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Article

Implementing multi criteria decision making methods for computing complexity involved in industrial investment castings

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Abstract: Investment casting is admired for its ability to produce industrial castings with remarkable precision, exceptional exterior finish and complex designs among diverse industrial application. Traditionally, the complexity of these castings is generally assessed qualitatively while quantitative measurement of this complexity remains largely unexplored. To identify the various parameters that affects the complexity of industrial investment casting, an in-person industrial survey was carried out in one of the major investment casting clusters that accounts for nearly 25% of India's investment casting foundries. Through this survey it was found that complexity of investment casting is determined by three factors related to geometry, features and manufacturability. These three factors are further driven by 19 elements and 52 attributes. These 52 attributes are further characterised by 212 meta-attributes. This research focuses on applying multi-criteria decision-making methods to quantify the complexity affects in manufacturing industrial investment castings. Numerous methodologies within the domain of Multi-Criteria Decision-Making (MCDM) have been explored to determine the appropriate weightage for the factors, elements, attributes and meta-attributes involved. It was observed that for the specific problem mentioned, the Weighted Criteria Approach (WCA) and Analytical Hierarchy Process (AHP) were identified as suitable choices, aligning well with the required level of accuracy. The result obtained through these methods were used to compute the complexity of industrial castings. The proposed complexity index was validated using various industrial castings and proved to be a valuable tool for designers in adopting investment casting process for producing complex castings.

Keywords: investment casting; complexity index; multi-criteria decision-making; weighted criteria approach; analytical hierarchy process

1. Introduction

Investment casting is a long-established manufacturing process used for developing complex castings with high precision, tight dimensional control and excellent surface finish. Investment casting process extends its application across diverse sectors such as aerospace, bio-medical, chemical, automobile and defense etc. The process contains several sub stages begins with development of die and wax pattern. A ceramic material is invested to the wax pattern to build a shell followed by dewaxing to form a cavity. This ceramic shell is then baked and filled with molten metal. After molten metal cooling, fettling is carried out to remove gating and feeding system followed by finishing of the component. Finally, the castings are thoroughly measured and verified to ensure quality standards are met.

An in-person industrial survey was carried out in an important investment casting cluster representing about 25% of India's total investment casting foundries. This survey intended to gain comprehensive insights related to capacity, capability, competency, concerns and challenges of these foundries. It was discovered that these foundries employ a holistic approach to producing industrial castings through investment casting process. Typically, the decision to adopt investment casting process is made by the design and manufacturing teams based on a qualitative assessment of the production process. However, erroneous selection often leads to more shop floor trials that can waste resources, extend lead times and lower overall productivity. Moreover, the successful production of industrial castings through investment casting rest on various parameters related to geometry, desired features and manufacturability. This highlights the need for a systematic approach in selecting the investment casting process for optimum outcomes.

2. Prior work

Numerous investigators have endeavoured to develop complexity index that assist in decision-making to select appropriate manufacturing process for industrial components. Oliver et al. [1] proposed a method for assessing the complexity of manufacturing processes in both machining and layered manufacturing. Merkt et al. [2] presented a geometric complexity assessment within an Integrative Technology Evaluation Model known as ITEM. The proposed model includes a product, process, economic and technological factors to measure geometric complexity. Conner et al. [3] introduced a modified complexity factor based on geometric attributes. This factor serves as a crucial factor in selection of an additive manufacturing process and a subtractive manufacturing process for a particular industrial component. Hosseini et al. [4] presented a shape complexity index specifically designed for H-shaped forging. This index incorporates several geometric attributes of the process. It was found that proposed index proves valuable in determining the ideal number of preform steps.

Pradel et al. [5] discovered the impact of complexity on the time required for the building process for the material extrusion and jetting. It was found that factors related to geometry contribute to the overall duration of the building process. Qamar et al. [6] extended the application of shape complexity to predict process parameters, defects, friction and cost involved in extrusion process. Qamar et al. [7] explored the effects of profile complexity on various aspects of the cold extrusion process including process parameters and occurrence of defects. It was concluded that dies with more intricate geometries resulted in a non-uniform flow of metal and leading to an increased requirement for extrusion force.

Joshi et al. [8] presented shape complexity factor that takes into account various geometric features of the desired casting. This index was afterward correlated with both tooling and manufacturing costs providing valuable insights into the intricate relationship between geometric considerations and the associated economic implications in the sand casting process. Martof et al. [9] demonstrated a complexity assessment method using computer aided design models to identify the optimal and economical approach for casting. This tool assesses interior and exterior complexity. This innovative complexity assessment tool was applied to inform decisions concerning the potential integration of additive manufacturing techniques with conventional manufacturing process.

It was observed from comprehensive study of literature reported in direction of development of complexity index that they are mostly related to Multi-Criteria Decision Making (MCDM) problems. MCDM methods are employed for outranking relations, global ranking, relative weight computation and preferences for complex decision making problems and its use has been exponentially increase in last thirty years [10,11]. Different MCDM methods including Analytical Hierarchy Process (AHP), Fuzzy Analytical Hierarchy Process (FAHP), Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE), Analytic Network Process (ANP), Decision Making Trial and Evaluation Laboratory (DEMATEL), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Elimination and Choice Translating Reality (ELECTRE), Compromise Ranking Method (VIKOR) and Weighted Criteria Approach (WCA) were widely employed in decision making applications. Detailed understanding of these methods as well as their capabilities are discussed in various technical literatures published in that direction [12–20]. It was observed that TOPSIS, VIKOR, PROMETHEE, DEMATEL and ELECTRE methods are used for finding best alternative solution and ANP is used for finding solution of network related problem. Furthermore, it was also concluded that WCA method is useful in computation of relative weightage for early stage of complex decision making problems. It was also revealed from a comprehensive literature published in the direction of MCDM methods and its applications that AHP and FAHP were widely employed for finding relative weightage of various parameters related to complex MCDM problems [21].

Numerous researchers have implemented WCA and AHP for calculating weightage in various engineering problem. Karthik et al. [22] established a method to adopt a metal casting process based on a WCA. The proposed methodology comprises several criteria related to geometric and manufacturing parameters for choosing the metal casting process. Fadzli et al. [23] considered use of kenaf fibers compared to usual fibers for friction material using WCA. It was recognized that selection of kenaf fibers using WCA provides possible use as a friction material. Anjum et al. [24] proposed a method based on WCA for measurement of performance. It was identified that the WCA provides a valuable technique in software reliability growth models comparisons.

Akarte et al. [25] developed web-based system for the assessment of casting suppliers. The relative weightage of the criteria has been computed using the AHP. This system proves valuable in evaluating the compatibility of product, process and producer. Chougale et al. [26] demonstrated shape complexity for sand casting process using parameters related to geometry and process. Shape complexity was established by comparing the surface area and volume of the intended casting with that of a simple geometric shape like a cube. The AHP was utilized for pairwise comparisons enabling the calculation of relative weightage for different parameters. Joshi et al. [27] implemented AHP to calculate the relative weightage of several criteria in the early assessment of castability. This proposed methodology presents a systematic approach for assessing the manufacturability of casting design during the early stage of the design process.

It was concluded from the published literature that WCA as well as AHP were more suitable for calculating relative weightage of influencing parameters. In this paper, implementation of a MCDM methods for computing complexity index of investment casting process has been demonstrated.

3. Methodology

An in person industrial survey was carried out in one of the important clusters of investment casting foundries that represents 30% of total investment casting foundries of India. This survey mainly focused on collection and interpretation of inputs received from investment casting foundries that further categorized for development of complexity index [28]. Industry experts provided input to recognize the key parameters related to geometry, features and manufacturability that affect the complexity of the investment casting process. This information was methodically categorized into factors, elements, attributes and meta-attributes to facilitate complexity index calculation for the investment casting process. It was observed that the geometry factor is primarily influenced by two main elements: surface characteristics and dimensional characteristics. The features factor is driven by eight elements that include hole, slot, groove, fillet, chamfer, hollow region, rib and boss. The manufacturability factor is influenced by nine elements encompassing type of alloy, property requirements, bulk density, melting aids, solidification aids, supplementary aids, melting temperature, batch size and application. Furthermore, the dimensional characteristics element is associated with four attributes: overall length, height, width, and average thickness. Similarly, the surface characteristics element is determined by three attributes: flat, curved, and slanted surfaces.

Overall, it was found that complexity is driven by 3 factors (broad category of parameters), 19 elements (characteristics of the factors), 52 attributes (possible variations of elements) and 212 meta-attributes (values of each variation for attributes). A framework designed for all factors, elements, attributes and meta-attributes is shown in **Figure 1**. These recognized parameters were then organized into a hierarchical structure to enable the calculation of relative weightage. This weightage calculation was achieved using the WCA and AHP. In the WCA, equal importance is assigned to all criteria and a value scale is established for each level of the hierarchy. For the AHP, inputs regarding the relative importance of criteria are collected from industry experts. These inputs are then used to calculate the geometric mean, determine the relative weightage and assess the consistency ratio to ensure reliability in decision-making. The detailed calculation of the relative weightage has been demonstrated in the published literature [29,30].

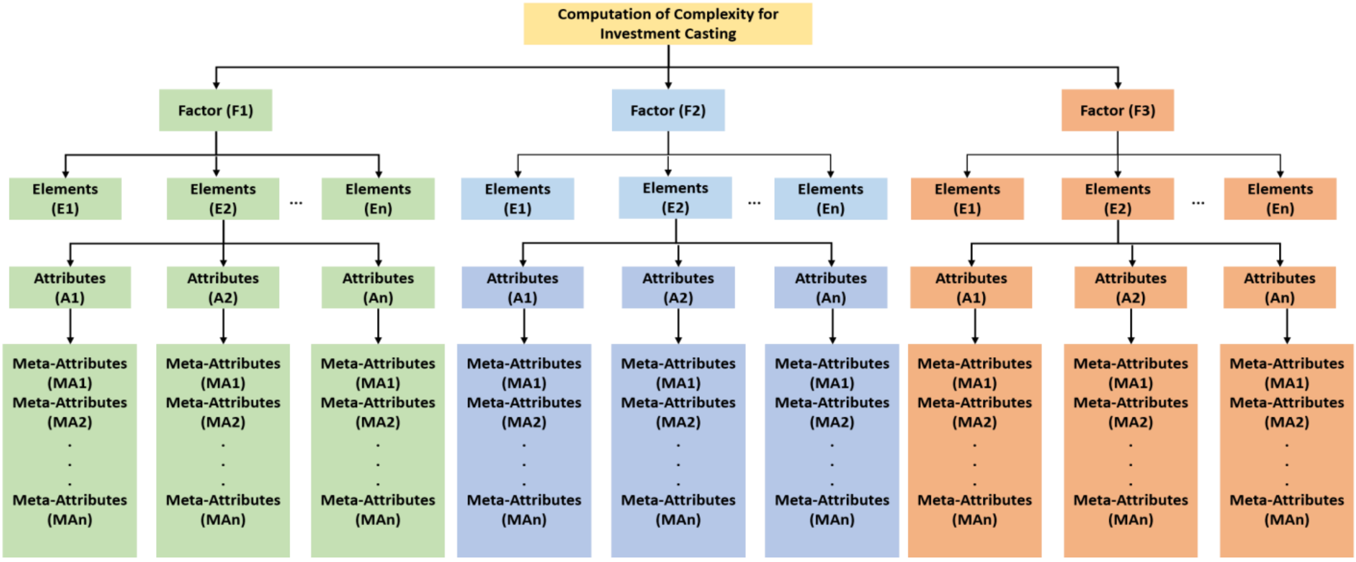


Figure 1. Structure of factor, elements, attributes and meta-attributes for computing complexity index [29].

To demonstrate the application of the complexity index in selecting the investment casting process, a set of specific industrial castings were chosen as use cases focusing on the architecture, automobile, biomedical, chemical and machine tool sectors. This selection provides different requirements of these sectors by investment casting process. The complexity index for each industrial casting was computed and presented in **Tables 1** to **5**. Meta-attributes related to all factors for each selected casting were collected from investment casting foundries that provides a accurate industry perspective.

Table 1. Industrial casting 1.

Attributes	**Meta Attributes**	**Complexity WCA**	**Complexity AHP**
Overall Length (mm)	235.90	1.37	0.20
Overall Height (mm)	134.60	1.37	0.16
Overall Width (mm)	235.90	4.12	0.12
Average Thickness (mm)	9.85	4.12	1.03
Surface Characteristics	C	5.50	12.28
Number of Holes	1.00	0.13	0.02
Maximum Length of Hole (mm)	27.20	0.68	0.02
Maximum Diameter of Hole (mm)	18.60	0.68	0.22
Contour of Hole (Circular, Square)	C	0.34	0.10
Open to Surface (Flat, Curvature))	F	0.34	0.14
Type of Hole (Through, Blind)	T	0.34	0.19
Number of Slots	-	-	-

Table 1. (*Continued*).

Attributes	Meta Attributes	Complexity WCA	Complexity AHP
Maximum Length of Slot (mm)	-	-	-
Maximum Width of Slot (mm)	-	-	-
Maximum Depth of Slot (mm)	-	-	-
Number of Grooves	2.00	0.20	0.08
Maximum Length of Groove (mm)	68.10	0.34	0.20
Maximum Width of Groove (mm)	37.70	1.03	0.11
Maximum Depth of Groove (mm)	37.70	1.03	1.83
Number of Fillets	22.00	2.06	0.14
Maximum Radius of Fillet (mm)	3.00	2.06	0.18
Number of Chamfers	-	-	-
Chamfer Angle (degree)	-	-	-
Distance (mm)	-	-	-
Number of Hollow Regions	-	-	-
Maximum Length of Hollow Region (mm)	-	-	-
Maximum Diameter of Hollow Region (mm)	-	-	-
Number of Ribs	8.00	0.61	0.05
Maximum Length of Rib (mm)	50.61	1.03	0.09
Maximum Thickness of Rib (mm)	5.80	1.03	0.19
Maximum Width of Rib (mm)	17.52	0.68	0.07
Number of Bosses	-	-	-
Maximum Diameter of Boss (mm)	-	-	-
Maximum Thickness of Boss (mm)	-	-	-
Alloying Elements	9.00	2.20	0.36
Hardness (HRC)	19.00	0.73	0.39
Relative Density (gm/cm^3)	8.00	0.73	0.35
Insulating Sleeve	-	-	-
Chills	-	-	-
Exothermic Powder	-	-	-
Degassing	Y	1.23	1.31
Filler	-	-	-
Slag Powder	Y	1.22	0.69
Heat Treatment	Y	0.91	0.76
Machining	Y	0.91	1.56
Destructive Testing	Y	0.91	0.98
Non-Destructive Testing	-	-	-
Melting Temperature (°C)	1450.00	2.19	0.46

Table 1. (*Continued*).

Attributes	Meta Attributes	Complexity WCA	Complexity AHP
Application	Architecture	2.19	0.62
Quantity	500.00	2.19	0.35
Overall Complexity (Normalize):		40.23	38.28

Table 2. Industrial casting 2.

Attributes	Meta Attributes	Complexity WCA	Complexity AHP
Overall Length (mm)	482.50	2.75	0.51
Overall Height (mm)	172.00	2.75	0.22
Overall Width (mm)	162.00	4.13	0.09
Average Thickness (mm)	20.00	2.75	0.29
Surface Characteristics	F	5.50	9.38
Number of Holes	6.00	0.14	0.03
Maximum Length of Hole (mm)	25.00	0.69	0.03
Maximum Diameter of Hole (mm)	20.05	0.69	0.22
Contour of Hole (Circular, Square)	C	0.34	0.11
Open to Surface (Flat, Curvature))	F	0.34	0.14
Type of Hole (Through, Blind)	T	0.34	0.20
Number of Slots	2.00	0.21	0.06
Maximum Length of Slot (mm)	47.00	0.69	0.09
Maximum Width of Slot (mm)	4.00	1.03	0.32
Maximum Depth of Slot (mm)	3.00	1.03	0.15
Number of Grooves	-	-	-
Maximum Length of Groove (mm)	-	-	-
Maximum Width of Groove (mm)	-	-	-
Maximum Depth of Groove (mm)	-	-	-
Number of Fillets	1.00	0.41	0.09
Maximum Radius of Fillet (mm)	2.00	2.06	0.19
Number of Chamfers	-	-	-
Chamfer Angle (degree)	-	-	-
Distance (mm)	-	-	-
Number of Hollow Regions	-	-	-

Table 2. (*Continued*).

Attributes	Meta Attributes	Complexity WCA	Complexity AHP
Maximum Length of Hollow Region (mm)	-	-	-
Maximum Diameter of Hollow Region (mm)	-	-	-
Number of Ribs	-	-	-
Maximum Length of Rib (mm)	-	-	-
Maximum Thickness of Rib (mm)	-	-	-
Maximum Width of Rib (mm)	-	-	-
Number of Bosses	-	-	-
Maximum Diameter of Boss (mm)	-	-	-
Maximum Thickness of Boss (mm)	-	-	-
Alloying Elements	11.00	2.94	0.41
Hardness (HRC)	10.00	0.73	0.39
Relative Density (gm/cm^3)	7.80	0.73	0.36
Insulating Sleeve	Y	1.23	1.09
Chills	-	-	-
Exothermic Powder	Y	1.22	0.73
Degassing	Y	1.23	1.31
Filler	Y	1.22	1.64
Slag Powder	Y	1.22	0.69
Heat Treatment	Y	0.92	0.76
Machining	Y	0.92	1.57
Destructive Testing	Y	0.92	0.99
Non-Destructive Testing	Y	0.92	1.16
Melting Temperature (°C)	1460.00	2.20	0.46
Application	Automobile	0.73	0.32
Quantity	1500.00	3.66	0.46
Overall Complexity (Normalize):		43.02	35.53

Table 3. Industrial casting 3.

Attributes	Meta Attributes	Complexity WCA	Complexity AHP
Overall Length (mm)	35.52	4.13	0.31
Overall Height (mm)	170.00	2.75	0.22
Overall Width (mm)	10.50	4.13	0.24
Average Thickness (mm)	10.50	4.13	1.04
Surface Characteristics	F	5.50	9.38
Number of Holes	-	-	-
Maximum Length of Hole (mm)	-	-	-
Maximum Diameter of Hole (mm)	-	-	-
Contour of Hole (Circular, Square)	-	-	-
Open to Surface (Flat, Curvature))	-	-	-
Type of Hole (Through, Blind)	-	-	-
Number of Slots	8.00	0.41	0.08
Maximum Length of Slot (mm)	108.96	1.03	0.11
Maximum Width of Slot (mm)	1.00	1.03	0.32
Maximum Depth of Slot (mm)	1.00	1.03	0.15
Number of Grooves	-	-	-
Maximum Length of Groove (mm)	-	-	-
Maximum Width of Groove (mm)	-	-	-
Maximum Depth of Groove (mm)	-	-	-
Number of Fillets	6.00	0.82	0.09
Maximum Radius of Fillet (mm)	1.00	2.06	0.19
Number of Chamfers	-	-	-
Chamfer Angle (degree)	-	-	-
Distance (mm)	-	-	-
Number of Hollow Regions	-	-	-
Maximum Length of Hollow Region (mm)	-	-	-
Maximum Diameter of Hollow Region (mm)	-	-	-
Number of Ribs	-	-	-
Maximum Length of Rib (mm)	-	-	-
Maximum Thickness of Rib (mm)	-	-	-
Maximum Width of Rib (mm)	-	-	-
Number of Bosses	-	-	-
Maximum Diameter of Boss (mm)	-	-	-
Maximum Thickness of Boss (mm)	-	-	-
Alloying Elements	8.00	2.20	0.37
Hardness (HRC)	37.00	1.47	0.44

Table 3. (*Continued*).

Attributes	Meta Attributes	Complexity WCA	Complexity AHP
Relative Density (gm/cm^3)	7.80	0.73	0.36
Insulating Sleeve	-	-	-
Chills	-	-	-
Exothermic Powder	Y	1.22	0.73
Degassing	Y	1.23	1.31
Filler	-	-	-
Slag Powder	Y	1.22	0.69
Heat Treatment	Y	0.92	0.76
Machining	-	-	-
Destructive Testing	Y	0.92	0.99
Non-Destructive Testing	Y	0.92	1.16
Melting Temperature (°C)	1600.00	2.93	0.54
Application	Biomedical	3.66	2.00
Quantity	100.00	0.73	0.39
Overall Complexity (Normalize):		41.00	28.01

Table 4. Industrial casting 4.

Attributes	Meta Attributes	Complexity WCA	Complexity AHP
Overall Length (mm)	122.20	2.75	0.31
Overall Height (mm)	71.00	2.75	0.17
Overall Width (mm)	122.20	2.75	0.09
Average Thickness (mm)	5.50	4.13	1.04
Surface Characteristics	C	5.50	12.29
Number of Holes	1.00	0.14	0.03
Maximum Length of Hole (mm)	25.50	0.69	0.03
Maximum Diameter of Hole (mm)	33.00	0.46	0.22
Contour of Hole (Circular, Square)	C	0.34	0.11
Open to Surface (Flat, Curvature))	F	0.34	0.14
Type of Hole (Through, Blind)	T	0.34	0.20
Number of Slots	12.00	0.62	0.08

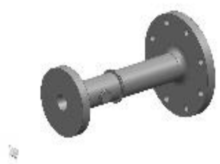
Table 4. (*Continued*).

Attributes	**Meta Attributes**	**Complexity WCA**	**Complexity AHP**
Maximum Length of Slot (mm)	6.00	1.03	0.09
Maximum Width of Slot (mm)	25.00	1.03	0.10
Maximum Depth of Slot (mm)	7.32	0.69	0.15
Number of Grooves	1.00	0.21	0.09
Maximum Length of Groove (mm)	110.00	0.69	0.21
Maximum Width of Groove (mm)	13.84	0.34	0.28
Maximum Depth of Groove (mm)	5.63	1.03	0.33
Number of Fillets	19.00	1.65	0.12
Maximum Radius of Fillet (mm)	4.00	2.06	0.12
Number of Chamfers	-	-	-
Chamfer Angle (degree)	-	-	-
Distance (mm)	-	-	-
Number of Hollow Regions	-	-	-
Maximum Length of Hollow Region (mm)	-	-	-
Maximum Diameter of Hollow Region (mm)	-	-	-
Number of Ribs	-	-	-
Maximum Length of Rib (mm)	-	-	-
Maximum Thickness of Rib (mm)	-	-	-
Maximum Width of Rib (mm)	-	-	-
Number of Bosses	1.00	0.28	0.06
Maximum Diameter of Boss (mm)	45.19	1.38	0.04
Maximum Thickness of Boss (mm)	6.09	0.92	0.13
Alloying Elements	10.00	2.94	0.37
Hardness (HRC)	22.00	1.47	0.44
Relative Density (gm/cm^3)	7.90	0.73	0.36
Insulating Sleeve	Y	1.23	1.09
Chills	-	-	-
Exothermic Powder	Y	1.22	0.73
Degassing	Y	1.23	1.31
Filler	-	-	-
Slag Powder	Y	1.22	0.69
Heat Treatment	Y	0.92	0.76
Machining	Y	0.92	1.57
Destructive Testing	Y	0.92	0.99
Non-Destructive Testing	Y	0.92	1.16
Melting Temperature (°C)	1450.00	2.20	0.46

Table 4. (*Continued*).

Attributes	Meta Attributes	Complexity WCA	Complexity AHP
Application	Chemical	1.46	0.41
Quantity	1000.00	3.66	0.46
Overall Complexity (Normalize):		51.98	43.52

Table 5. Industrial casting 5.



Attributes	Meta Attributes	Complexity WCA	Complexity AHP
Overall Length (mm)	385.19	2.75	0.27
Overall Height (mm)	222.00	4.12	0.22
Overall Width (mm)	222.00	4.12	0.12
Average Thickness (mm)	17.42	2.75	0.28
Surface Characteristics	F	5.50	9.37
Number of Holes	9.00	0.13	0.04
Maximum Length of Hole (mm)	340.19	0.68	0.30
Maximum Diameter of Hole (mm)	45.00	0.23	0.22
Contour of Hole (Circular, Square)	C	0.34	0.10
Open to Surface (Flat, Curvature))	F	0.34	0.14
Type of Hole (Through, Blind)	T	0.34	0.19
Number of Slots	-	-	-
Maximum Length of Slot (mm)	-	-	-
Maximum Width of Slot (mm)	-	-	-
Maximum Depth of Slot (mm)	-	-	-
Number of Grooves	-	-	-
Maximum Length of Groove (mm)	-	-	-
Maximum Width of Groove (mm)	-	-	-
Maximum Depth of Groove (mm)	-	-	-
Number of Fillets	5.00	0.41	0.09
Maximum Radius of Fillet (mm)	15.00	0.68	0.07
Number of Chamfers	-	-	-
Chamfer Angle (degree)	-	-	-
Distance (mm)	-	-	-

Table 5. (*Continued*).

Attributes	Meta Attributes	Complexity WCA	Complexity AHP
Number of Hollow Regions	-	-	-
Maximum Length of Hollow Region (mm)	-	-	-
Maximum Diameter of Hollow Region (mm)	-	-	-
Number of Ribs	-	-	-
Maximum Length of Rib (mm)	-	-	-
Maximum Thickness of Rib (mm)	-	-	-
Maximum Width of Rib (mm)	-	-	-
Number of Bosses	1.00	0.27	0.05
Maximum Diameter of Boss (mm)	33.00	1.37	0.04
Maximum Thickness of Boss (mm)	42.95	1.37	0.19
Alloying Elements	9.00	2.20	0.36
Hardness (HRC)	18.00	0.73	0.39
Relative Density (gm/cm^3)	7.90	0.73	0.35
Insulating Sleeve	-	-	-
Chills	-	-	-
Exothermic Powder	-	-	-
Degassing	-	-	-
Filler	-	-	-
Slag Powder	-	-	-
Heat Treatment	-	-	-
Machining	Y	0.91	1.56
Destructive Testing	Y	0.91	0.98
Non-Destructive Testing	-	-	-
Melting Temperature (°C)	1450.00	2.19	0.46
Application	Machine tool	0.73	0.31
Quantity	500.00	2.19	0.35
Overall Complexity (Normalize):		28.49	12.62

4. Discussion

The analysis of the complexity index for various industrial castings reveals that complexity is primarily affect by required features and manufacturability. Additionally, it is observed that simple geometric castings exhibit higher complexity using WCA compared to AHP due to equal importance assigned to all parameters in WCA. It was observed that addressing criteria related to feature and manufacturability presents significant challenges leading to increased complexity in the investment casting process.

Moreover, the complexity index is further divided into five categories: Low (0–20), Medium (21–40), High (41–60), Very High (61–80), and Extremely High (81–100). These categories establish a connection between the complexity value and manufacturing cost. In the computation of the complexity index for various use cases, it was noted that the complexity of industrial castings varied from 28 to 52 using WCA and while using AHP complexity varied from 12 to 43 falling within the low, medium and high categories. This correlation proves advantageous for cost estimation where castings exhibit very closed complexity values. The categorization of the presented use cases is illustrated in the **Figures 2–6**.

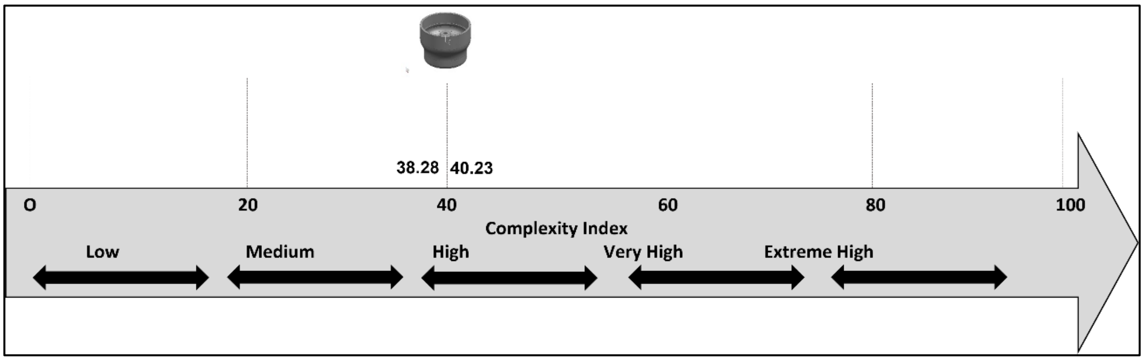


Figure 2. Categorization of industrial casting 01.

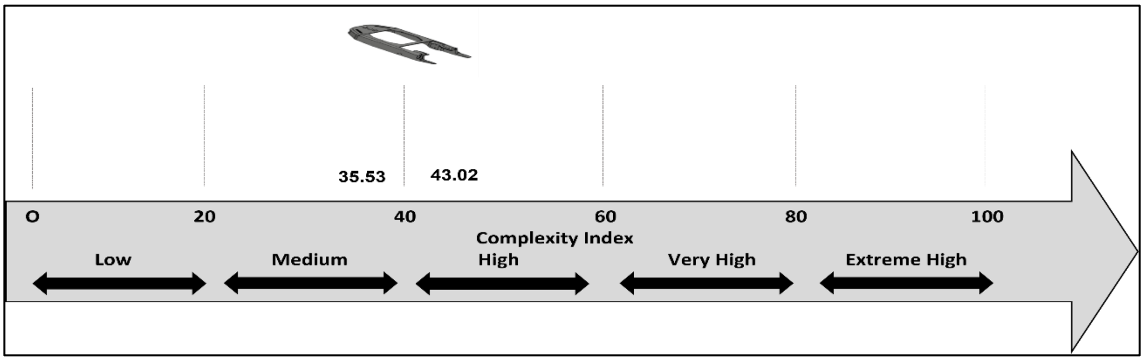


Figure 3. Categorization of industrial casting 02.

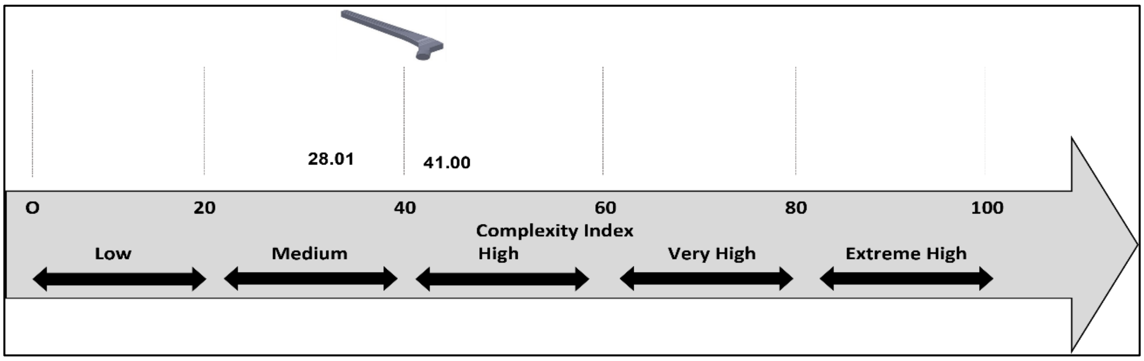


Figure 4. Categorization of industrial casting 03.

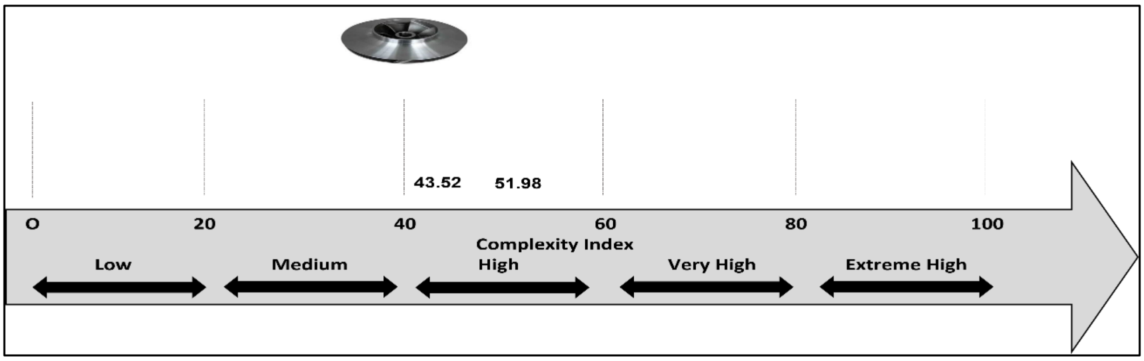


Figure 5. Categorization of industrial casting 04.

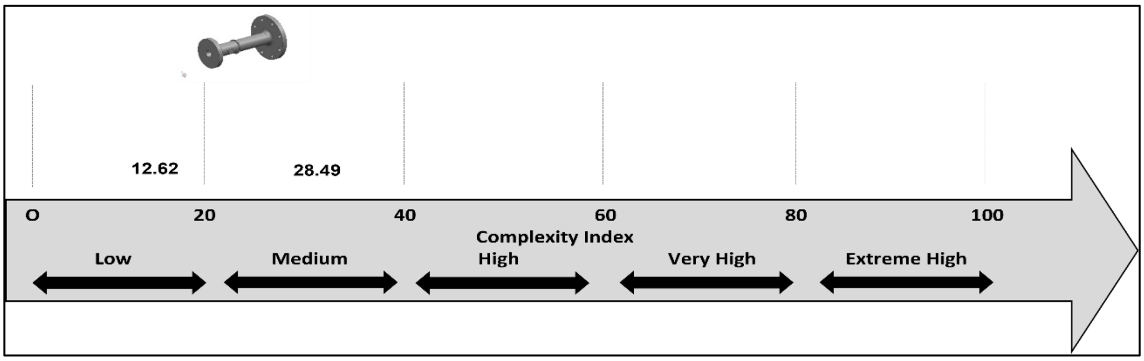


Figure 6. Categorization of industrial casting 05.

5. Conclusions

Investment casting process is a widely familiar process for manufacturing intricate industrial castings with high surface quality and tight dimensional tolerances. Selecting the investment casting process for manufacturing specific castings generally involves a comprehensive approach that qualitatively assesses various parameters of each casting. However, inaccurate decisions in this selection can lead to unnecessary resource and energy consumption, longer lead times and decreased productivity.

In this paper, implementation of MCDM methods for computing complexity involved in investment casting has been presented. More than 5 use cases were demonstrated to assess the complexity of industrial investment castings. The findings revealed that these castings exhibit complexities ranging from 28 to 52 using WCA and while using AHP complexity varied from 12 to 43. This index offers designers a more comprehensive understanding of the influence of individual parameters (such as geometry and features) on the overall complexity index. Additionally, this approach plays an important role in predicting early-stage critical parameters and helps in making informed decisions about employing process.

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