METHODING DESIGN IN SAND CASTING, PAPER (2), FUZZY EXPERT SYSTEM AND FEATURE-BASED FOR BUILDING CASTINGS AND FEEDERS DESIGN

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Abstract

In this paper, a feature-based solid modeling integrated with a fuzzy expert system was developed. The feature-based model had been developed by the authors, to provide manufacturing information to the fuzzy system application. The fuzzy system is based on heuristic rules of feeder in paper (1), to classify castings and design feeders. Heuristic rules were encoded inside the fuzzy system in production rules: IF-THEN-ELSE. The fuzzy system was connected with the model through open database connectivity database. Results inferred from fuzzification of inputs and defuzzification of outputs through inference process. A design condition flow chart was built to evaluate the results.

Keywords: design by feature, fuzzy logic, heuristic, classification, feeders

1 INTRODUCTION

Fuzzy expert systems are being used successfully in an increasing number of application areas; they use linguistic and heuristic rules to describe systems. These rules-based systems are more suitable for complex system problem where it is very difficult, if not impossible, to describe the system mathematically. One of the most important considerations in designing any fuzzy expert system is the generation of the fuzzy rules as well as the membership function for each fuzzy set. In most existing applications, the fuzzy rules are generated by experts in the area, especially for solving problem with vague area [1-4].

Fuzzy expert system is widely applied in manufacturing as reported in literature [5-7], but a few attempts have been made to developing fuzzy systems in sand casting. Recently, Elbasheer and others have developed fuzzy expert system for designing rigging system [8]. Fazel used fuzzy agent-based for steel making process [9]. The design by features approach uses a set of defined features. The trade oriented library reflects the manufacturing activities as related to the machining, metal forming and
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sheet metal, and assembly applications [10,11,12].

In this work, a fuzzy system integrated with the feature-based system is proposed for designing feeders. The main objectives of this work are to: develop a fuzzy expert system to classify cast components and design feeders. Automate feeders design by connecting the fuzzy system with the solid model in [13].

2 OVERVIEW

2.1 Feeder design

Heuristic rules that aid the design of feeder elements are compiled from expertise of method engineers and well known published literature. These rules are listed and reported in paper (1). From the feeders rules of thumb it can be observed that, beside the geometric feature of casting, solidification rate, directional solidification, and location of gating system are important factors of feeders design [14,15]. Most of feeders design based on Chvorinov rules, NRL method as reported in literature [16-20].

2.2 Fuzzy expert system

Expert systems (ESs) provide powerful and flexible means for obtaining solutions to a large variety of engineering problems that cannot be dealt with traditional methods. In this regard, fuzzy logic (FL) [21] provides a very attractive modeling paradigm for its intrinsic ability of handling linguistic information. Fuzzy logic effectively deals with the uncertainty unavoidably present in the knowledge of the expert. Fuzzy logic provides a general concept for description, classification and measurement. FL comprises fuzzy sets, which are a way of representing non-statistical uncertainty. ESs often rely on a FL framework of inference called fuzzy expert systems (FESs) [22].

A fuzzy expert system uses fuzzy logic instead of conventional logic. It uses a collection of fuzzy membership functions and rules to facilitate reasoning. In fuzzy logic, fuzzy set membership occurs by degree over the range interval “[0, 1]”, which is represented by a membership function. This is called a degree of belief or membership value or confidence value [23]. Rules can be easily demonstrated human thinking as they can be easily formulated. [24-27]. In a FES, the expert knowledge is represented by means of a set of IF–THEN–ELSE rules. These rules link different linguistic concepts qualitatively describing the input variables (called antecedents of the rules) to those describing the output variables (consequents of the rules).

3 STRUCTURE OF THE FUZZY EXPERT SYSTEM

This fuzzy expert system aimed to classify casting component features and design of feeders. The fuzzy rules inside rule sets are built from feeder heuristic rules in paper (1). These rules judge the relationship between classification and feeders design. The fuzzy system has been built by using XpertRule Knowledge Builder software.

3.1 Fuzzy logic for classifications

The linguistic categories referring to the levels of thickness classification are defined: thick, thin and very thin. The domain of these set is an arbitrary “shape factor” scale from 1 to 50. The function used for this classification is illustrated in Figure 1. Thus the feature with shape factor equal 20 is “Thin” with full membership, while a feature with 32 would be both “Thin” and “Very thin” with partial membership to each. This type of classification will be used for selection of required type of feeder.
3.2 Fuzzy Rules for feeders design

The fuzzy rules that judge the relationship between the classification and feeder’s design are built. The design of feeder includes: selection, positioning and determining the number of feeders. There are many fuzzy rules for selecting the suitable types of feeders defined among them as shown in Figure 2.

The linguistic categories referring to the levels of required number feeders to feed the feature with molten metal as defined by: one feeder, two, three, four and five feeders. The domain of for these sets is an arbitrary “base dimension i.e. for cylinder feature the base dimension is “diameter” scale from 1 to 800 mm. The function used for this classification is illustrated in Figure 3.

4 THE FUZZY SYSTEM AND SOLID MODELING CONNECTION

The feature-based solid modeling system is implemented to extract and deliver cast component features information as described and explored clearly in [1]. The outputs (attributes) of the solid model are stored in Open Database Connectivity (ODBC). The fuzzy system connected with this database, and then the system holds the attributes and precedes the classification and feeder design as shown in Figure 4.

5 CASE EXAMPLE AND RESULTS

Figure 5, shows a case example of a cast component, the procedure of creating a solid model of the component and designing of feeders are explored in [1].

5.1 The feature-based software outputs

The outputs of the solid model are: visualization of 3D and features information attributes as follows:
(A) Modeling of the cast component

The procedure of creating a solid model of the component and designing of feeder are explored in [1]. Visualization of 3D of the casting component is displayed as shown in Figure 6.

(B) Features information

The software extracted the features information is shown in Figure 7.

5.2 Fuzzy system software outputs

The fuzzy system holds the features input attributes from the open database connectivity, as shown in Figure 7. Then the system fuzzified the inputs of casting component features attributes. The system is firing the coded fuzzy rules and inferred the output. The results included, classification of features thickness, the suitable type of feeder and number of feeders required with their confidence values are shown in Tables (1, 2) and Figures (8, 9) respectively.

5.3 Results evaluation

Condition flow chart was developed to evaluate the feeder design elements. This chart based on membership values, cost and condition of design (under, over, borderline design). Figure 10 shows the condition level of feeder design in the example.

6 CONCLUSION

In this paper, fuzzy expert system for casting’s classification and feeders design was developed. The fuzzy system was connected with feature-based model in [1]. The fuzzy expert is developed as robust hybrid systems, expert system and fuzzy logic. The (ES) structure is decision’s tree that holds fuzzy rules; these rules describe linguistic variables and have linguistic values for the classification and feeder design. The
system classifies castings such as thickness variable, with thick or thin or very thin values and design feeders such as type of feeder variable with side or top feeder values with their confidence values. The systems were examined by an industrial example and evaluated by condition chart.

**Figure 9: Fuzzy output with number of feeders**

**Figure 10: Evaluation chart of feeders design elements**

**REFERENCES**


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