, the Taguchi approach reduced casting defects by 3.36 percent of the total castings produced, compared to 5.18 percent previously. The Taguchi method was proven to be successful in reducing casting defects as well as reducing costs.

The Taguchi technique was proposed by Jayalaxmi et al.[36] to enhance the green sand casting operating variables.. Each sample was subjected to a dye penetrant test and an ultrasonic test to investigate surface and interior flaws, respectively. ANOVA is used to determine how specified process parameters affect a casting's mechanical properties. The entire performance of the sand casting method is significantly improved by integrating experimental and analytical methods, including the most significant variable is obtained from the result reaction. Taguchi's technique predicts better parameters for castings with the best tensile strength and hardness, and casting samples are then created. The Taguchi technique proved effective in forecasting the components that provide the key attributes, according to the numerical and computational data. Manjunath Patel G C et al.[37] The benefits of both forging and casting are integrated in the hybrid squeeze casting technique. The three most significant casting quality criteria are yield strength, surface roughness and ultimate tensile strength. If the control factors were adjusted appropriately, most squeeze casting defects could be avoided. Bhaskar Chandra Kandpal et al.[38] mentioned that the same issue exists in the sand casting technique. In this study, he stated how to reduce casting flaws in the sand casting process by adopting best practices. Blowholes, shrinkage, sand inclusions, and other sand casting problems arose as a result. Any casting technique has one and only one limitation: casting flaws. Overall clay proportion in the soil matrix was abnormally high, as well as the sand size of the particles were large, according to sand tests.. The grade of moulding sand, including size of the sand particles, clay content, as well as humidity proportion, can be adjusted to eliminate defects, according to Casting difficulties and their solutions. It is critical to take preventative actions in order to improve industrial quality and productivity. Chelladurai C et al.[39] explained about An in depth grasp of critical casting flaws and their primary causes. For effective castings, the demanding circumstances of defects occurring in casting must be spotted and minimized. A foundry's entire performance as a key organization should be successfully excessive in terms of producing with the fewest possible rejections. Precasting processes include pattern creation, centre forming, moulding and mildew assembling, Casting processes include metal charging, melting, protecting, pouring, and Postcasting processes include shakeout, inspection, and delivery, among others. Foundries, being the primary deliverer of castings, contribute a critical part for casting industries in the current globalization environment.

Dabade et al.[40] attempted to find the best processing parameters settings for molding sand of the specified ductile cast iron component in a green sand casting process. For casting defect investigation, the Taguchi method is utilized. The Taguchi optimization approach is used to select optimal values that correlate to the mould process parameters. The selected process parameters are considered after the rejection rate and casting faults, according to ANOVA. The Taguchi approach was used to obtain the optimum amounts of mould process parameters, according to the results. The percentage of casting faults that are rejected has decreased from 10% to 3.59 percent. Casting yield and quality were greatly enhanced as a result of the use of the casting simulation technique. Skryabin M L et al.[23] studied that Grain barriers, such as high-quality character particles or movies made from molten eutectics, are slightly soluble within the austenite phase. It is indeed important to keep in mind that rock fractures are also most prominent near grain boundary. A strongly outlined homogeneous flooring upon which crack occurs distinguishes a rock type fracture. The types of defects seen in castings made using an electric driven arc smelting are examined. The rock-like and naphthalene fractures are of particular interest to researchers. Amit Sata et al.[41] said, Many castings include faults and must be rejected, fixed, or recycled, despite the best efforts of foundry experts (remelted). This results in waste of production resources, decreased productivity and a delay in the delivery of components to consumers. By recognizing and regulating the critical factors, these defects can be considerably eliminated (connected to process and composition). Because the above criteria vary so much, this is a tough process. Data related to process parameters and chemical composition of alloys are collected and the most influential parameters are found using Bayesian inference. These are then compared to real time industry data. The methodology was easy to follow even for people without any training.

T.R. Vijayaram et al.[42] provide remedies including quality check variables to ensure that foundry business personnel as in quality assurance divisions of casting manufacture are not in the dark. Quality is described as the ability of finished cast objects to fulfill established requirements, standards as well as the belief that perhaps the quality of products & services would decide the customer's enjoyment. Both of these goals can be met by combining product development, maintenance, and enhancement. It has been established all of this in attempt to lessen metal casting production rejections as well as scrap, rigorous supervision and effective incentive of individual employees are required. To improve quality, a scrap prevention team, in addition to the quality control department, is essential, and each employee should be aware of this. Sarabjit Singh et al.[43] Due to machining, the component which has shrinkage porosity at bearing surfaces and bores, casting was rendered purposeless. The reduced rejection of machined casting of the component's casting from 5.8 - 0.7 percent resulted in a savings of around 13000 USD over a 14-month period. Reynolds numbers of 16307 and 13806 were found in ancient gating casting parts with transmission housing perimeters of 290 mm and 264 mm, respectively, using simulation software. The aim of this journal is to minimize porosity and shrinkage defects in sand casting parts with the help of MAGMAS modelling software. In various grades and weight ranges, casting defects are being investigated and reduced. Through an experimental investigation Charnnarong Saikaew et al.[44] in the iron casting sector, they discovered that the purity of the sand mold is essential for foundry makers to create significant iron casting. In a reused sand mould, the impact of varied concentrations of bentonite as well as water on the characteristics of the sand mold were examined. To use the preceding analytic methods, the goal of this study has been to enhance the quantity of bentonite as well as water pumped together into reusable moulding sand in terms of reducing ferrous castings waste. A stereo microscope has been used to examine the purity of the iron castings, as well as Rockwell hardness test apparatus was being used to measure the surface roughness. Experiment design, response surface approaches, and error propagation are all combined in this strategy. The ideal proportion was 93.3 percent each reused molding sand, 5 percent bentonite, plus 1.7 percent water, including a green compressive strength of about 53,090 N/m2 as well as permeability of 30 A.F.S., according to the study.

Girish Naik [45] aims to improve the foundry process by reducing defects. The gearbox housing is the component under investigation. The overall purpose of the research suggested here is to use Pareto analysis and cause and effect diagrams to lower the rejection rate. Casting rejection rates are lowered and quality improves as a result of detailed root cause investigation and successful implementation of treatments, resulting in a lasting solution to the problem. For the last six months, the avenge percentage rejection was found to be 13.02 percent. So the average cost of housing is Rs. 5000 per unit, these faults cost a lot of money. It is envisaged that faults in product use studies will be reduced by combining a simulation technique with a design of experiment strategy. JIS AD12.1 aluminium alloy was employed, and it was produced inside a green moulding sand, according to Yuki Inoue et al.[46]. As from hardening temperature until the squeeze temperature, the constraining force as from sand mould as well as the shrinkage of the castings were continuously measured using sophisticated equipment. The experiment was subsequently submitted to thermal stress assessments using the FEM (Finite Element Method). The study included four different forms of representational governing equations, as well as mechanical properties for the green sand mould derived from prior research publications. The computed restraining force as well as casting shrinkage were evaluated simultaneously to observed data and tested as proof under this investigation

Kamal et al. [47] thought that if the perfect configuration parameter is applied, it is thought that the green sand composition can generate sound casting. The findings of the compression strength experiment were gathered, and the compositional influence of green sand was investigated. The sand composition indicated above has a compressive strength of $35kN/m^2$. Researchers employed a 2^4 factorial experimental design process to eliminate defects in casting goods by improving the mixture including silica sand, bentonite, water as well as coal in green sand. The study resulted in the identification of the optimum parameter for each factor.The version defined 86.92 percent of overall variation, as per the corrected R-squared value, and the model accurately forecasted and aligned with test outcomes. Omprakas M A et al.[48] explained that within the manufacturing discipline, casting industries play an important role. The Taguchi method is also used in the Minitab software to create the L9 orthogonal array. The precisely manipulated gears are used in one-of-a-kind ranges of the DMAIC approach to identify and control defects. Finally, the pleasant feasible answer is received and its miles advised to the firm, for defects reducing the defects. When generating the casting, the fine of the casting has to be maintained with reduced defects. But the percent of defects may be decreased with the assistance of positive fine manipulation gear and techniques. The manufacturing of complicated form and length merchandise is a synthetic method, which can't be produced in different production processes. The key recognition in this research is to minimize the shrinkage disorder that arises within the ductile forged external bearing ring. The alternative process necessitates a few procedures to turn a raw fabric into a finished product. Vaibhav Ingle et al.[16] presented that many industries aim to enhance high-satisfaction in addition to productiveness of producing products. A wide variety of method parameters to be managed, even as a casting method, there is no uncertainty and defects are faced by means of organizations. In casting method industries want a technical option to limit the uncertainty and defects. Also offer preventive movement to enhance high-satisfaction in addition to productiveness at a commercial level.

V. CONCLUSION

After analyzing several research papers, it was discovered that a single optimization technique is ineffective in eliminating all casting faults. Various casting optimization techniques were reviewed in the research papers included in this review publication, including the Taguchi method, Artificial Neural Networks, Back Propagation Neural Networks, and so on. Taguchi optimization technique was found to be effective in determining the optimum levels for various process parameters in the casting process, as well as in reducing casting defects. Other optimization techniques, such as Artificial Neural Networks (ANNs) and Back Propagation Neural Networks (BPNNs), can be utilized to avoid casting defects by training the system with previously available data. Rejection rate in total casting is one of the major issues in small-scale and medium-scale foundries. Productivity and Casting yield is improved by reducing the Rejection rate of casting products. Any type of foundry can benefit from optimization approaches to reduce casting defects to a significant amount.

REFERENCES

[1] A. Sunanda and M. V. Jagannadha Raju, “Simulation for prediction analysis of defects in pulley casted using sand casting process,” *Mater. Today*, Mar. 2021, doi: 10.1016/j.matpr.2021.01.734.

[2] M. W. Fu and M. S. Yong, “Simulation-enabled casting product defect prediction in die casting process,” *International Journal of Production Research*, vol. 47, no. 18. pp. 5203–5216, 2009. doi: 10.1080/00207540801935616.

[3] N. Sultana, M. Rafiquzzaman, Y. Rahman, and A. Das, “Solidification and Filling Related Defects Analysis Using Casting Simulation Technique with Experimental Validation,” *International Journal of Mechanical Engineering and Applications*, vol. 6, no. 6, pp. 150–160, May 2019.

[4] “Casting Design and Simulation of Cover Plate Using AutoCAST-X Software for Defect Minimization with Experimental Validation,” *Procedia Materials Science*, vol. 6, pp. 786–797, Jan. 2014.

[5] N. Hebsur *et al.*, “Casting Simulation for Sand Casting of Flywheel,” *IOSR Journal of Mechanical and Civil Engineering*, vol. 11, no. 4. pp. 37–41, 2014. doi: 10.9790/1684-11473741.

[6] R. P. Barot and V. S. Ayar, “Casting simulation and defect identification of geometry varied plates with experimental validation,” *Materials Today: Proceedings*, vol. 26. pp. 2754–2762, 2020. doi: 10.1016/j.matpr.2020.02.575.

[7] P. M. Kumar, P. Madhan Kumar, E. Jacob, S. Savithri, and G. S. Suneeth, “Quantitative Feeder Design for Metal Castings,” *Materials Science Forum*, vol. 830–831. pp. 49–52, 2015. doi: 10.4028/www.scientific.net/msf.830-831.49.

[8] J. As, A. S. Jabur, and F. M. Kushnaw, “Casting Simulation and Prediction of Shrinkage Cavities,” *Journal of Applied & Computational Mathematics*, vol. 06, no. 04. 2017. doi: 10.4172/2168-9679.1000371.

[9] F. Nurjaman, A. Shofi, U. Herlina, N. M. Prilitasari, and Y. Triapriani, “Simulation for grinding balls production using sand mold-gravity casting,” *IOP Conference Series: Materials Science and Engineering*, vol. 285. p. 012029, 2018. doi: 10.1088/1757-899x/285/1/012029.

[10] D. Wang, J. Sun, A. Dong, D. Shu, G. Zhu, and B. Sun, “An optimization method of gating system for impeller by RSM and simulation in investment casting,” *The International Journal of Advanced Manufacturing Technology*, vol. 98, no. 9–12. pp. 3105–3114, 2018. doi: 10.1007/s00170-018-2474-z.

[11] C. M. Choudhari, K. J. Padalkar, K. K. Dhumal, B. E. Narkhede, and S. K. Mahajan, “Defect Free Casting by Using Simulation Software,” *Applied Mechanics and Materials*, vol. 313–314. pp. 1130–1134, 2013. doi: 10.4028/www.scientific.net/amm.313-314.1130.

[12] S. I. Jeong, C. K. Jin, H. Y. Seo, J. D. Kim, and C. G. Kang, “Mould design for clutch housing parts using a casting simulation of high pressure die casting,” *International Journal of Precision Engineering and Manufacturing*, vol. 17, no. 11. pp. 1523–1531, 2016. doi: 10.1007/s12541-016-0178-6.

[13] S.-L. Lu, F.-R. Xiao, S.-J. Zhang, Y.-W. Mao, and B. Liao, “Simulation study on the centrifugal casting wet-type cylinder liner based on ProCAST,” *Applied Thermal Engineering*, vol. 73, no. 1. pp. 512–521, 2014. doi: 10.1016/j.applthermaleng.2014.07.073.

[14] R. Kumar, S. Madhu, K. Aravindh, V. Jayakumar, G. Bharathiraja, and A. Muniappan, “Casting design and simulation of gating system in rotary adaptor using procast software for defect minimization,” *Materials Today: Proceedings*, vol. 22. pp. 799–805, 2020. doi: 10.1016/j.matpr.2019.10.156.

[15] S. Aravind, P. Ragupathi, and G. Vignesh, “Numerical and experimental approach to eliminate defects in al alloy pump- crank case processed through gravity die casting route,” *Materials Today: Proceedings*, vol. 37. pp. 1772–1777, 2021. doi: 10.1016/j.matpr.2020.07.365.

[16] V. Ingle and M. Sorte, “Defects, Root Causes in Casting Process and Their Remedies: Review,” *International Journal of Engineering Research and Applications*, vol. 07, no. 03. pp. 47–54, 2017. doi: 10.9790/9622-0703034754.

[17] M. P. S. S, Mr. Patil Sachin S, and G. R. Naik, “Defect Minimization in Casting through Process Improvement-A Literature Review,” *IOSR Journal of Mechanical and Civil Engineering*, vol. 14, no. 2. pp. 09–13, 2017. doi: 10.9790/1684-1402010913.

[18] “Effectiveness of Feeding System for Enhanced Product Quality in Sand Casting Industries,” *International Journal of Recent Technology and Engineering*, vol. 8, no. 4S2. pp. 231–237, 2019. doi: 10.35940/ijrte.d1048.1284s219.

[19] D. Han, W. Jiang, J. Xiao, K. Li, Y. Lu, and L. Lou, “Investigating the evolution of freckles into sliver defects in Ni-based single-crystal superalloy castings,” *Materials Today Communications*, vol. 27. p. 102350, 2021. doi: 10.1016/j.mtcomm.2021.102350.

[20] R. Tasaki, H. Seno, and K. Terashima, “Process design and control of greensand mold press casting using estimation of metal filling behavior,” *Procedia Manufacturing*, vol. 15. pp. 443–450, 2018. doi: 10.1016/j.promfg.2018.07.241.

[21] M. Blair, R. Monroe, C. Beckermann, R. Hardin, K. Carlson, and C. Monroe, “Predicting the occurrence and effects of defects in castings,” *JOM*, vol. 57, no. 5. pp. 29–34, 2005. doi: 10.1007/s11837-005-0092-3.

[22] L. Jia, D. Xu, M. Li, J. Guo, and H. Fu, “Casting defects of Ti-6Al-4V alloy in vertical centrifugal casting processes with graphite molds,” *Metals and Materials International*, vol. 18, no. 1. pp. 55–61, 2012. doi: 10.1007/s12540-012-0007-0.

[23] M. L. Skryabin and V. A. Likhanov, “The study of casting defects in steel 35HGSL,” *Journal of Physics: Conference Series*, vol. 1399. p. 044063, 2019. doi: 10.1088/1742-6596/1399/4/044063.

[24] D. B. Karunakar, D. Benny Karunakar, and G. L. Datta, "Prevention of defects in castings using back propagation neural networks," *The International Journal of Advanced Manufacturing Technology*, vol. 39, no. 11–12. pp. 1111–1124, 2008. doi: 10.1007/s00170-007-1289-0.

[25] L. A. Dobrzański, M. Krupiński, J. H. Sokolowski, P. Zarychta, and A. Włodarczyk-Fligier, "Methodology of analysis of casting defects," *Journal of Achievements of Materials and Manufacturing Engineering*, vol. 18, no. 1–2, Aug. 2006, Accessed: Oct. 17, 2021. [Online]. Available: http://dx.doi.org/

[26] S. Nallusamy, A. M. Muhammad Umarmukdhar, and R. Suganthini Rekha, "A Proposed Supply Chain Model for Productivity Enhancement in Medium Scale Foundry Industries," *International Journal of Engineering Research in Africa*, vol. 20. pp. 248–258, 2015. doi: 10.4028/www.scientific.net/jera.20.248.

[27] C. Wood, "Review of Design Optimization Techniques," *IEEE Transactions on Systems Science and Cybernetics*, vol. 1, no. 1. pp. 14–20, 1965. doi: 10.1109/tssc.1965.300054.

[28] S. Cockcroft, "Optimization of Industrial Casting Processes," *Metals*, vol. 10, no. 3. p. 360, 2020. doi: 10.3390/met10030360.

[29] M. Papanikolaou, E. Pagone, K. Georgarakis, K. Rogers, M. Jolly, and K. Salonitis, "Design Optimisation of the Feeding System of a Novel Counter-Gravity Casting Process," *Metals*, vol. 8, no. 10. p. 817, 2018. doi: 10.3390/met8100817.

[30] J. Jezierski, R. Dojka, and K. Janerka, "Optimizing the Gating System for Steel Castings," *Metals*, vol. 8, no. 4. p. 266, 2018. doi: 10.3390/met8040266.

[31] M. B. N. Shaikh, S. Ahmad, A. Khan, and M. Ali, "Optimization of Multi-Gate Systems in Casting Process: Experimental and Simulation Studies," *IOP Conference Series: Materials Science and Engineering*, vol. 404. p. 012040, 2018. doi: 10.1088/1757-899x/404/1/012040.

[32] M. Nandagopal, K. Sivakumar, S. Velmurugan, R. B. Durairaj, and G. Mageshwaran, "Multi-objective optimization of western bentonite (Al2H2Na2O13Si4)-blended green sand casting process parameters to improve mould quality," *Transactions of the Canadian Society for Mechanical Engineering*, vol. 45, no. 1. pp. 110–119, 2021. doi: 10.1139/tcsme-2020-0011.

[33] M. Arulraj, P. K. Palani, and M. Sowrirajan, "Optimization of squeeze casting parameters of hybrid aluminium matrix composite using Taguchi approach," *Proceedings of the Institution of Mechanical Engineers, Part E: Journal of Process Mechanical Engineering*, vol. 235, no. 4. pp. 1073–1081, 2021. doi: 10.1177/0954408921989864.

[34] Y. K. Park and J.-M. Yang, "Optimization of mixed casting processes considering discrete ingot sizes," *Journal of Mechanical Science and Technology*, vol. 23, no. 7. pp. 1899–1910, 2009. doi: 10.1007/s12206-009-0428-y.

[35] S. Kumar, P. S. Satsangi, and D. R. Prajapati, "Optimization of green sand casting process parameters of a foundry by using Taguchi's method," *The International Journal of Advanced Manufacturing Technology*, vol. 55, no. 1–4. pp. 23–34, 2011. doi: 10.1007/s00170-010-3029-0.

[36] J. A, A. Jayalaxmi, B. S. Kodli, PDA COLLEGE OF ENGG, and GULBARGA, "A Study to Optimize the Casting Process Parameters of IS1030 Steel using Taguchi Technique," *International Journal of Engineering Research and*, vol. V4, no. 06. 2015. doi: 10.17577/ijertv4is060641.

[37] G. C. M. Patel *et al.*, "Teaching learning based optimization of squeeze casting process for quality castings," *IOP Conference Series: Materials Science and Engineering*, vol. 376. p. 012112, 2018. doi: 10.1088/1757-899x/376/1/012112.

[38] B. C. Kandpal *et al.*, "Experimental study of foundry defects in aluminium castings for quality improvement of casting," *Materials Today: Proceedings*. 2021. doi: 10.1016/j.matpr.2021.01.513.

[39] C. Chelladurai, N. S. Mohan, D. Hariharashayee, S. Manikandan, and P. Sivaperumal, "Analyzing the casting defects in small scale casting industry," *Materials Today: Proceedings*, vol. 37. pp. 386–394, 2021. doi: 10.1016/j.matpr.2020.05.382.

[40] U. A. Dabade and R. C. Bhedasgaonkar, "Casting Defect Analysis using Design of Experiments (DoE) and Computer Aided Casting Simulation Technique," *Procedia CIRP*, vol. 7. pp. 616–621, 2013. doi: 10.1016/j.procir.2013.06.042.

[41] A. Sata and B. Ravi, "Bayesian inference-based investment-casting defect analysis system for industrial application," *The International Journal of Advanced Manufacturing Technology*, vol. 90, no. 9–12. pp. 3301–3315, 2017. doi: 10.1007/s00170-016-9614-0.

[42] T. R. Vijayaram, S. Sulaiman, A. M. S. Hamouda, and M. H. M. Ahmad, "Foundry quality control aspects and prospects to reduce scrap rework and rejection in metal casting manufacturing industries," *Journal of Materials Processing Technology*, vol. 178, no. 1–3. pp. 39–43, 2006. doi: 10.1016/j.jmatprotec.2005.09.027.

[43] S. Singh, N. Sharma, and R. Khanna, "Defect elimination in green sand casting using simulation techniques: A case study," *International Journal of Modeling, Simulation, and Scientific Computing*, vol. 11, no. 05. p. 2050049, 2020. doi: 10.1142/s179396232050049x.

[44] C. Saikaew and S. Wiengwiset, "Optimization of molding sand composition for quality improvement of iron castings," *Applied Clay Science*, vol. 67–68. pp. 26–31, 2012. doi: 10.1016/j.clay.2012.07.005.

[45] G. R. Naik, "Process Improvement in Casting through Defect Minimization: A Case Study," *International Journal of Scientific and Engineering Research*, vol. 8, no. 4, Apr. 2017, Accessed: Oct. 17, 2021. [Online]. Available: http://dx.doi.org/

[46] "Effect of sand mold models on the simulated mold restraint force and the contraction of the casting during cooling in green sand molds," *J. Mater. Process. Technol.*, vol. 213, no. 7, pp. 1157–1165, Jul. 2013.

[47] R. M. Said, M. Kamal, N. Miswan, and S. J. Ng, "Optimization of Moulding Composition for Quality Improvement of Sand Casting," 2018, Accessed: Oct. 17, 2021. [Online]. Available: https://www.semanticscholar.org/paper/Optimization-of-Moulding-Composition-for-Quality-of-Said-Kamal/b434677c4ff8d03ec161059eb1c427b13b648388

[48] M. A. Om Prakash *et al.*, "Analysis of Shrinkage Defect in Sand Casting by Using Six Sigma Method with Taguchi Technique," *IOP Conference Series: Materials Science and Engineering*, vol. 1059, no. 1. p. 012047, 2021. doi: 10.1088/1757-899x/1059/1/012047.