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Original Article

Inclusive Module to foster SMEs for Defect Identification in Sand Casting

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Abstract - *Even with extreme caution while producing casting components, flaws will inevitably arise due to the broad range of variables that can go wrong during the specific phases of pattern, moulding, melting, pouring, heat treating, etc. Accurately identifying flaws and taking corrective action requires real experience and information gathered over time. Small and medium-sized casting companies, however, try to locate and hire quality specialists for fault identification. Research on creating a module to help SMEs identify defects and become less reliant on human expertise was presented. The most crucial step in the casting defect analysis procedure was creating a structural database, which was accomplished by assessing the literature and applying it practically. Developing a module to detect casting defects and provide corrective actions was part of the present research. The physical characteristics of the casting flaw were used to identify it, and the appropriate remediation was then performed. Both experts and novices can utilize the computer-assisted created module to solve the problem. The module's confirmation was also achieved by doing a defect analysis in the casting sector to remedy the casting flaw.*

Keywords - *Casting defects, Defect identification, Defect analysis module, Expert system, Sand Casting.*

1. Background

One of the oldest direct manufacturing methods used to produce components with the required geometry is metal casting. Foundries today face various challenges in the casting process due to defects occurrence that often emerge. In the current era of global dynamism and competitiveness, foundries need to execute professionally with the least number of rejections owing to defect incidence. Because casting involves the combination of many engineering and scientific disciplines at several manufacturing levels, it is sometimes described as the process with the highest degree of uncertainty. Because so many manufacturing parameters are involved in the casting process—from design and pattern generation to moulding, melting, pouring, and so on—defects could occur at any point during the production process, including shakeout and heat treatment. Furthermore, casting product flaws, or the incidence of defects, are also attributed to carelessness, a lack of coordination and controls, and occasionally the insufficient expertise of different production-related personnel.

Since describing the examined problem is only half the battle fought, precise identification of the casting defect is critical to achieving defect-free casting. Since there is a greater chance that an incorrect diagnosis will lead to a casting product with flaws, inaccurate identification puts the entire production at risk. Although quality control personnel are still at the forefront of their field when it comes to diagnosing casting flaws, for the foundry industries to expand more successfully, this expertise requires to be transformed into technical knowledge. Over the past ten years, a few academics have undoubtedly developed modules based on engineering skills, but the modules are still not used in industries. Consequently, the work presented here attempts to bridge the implementation gap for the foundry fault diagnosis module. The implementation of a module for foundry defect diagnostics will be based on this specification.

2. Rationale

High-end production and measurement equipment is lacking in small and medium-sized enterprises. These conditions could result in the emergence of flaws that are created throughout the production process. In addition, these sectors lack the professional qualifications required for casting flaw investigation. Therefore, it may be inferred that the ability of the individual in question to handle casting defects is a major factor in small and medium-sized enterprises. Undoubtedly, a small number of researchers have created engineering-based modules in the past ten years, but the industry is still a long way from implementing these modules. It is challenging to deploy in foundries when modules are developed without taking into account the conditions on the shop floor. Therefore, the work that is being discussed here focuses on closing the implementation gap for defect diagnosis modules in foundries. This study will be used as a first step towards the implementation of a defect diagnosis module in foundries.

3. Literature Review

Despite being the most traditional manufacturing process, casting still has casting flaws because of the challenges associated with producing certain items. Many researchers have examined casting faults in this way. This paper discusses a unique approach designed for casting defect analysis to enhance the casting industries, with a focus on small and medium-sized casting industries in defect analysis. However, when one looks at the actual industry representation of these modules, one finds very few people. Creating research on casting defect analysis that applies to companies requires acknowledging the many developments made over the years.

It was concluded in the research article that no single piece of software completely satisfies the requirements of the foundry industry. It is also dubious that any sole numerical technique will be able to cope with the range of problems. For practical reasons, mainly timescales, it is hybrid software packages that are possibly be most successful, combining experimental data with a numerical analysis and optimization approach [1]. A knowledge-based engineering module was developed to detect casting flaws in cylinder blocks. Two modules were developed: one for diagnosing issues and the other for offering solutions. In an alternative module, complex inspection and defect interpretation problems were resolved by the employment of the magnetic method, dye penetrant test, and ultrasonic test [2]. This research article [3] examines the creation of expert systems and their use in the casting industries. Expert systems have the advantage of increasing productivity by letting novice users perform expert-level activities, saving time, streamlining the process, and automating some operations. Expert systems address novel types of issues that conventional software cannot handle. An expert system can function independently as software or as a component of an embedded system, in which case it is integrated into the traditional program and vice versa. Production rules comprise the mainstream of knowledge bases, while other methods for exhibiting knowledge are also employed. Expert systems are capable of handling vague and unclear knowledge by giving rules, probability and certainty factors that indicate the degree of truth or confidence.

Research was carried out on the application of an expert system approach to the problem of metal cutting in a range of machining processes. Inaccurate cutting data is the primary cause of issues in the manufacturing sector, particularly in small and medium-sized machine shops. In order to extend their lifespan for fewer changes, tools were typically operated at lower cutting data. Correct cutting data will result in shorter stoppages caused by breakdowns, good power capacity utilisation, and a reduction in metal cutting time if the problems with metal cutting are resolved. This translates into a significant decrease in production costs. The system created was also meant to educate those working in the metal-cutting business. The images and the details regarding the issues assist users in identifying and understanding them better [4]. Strong, thorough cooperation across Swedish foundries, along with innovative experimental setup and new research techniques, have revealed some fundamental knowledge about the processes behind the creation of metal expansion penetration, shrinkage porosity, and gas porosity in grey cast iron components [5]. The range of instruments, including procedures and experimental configurations, required to produce the complicated mechanisms that are given are thought to be crucial.

It was found during the research that in the present casting industries, designing a casting product and systematically defining processes for product manufacturing is a trial-and-error process based on heuristic know-how [6]. Such an approach produces a result devoid of scientific computation and analysis. This type of process determination requires a lot of trial and error in the workshop since the casting process is highly complex in terms of casting geometry and the physical, metallurgical, and thermal behaviour involved in the casting process. It is challenging to forecast the product’s quality and flaws in the first design phase. The method of virtually realising and verifying the casting quality forecast and defect evaluation through simulation minimises trial-and-error in the workshop. This is because any quality issue may be identified, and corresponding solutions can be suggested. This article outlined the scope of defect analysis and prediction and casting quality enabled by simulation. The framework, steps, and methodology for casting defect prediction enabled by simulation were introduced.

To minimise flaw appearances on the iron casting, the amounts of clay and water added to the recycled moulding sand were optimised using a combination of experimental design, RSM, and POE [7]. The qualities of the moulding sand and the iron casting’s surface quality were greatly impacted by the component proportions. 93.3 mass% of once-recycled moulding sand, 5% mass% of bentonite, and 1.7% mass% of water were found to be the ideal component ratios. The ideal green compression strength of 53,090 N/m2, the ideal permeability of 30 A.F.S. permeability numbers, and the overall attractiveness of 72% were obtained from this mixture. Finding a good set of moulding sand combinations that maximised the desirability function was the goal of optimisation. While specifics about the research findings would only apply to the products of certain manufacturers, the research methodology itself might be broadly applied to other comparable foundry processes. The research was conducted on a critical assessment of Knowledge-Based Engineering (KBE). The topic of Knowledge-Based

Engineering (KBE) investigates technology and methods for capturing and repurposing knowledge in process and product engineering. KBE's main goal was to cut down on the time and expense associated with product development. This was accomplished by automating repetitive design chores and capturing, storing, and repurposing design knowledge. The topic of knowledge-based engineering was found to have great potential, but it also presents a number of obstacles that will need to be researched and resolved during the next ten years [8].

To analyse casting rejection caused by defects related to sand, moulding, methoding, filling, and solidification in green sand casting, a new method of casting defect analysis is proposed and studied. This method combines the design of the experiments method (Taguchi method) with the computer-aided casting simulation technique. The Taguchi approach yielded the optimal amounts of the following selected process parameters: moisture content (A): 4.7%, green compression strength (B): 1400 gm/cm2, permeability number (C): 140, and mould hardness number (D): 85. By using the Taguchi optimisation approach, the percentage of castings that are rejected because of flaws connected to sand is decreased from 10% to a maximum of 3.59%. The way that experiments are designed A technique like the Taguchi method can be effectively used to analyse current casting flaws as well as determine the ideal process parameter settings for a new casting to have the least amount of rejection owing to defects [9].

A complete and hierarchical categorization system for casting defects was attempted to be presented in this work to provide a more scientific and approachable method of casting fault analysis. While the Identification and Diagnosis module outlines the defect's causes and solutions, the Atlas module makes it easier to classify faults. Accurate fault identification and categorization are made possible by an expanding database of reference photos of casting defects. It has been put into practice in an interactive web-based expert system environment that is being improved with industry participation [10].

An automated deep drawing die design method created on knowledge was created for axisymmetric parts. The suggested system was established using the Artificial Intelligence (AI) KBS approach based on production rules. Through the creation of KBS modules for deep drawing die modelling in two and three dimensions, process planning for deep drawn parts, strip-layout design, die components die component selection, and manufacturability assessment of deep drawn parts, the laborious and time-consuming manual task of designing deep drawings was automated [11].

The research discovered that the control variables differed according to the response variables, with the biggest impacts coming from pouring rates and moisture content. Given their experience and comparable skill sets, the trials demonstrated that the two distinct pouring operators had no discernible impact on the misrun faults. The misruns were not significantly affected by the size of the filter or the pouring temperature. The S/N ratio effects table and the average misrun defects table were used to determine the ideal parameter setting. In the confirmation run, the defect percentage dropped from 31% to 4% with the ideal parameter setup. The application of the Six Sigma technique proved effective in locating the issue, enhancing the workflow, and reducing errors, it can be said [12].

A viewpoint on the application of intelligent and knowledge-based systems in Industry 4.0. In this publication, researchers have provided a preliminary view of how intelligent systems may help Industry 4.0. The benefit resides in the more effective utilisation of the information and data produced throughout the production processes for tendency analysis, prognosis, and repurposing [13].

In a research study, a succinct outline of the expert system's growth and fundamental structure, as well as a technical history. The present expert systems are hooked on four categories based on the enabling technology: Rule-Based Expert System, Framework-Based Expert System, Fuzzy Logic-Based Expert System, and Expert System Based on Neural Network [14].

A prototype based on computer-assisted knowledge integration to identify the defect's source and search through it using various search terms was created. Information for the database was gathered from a variety of sources. The user-collected inputs were managed through relationships built into the database [15].

The article presented an expert system created for casting flaw analysis. It was a computer programme designed to solve casting quality issues using expert knowledge. The three distinct modules of the programme are identification, diagnosis, and remedies. The study showed that expert systems can be an effective instrument for foundrymen to identify and analyse casting problems. They can also be a means of ensuring higher-quality castings and lower reject costs [16].

This paper discusses casting faults with an emphasis on industry case studies. The notion of cause and defect analysis is used to recommend various reasons and corrective actions. This study will be very helpful in lowering casting flaws in the industry and raising casting quality while minimising rejection. Experts in foundries will find it very helpful in raising the casting yield [17].

Research on the identification of common casting faults and their effects on casting quality was provided in the article [18]. The study's findings demonstrated that notable casting flaws had a statistically significant impact on the castings' quality. It was found that few aspects were statistically significant, including Gas Porosity (GP), Shrinkage Porosity (SP), Hot Tears (HT), Metal Penetration (MP), Sand Inclusion (SI), Air Inclusion (AI), and Slag Inclusion (SLI). For any casting company to remain in business over the long run, choosing samples with the fewest possible flaws is essential. The robust Analytical Hierarchy Process (AHP) model was employed in the research work to pick casting samples with the fewest faults. The suggested methodology will be a very helpful instrument for making decisions. The approach used here can be applied to a number of issues related to obtaining the finest casting. Its criterion is similar to that of many other problems, so it can also be used for them.

An article represented literature on quality improvement of casting components through process knowledge [19]. Foundries should prioritise process improvement to get a competitive edge in the current global market. Sand casting foundries can gain a competitive edge by optimising their production and plant maintenance procedures, producing higher-quality products, and making efficient use of their limited resources. When it comes to mitigating the constraints of sand casting industries in reference to alternative metal manufacturing techniques, process expertise may be crucial. The objective of the presented research was to define process knowledge and highlight its significance for reducing defects in sand casting foundries, primarily using the Six Sigma technique. Process improvement depends on comprehending and applying process information. The literature on process knowledge in manufacturing applications was reviewed in this research. The Six Sigma technique was emphasised as a better process understanding than standard process statistical control, offering greater benefits. Ultimately, the goal of the article was to minimise process variance and enhance casting quality by connecting process knowledge to the Six Sigma methodology and the sand casting process [21].

The work [20] showcases a supervised classification method for mathematical modelling (soft modelling) in the context of forecasting certain ductile cast iron casting flaws. The study employs the kNN technique while accounting for various weight sets for the analysed attribute sets. The computer application created by the authors used the algorithm that was explained. Real historical data, such as pouring parameters, chemical composition, percentage share of defective castings (unsuitable for further repairs), and moulding sand, are required to ensure proper operation. It takes a customised strategy to employ a computer programme using the kNN algorithm in a certain foundry. The application's use has a broad scope. The creation of novel procedures and the choice of important production parameters for the pilot production management with the application that is being offered are two examples of this. It will be possible to forecast a variable share of particular errors thanks to the rectified parameters which were added to the reference object. If a sudden process instability increases the output of defective castings, the application will also be helpful. The degree of defective castings can, therefore, be predicted based on the parameter standards that are presently being measured.

The case study [23] employs a Six Sigma methodology that is based on DMAIC to optimise the foundry's process parameters. The ideal values of each process parameter are examined using the Taguchi method of experimental design. The factorial design's results shed light on the process variables influencing the casting procedure. Therefore, it can be inferred from the ANOVA analysis that all six process parameters—mold hardness, green strength, permeability, moisture content, pouring temperature, and pouring rate—are significant deliberations for generating new trials. The findings of the verification test show that the ideal process parameter setting significantly decreased the rejection percentage of casting process errors. However, after a few iterations of the experiments, several differences in the casting process flow were noted. It is because of some technological issues as well as the employee's ignorance of the casting techniques necessary to uphold standards. To raise the performance of the casting operation to the required level, remedial activities were made to rectify and prevent the process, which is extremely close to the key process input variables and key process output variables. The findings above demonstrate that the casting parameters were optimised, and the lowest percentage of casting defects was obtained [22].

The article offers several approaches for categorising casting flaws according to Polish, French, German, and English standards. A brief explanation of the identification process for a few chosen electronic atlases of casting faults was provided by the respective authors. The authors of the article also depicted their innovative tool, Open Atlas of Defects, which includes useful functionality for the evaluation of casting flaws through the naked eye (Visual Testing) and an element comprising programming for casting defects analysis based on years of experience in the field described. The enlarged Open Atlas of flaws is intended to make it easier to recognize the reasons for casting flaws, gather process knowledge about the incidence of unusual defects (defects that are difficult to identify), and conduct appropriate analysis [24].

A medium-sized foundry was surveyed, and it was discovered that the foundry had not standardised its production procedures across several regions. This paper discusses casting faults with an emphasis on industry case studies. Several casting flaws and the reasons behind them were noted in this review. This will assist in identifying the flaws and possible solutions. For better quality, there should be as little casting rejection based on casting flaws as feasible. For the industry, casting errors are extremely serious. Reduce these flaws as much as possible [25]. The researchers discovered that a medium-sized foundry had not standardised its production methods across several regions [26].

The Six Sigma (DMAIC) approach yielded the best possible combination of values. Six months of data collection during the define phase revealed that, out of 21689 total production, 95.54% of the castings were good, and 4.46% were rejected. One of the most common defects is shrinkage fault. because 187 out of the 3099 goods that were manufactured overall had defects or 400 rejections. During the analysis step, the cause and effect diagram is employed to determine the various parameters that may contribute to the shrinkage problem due to the fact that 187 out of the 3099 goods that were manufactured overall had defects or 400 rejections. During the analysis step, the cause and effect diagram is employed to determine the various parameters that may contribute to the shrinkage problem. Mould Hardness in nu, Pouring Temperature in℃, and Tapping Temperature in℃ are the selected parameters. Journals and seasoned business professionals are used to identify these factors. Using the Taguchi technique and Minitab software, the parameter ranges are determined, and three levels of values are selected during the improvement phase. The ideal result is a 75 nu mould hardness, a 1570 ´C tapping temperature, and a 1430℃ pouring temperature. Compared to the starting proportion of 12.90%, the obtained percentage of rejection is 6%. The Taguchi technique, which forms the orthogonal array, and Six Sigma can be utilised to reduce the defect percentage. From this combination, the ideal values can be obtained [27].

A detailed review of casting flaws in sand-mold cast-irons was presented in the article [28]. Metals can be shaped most easily by casting them, and because cast irons have a high eutectic fraction, they are said to be easy to shape. As the current study illustrates, it is not always easy to obtain high-quality cast parts, and the difficulty increases as the requirements for service properties rise. As a result, it has become evident that a variety of factors, including those about alloy composition, melt preparation, mould, gating system design, or sand mould production, may contribute to poor castings. It is anticipated that the examples described in this work will aid in determining the source of the numerous flaws that are displayed. The hands-on steps that are applied as remedies after the faults have been recognised mostly depend on the specifics of each instance, including the features of the foundry shop and facilities, the qualities of the castings, the needs of the clients, etc. It was possible, nevertheless, to enumerate many general fixes that can enhance castings produced using standard foundry procedures. It is noteworthy to notice that a medicine may have unanticipated negative effects or counter-effects. Therefore, foundry employees need to weigh the importance of each effect before selecting the best course of action in a particular situation.

The evaluation of the literature indicates that fewer scholars have presented work on casting flaw analysis. Progresses in the casting defect investigation have been perceived conceivable by the development of intelligent, computer-aided, expert, and module systems. However, as of yet, no information is available regarding the applicability of this kind of technology for the analysis of casting flaws in the casting industries. Reviews of the literature on several expert systems which were established helped to advance casting defect analysis, which is important for usage in the industrial sector. Engaging with the primary casting industry stakeholders was another critical area that required improvement to pinpoint the true problems with putting such a system for the analysis of flaws generated in casting into place in the sectors. Literature and conversations with companies have also emphasized how crucial it is to use simulation software to model casting products before actual manufacture to minimize casting faults. However, the cost of acquiring and retaining skilled personnel was a barrier to its profitability in businesses, particularly medium- and small-sized ones. Furthermore, casting flaw identification in industries has always been a subjective procedure because it relies on a particular human expert. Therefore, the current study is intended to contribute to the medium- and small-scale firms' casting defect analysis process by developing a module that may satisfy their needs.

4. Methodology

The theoretical technique entailed analysing a sizable body of literature that included research articles, casting handbooks, and handbooks on casting defect diagnosis. The practical method involved looking at a variety of casting industries. It was discovered that the expert systems now in use have different cognitive content databases, which made using them difficult for industrial contexts. The identification and rectification of casting flaws also yielded variable results when taking industry concerns and the norms of contemporary expert system analysis into account. There was a lot of information available that could be taken into account while creating a database utilising a theoretical framework. A few enterprises with an annual capacity of casting components ranging from 5000 to 10,000 were chosen to do a thorough study on casting faults. Businesses providing a vast array of goods in the mining, railroad, and earthmoving industries, among many others, have been selected. The company uses the no-bake method and excellent quality control facilities to manufacture exceptional grades of wear and abrasion-resistant steel castings. Carbon steel, low alloy steel, high alloy steel, manganese steel, and various steel grades are among the products. Additionally, the business has received approval and recognition for its quality standards from several public and private organizations.

4.1. The Framework of the Inclusive Module

The current study set out to develop a comprehensive module that would serve as a specialist in resolving issues about casting defects. To find answers, the inclusive Module applies strategy and domain expertise in the relevant domain. Because the inclusive Module is made up of multiple components, including a user interface, an interference engine, and a knowledge repository, it is a system rather than a program, as represented in Figure 1.

4.1.1. Knowledge Database

Casting is affected by several manufacturing process variables and techniques used during component casting, which may also initiate casting fault initiation. Rectifying the issue required identifying its cause, which was crucial. Through industry visits and literature studies, every stage of the casting production process has been meticulously assessed. The key components and features that affect the casting process have been analyzed as follows.

The interaction of all these components results in the use of the domain person's expertise to achieve the desired solution. Among these components is a knowledge base that compiles the domain-specific knowledge needed to solve the problem. This knowledge is derived from the experience of domain experts, as well as from manuals, research articles, old records, standard specifications, rules of thumb, approximate theories, causal models of processes, and common sense. Inference mechanisms are regulator strategies or search techniques that comb through the knowledge base to generate decisions. A regulator strategy entails giving instructions, recommendations, and relational details. IF (condition): The rule is said to fire, and the action component is carried out when the condition part of the rule is met. The state space and the inference make up the knowledge base. Mechanism is a method of reasoning. Until a predetermined objective is reached, this process is carried out with the assistance of user and integrated module interaction, acting as a chain. The user interface facilitates this communication between the user and the integrated module. It consists of an explanatory component, an interactive technique, and screen displays. The end-user interface plays a major role in how well the integrated module executes. To engage with the integrated module effectively, menu systems, interactive techniques including text inputs, an interactive graphics facility, and explanatory facilities are integrated. The relationships between the different causes and corrective measures have also been established to complete the framework of the casting defect analysis. A structure for the casting flaw has been created based on the previously listed components, which identifies the production stage at which the issue originated.

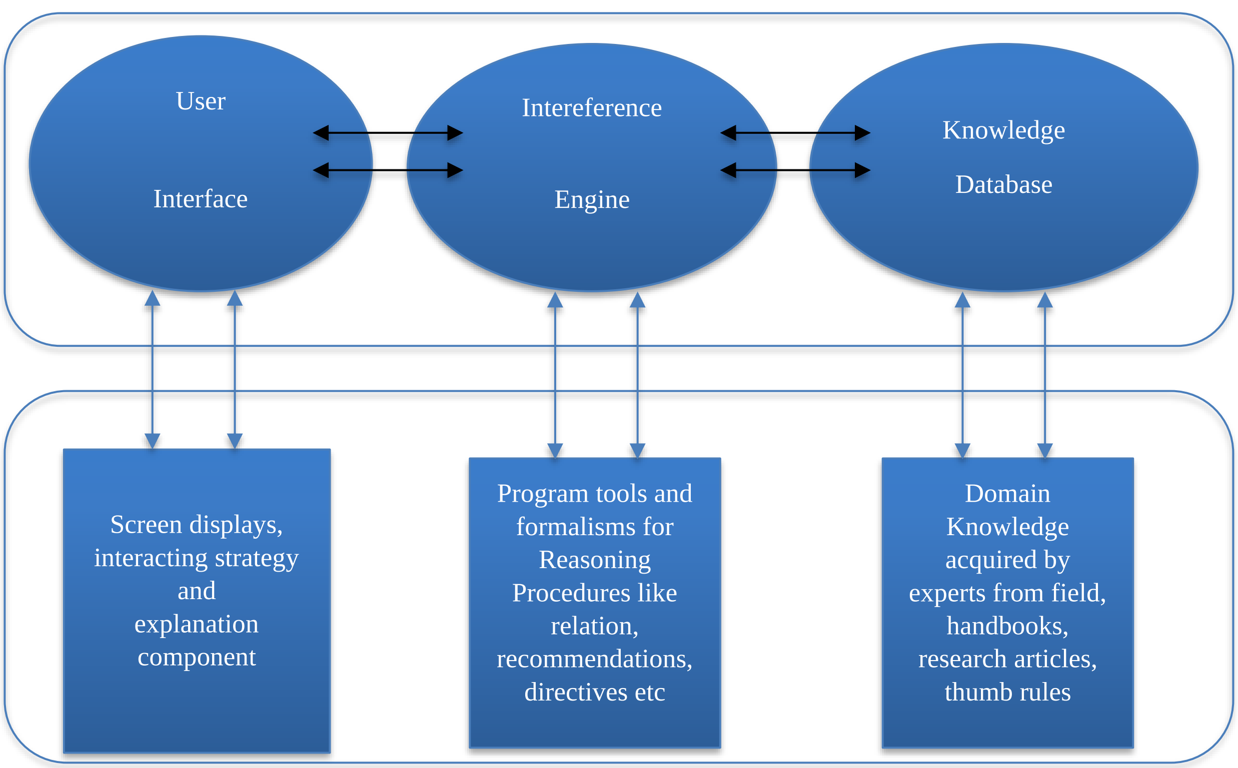

Fig. 1 Framework of the inclusive module

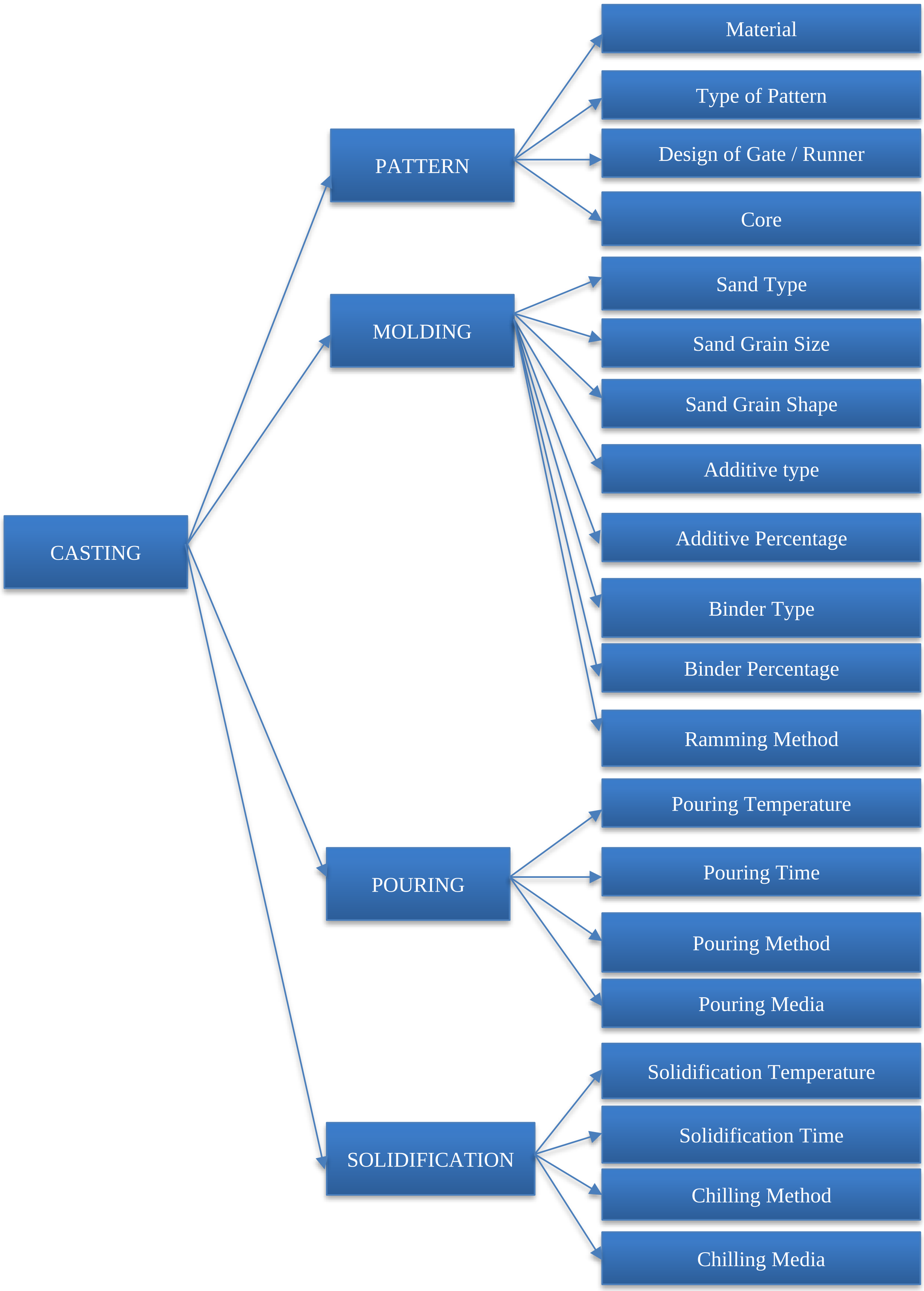

Fig. 2 Casting production stage and concern parameters

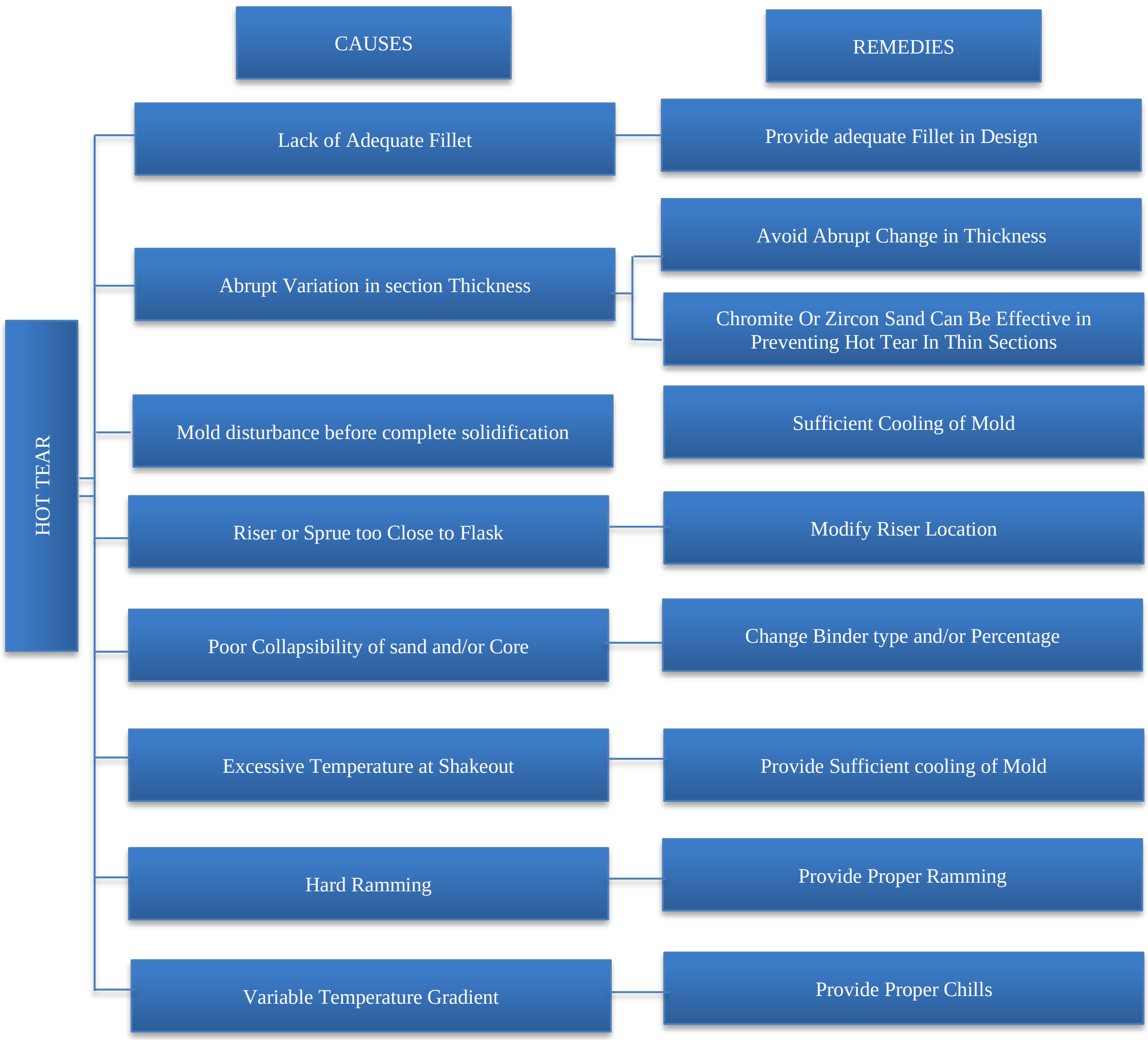

Fig. 3 Relation between defect, causes, and remedies of hot tear

4.2. Defect Causes and Remedies

Defect structure construction was an essential component of module development. Adding theoretical and industrial procedures to the database was the primary demand. For every casting failure, a defect structure was created utilizing theoretical and practical information. This study article presents the existing defect structure for the hot tear defect.

4.3. Casting Defect Analysis

The integral component of this inclusive module was defective diagnostic, on which its success was largely dependent, which helps small and medium-sized businesses with the process of diagnosing casting defects. The casting defect analysis used in the current research covered two distinct facets. The initial component was identifying the casting defect and subsequent was to suggest corrective action to rectify it. Defect diagnosis starts with the interaction between the inclusive module and the user through the user interface.

In the defect diagnosis process, a series of straightforward questionnaire steps were asked of the user. The chart represented in Figure 4 depicts the overview of the defect analysis process.

Inquiries about casting defects based on physical characteristics such as their appearance, position, and geometry were covered in the series of questioning steps. By responding to a series of questions, the type of defect was narrowed down.

The response helps to focus the examination of the casting defect and produce a precise identification of the defect. Figure 5 represents the defect diagnosis process steps in the framework format.

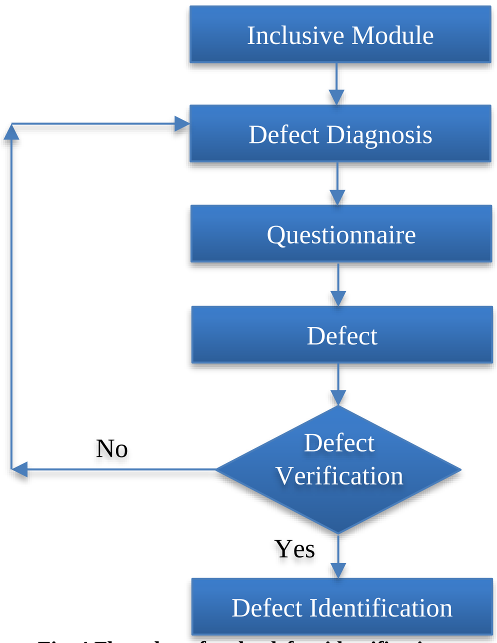

Fig. 4 Flow chart for the defect identification process

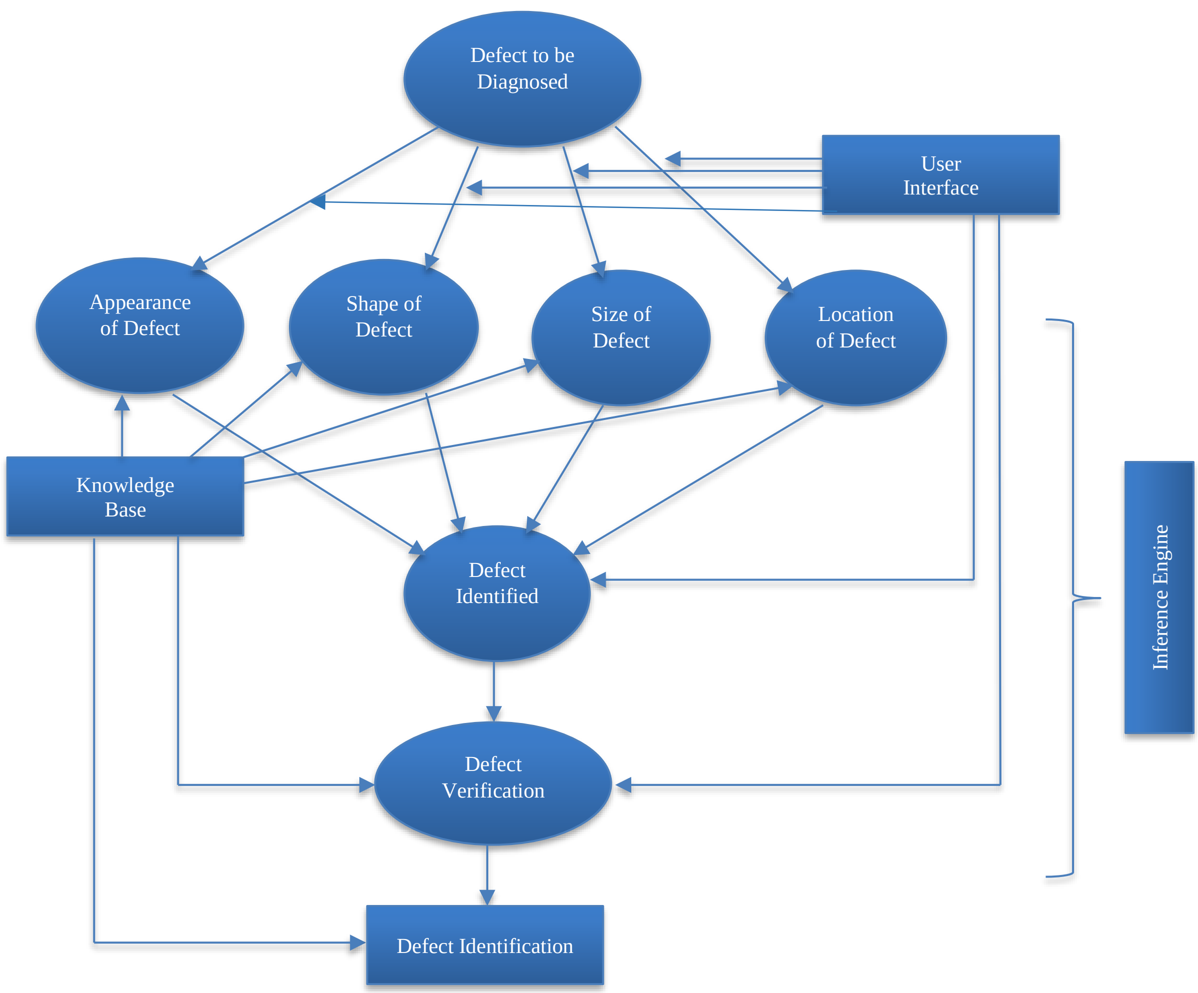

Fig. 5 Framework for the defect identification process

After defect identification, the subsequent step was to get remedies to be applied to rectify the defect. As discussed in the earlier section, the defect remedies are displayed on the screen after the successful identification of the defect. The remedies provided must include causes of the defects and remedies to be applied for rectification of the defect.

The creation of an inclusive module for ferrous casting was the main goal of the comprehensive defect analysis method. Initial testing and verification are done in collaboration with industry, but thorough verification is necessary for a successful deployment. This testing should be done with the participation of tangible stockholders or businesses who use it daily. Hence, validation of the inclusive module was accomplished in the industry.

5. Result and Discussion

A user interaction was necessary for the defect diagnosis procedure in the inclusive module. The following screenshots were captured from the module, for example, of a casting defect hot tear found in an industrial casting component. The following image represents the casting component with the defect.

It showed the defect diagnosis process for hot tears achieved through a series of questionnaires. The defect type carried out the procedures until the final feedback, or defect type, was determined. The gradual steps taken to identify the defect are depicted in Figure 7. The screenshot depicts the steps of the defect identification procedure, where the presence of metal on the surface, the profile of the defect, shape/geometry of the defect, and mould characteristics.

Fig. 6 Defect found in casting component

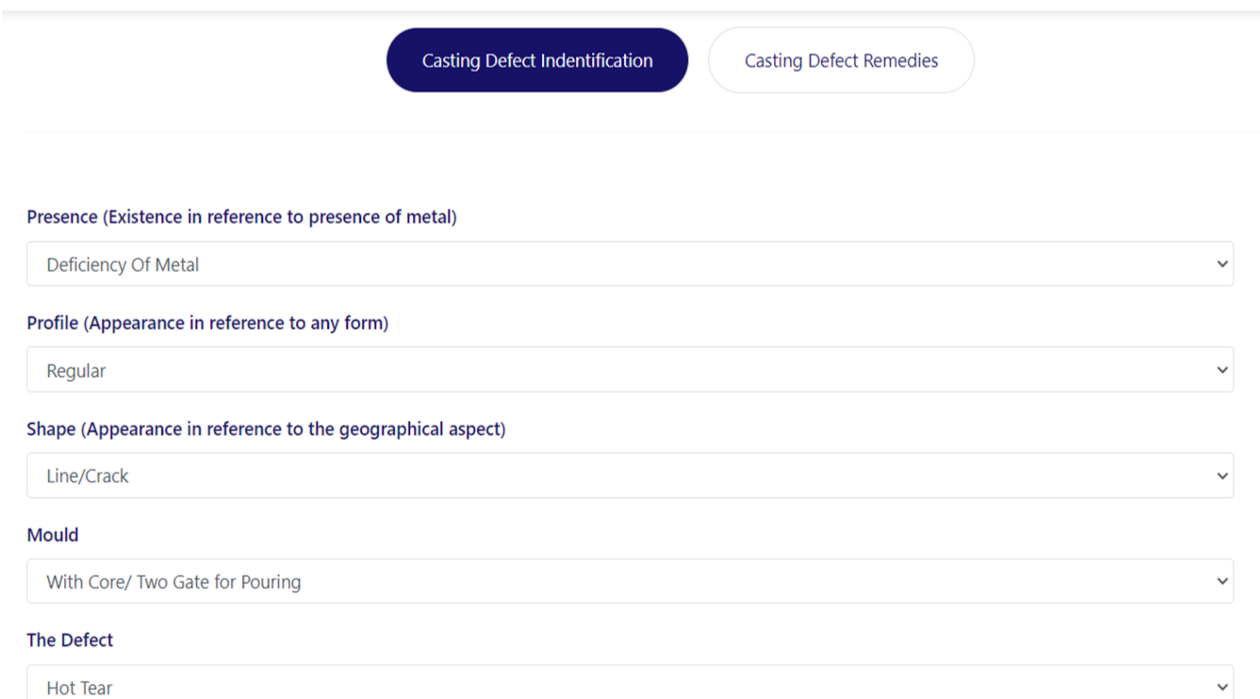

Fig. 7 Screenshot of steps for the defect identification procedure

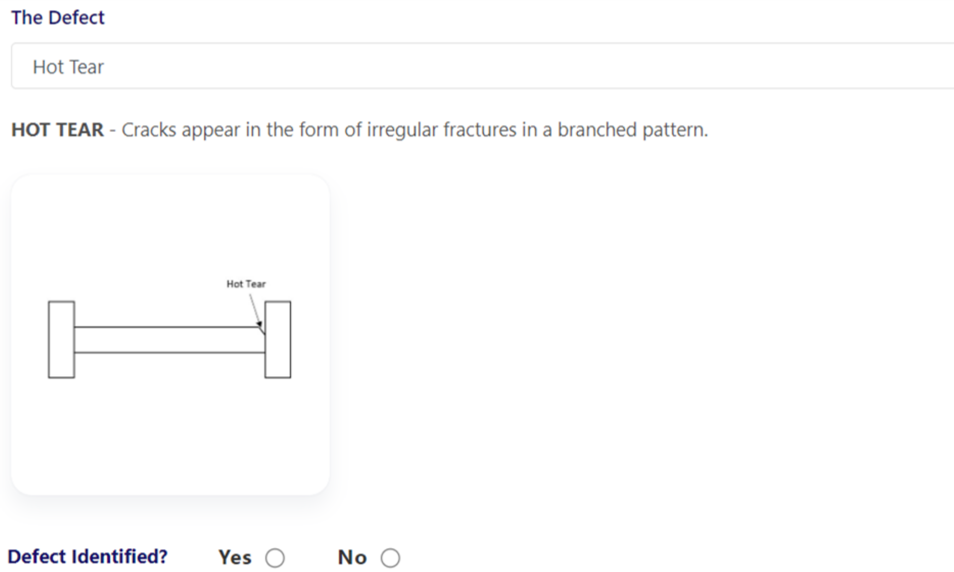

Fig. 8 Screenshot of steps for the defect identification procedure

After choosing the appropriate choice, the final response was a depiction of the casting defect. The module represents a schematic diagram, and the user can compare the defect with it. Finally, the defect identification could be completed by selection of yes/no at the end. After pressing "Yes," a representation of the causes and solutions appeared on the screen. If "no" is selected then the module is diverted back to the initial stage of defect identification. This demonstrated the methods for resolving a casting defect, which was the main goal of the inclusive module. On selecting "Yes", the causes and their remedies are displayed as represented in Figure 3. The final step of defect identification is depicted in Figure 8.

6. Conclusion

The research presented in this paper offers a knowledge-based inclusive module to support the casting defect analysis process in small and medium-sized businesses. A stronger database structure has been developed for casting defect analysis, taking into account both practical and theoretical viewpoints. The casting defect diagnosis technique used in the current research effort defines a defect identification process. Physical characteristics of the defects by visual inspection carried out identification of the defect. The input in the form of answers to the questionnaire was provided to the module through the user interface. Proper identification leads to the representation of causes and remedial action to be provided for defect rectification. This module was applied to the industry for defect identification and remedies and validated successfully for an industrial casting component DB1, DB2 and HUB1. Figure 9 represents the increase of 54% for hot tear defect identification for the grey iron casting components DB1 after the implementation of the inclusive module.

The inclusive module described here is used for three different purposes: defect identification, defect rectification and also learning databases for newcomers to the casting industry. The current study was restricted to the production of an inclusive module for surface defects found in casting products, but the present inclusive module possesses the ability to upgrade to include more casting defects.

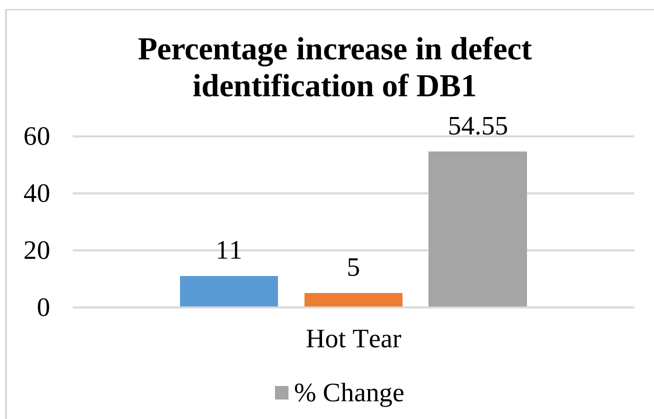

Fig. 9 Percentage increase in defect identification of DB1

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