Knowledge based Expert System for Welding Defect Analysis

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Abstract

Knowledge based expert systems are computer programs which can store human expertise, consists of a collection of thumb rules, facts about a particular area of specialization and have means to use this information to solve problems. This paper presents development of an expert system for the analysis of welding defects. The program for the welding defects was made using VC++ environment to obtain graphic user interface.

1. Introduction

Productions of some defective weldments are practically unavoidable. It is possible, however, to reduce significantly the wastage by careful control of all factors contributing to it such as unsuitable raw materials, equipment appliances and treatment, poor design, unsatisfactory welding practice by the individual welder.

In view of the above there existed considerable potential for a comprehensive defect analysis/ diagnosis (CDAD) expert system for welding defects. Expert System is an approach to decision making, or at least a methodology for use in support of decision making.

Most expert systems have four basic components; an acquisition module, a knowledge base, an inference engine, and an operator interface.

1. Knowledge base - a declarative representation of the expertise, often in If-Then rules.
2. Working Memory - the data which is specific to a problem being solved.
3. Inference engine - the code at the core of the system which derives recommendation from the knowledge base and problem-specific data in working memory.

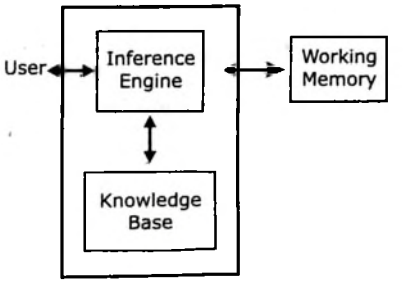

Fig.1 Expert System Architecture

2. Knowledge Base (KB)

It contains the entire relevant domain, specific, problem solving knowledge that has been gathered by the knowledge engineer. A knowledge base will typically contain two types of knowledge i.e. facts and rules. The facts within a knowledge base represent various aspects of specific domain that are known prior to the exercise (i.e. consultation session) of the expert system. The rules within the KB represent the knowledge engineers perception of heuristic that are employed by the expert in the decision 4.

Knowledge Base can be represented in different ways such as Object-attribute-value triplets (OAV), Semantic networks, Frames, Logic programming, Neural networks and Rules. Out of this most popular mode of knowledge representation is Rules. The Rule Base is represented in the form of If -Then[3].

Example is as follows:
If (crack is parallel to the joint root). Then (display - this is a longitudinal crack)

3. Working Memory (WM)

The contents of working memory consist of facts. However, unlike the facts within the knowledge base, these facts are those that have been determined for the specific problem under consideration during the consultation session. More specifically the results of inference process are new facts and these facts are stored in the working

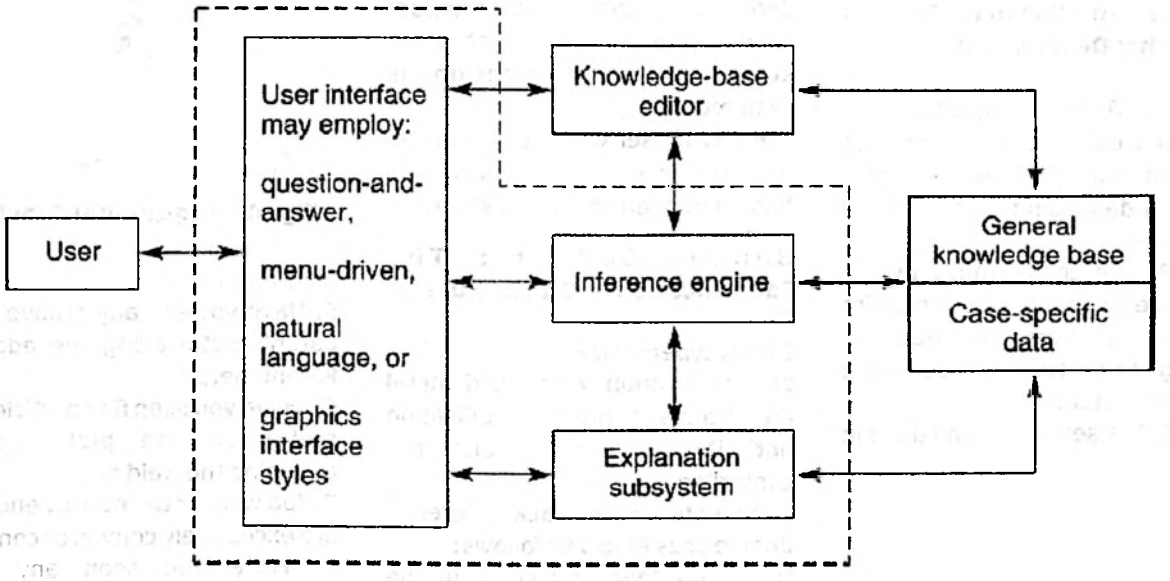

Fig.2 Interaction between the components of KBES and User

memory.

4. Inference Engine

It is employed during consultation session. During consultation it performs two tasks. First, it examines the status of the knowledge base and working memory so as to determine what facts are known at any given time. Second, it provides for the control of the session by determining the order in which inferences are made. It serves to merge facts with rules to develop or infer conclusion.

The fundamental process in defect analysis of weldments is that of identification. DEFCHAR program, the first module of the expert system involves rules to identify the casting defect by virtue of its appearance. The second module CAUSE consists of thumb rules related to the causes for the defects. The logic Conditions for defect analysis are in form of IF-THEN-ELSE conditions. The third module RECOMMENDATIONS which would scan all the defects identified and recommend the necessary action to be taken to correct the defect.

5. Welding Defects

Welding defect is 'a discontinuity or discontinuities which by nature or accumulated effect render a weldment unable to meet minimum acceptable standards.' Therefore defect is anything undesirable in the weld. It mayor may not be the cause for rejection or repair. Hence it is important to learn how to recognize, repair and avoid various types of weld defects.

Set of rules for defining welding defects by appearance (some examples):

Rule 1:
If
Defect group = porosity
Chars-of-cavities = small, elongated and smooth
Long axis of the defect is always perpendicular to the weldment and locations = small sized voids clustered over the weld metal surface.
then
defect name = pin holes

Rule2:
If
Defect group = porosity
Chars-of-cavities = smooth and round cavities, several mm in size and locations = scattered throughout the weld over the weld metal surface.
then defect name = blow holes

Algorithm for the Expert System Program

Since the program to be made must be interactive in nature i.e. it has to proceed according to the inputs given by the user. The program for the welding defects was made using VC++ environment to obtain graphic user interface.

Phases in Expert System Algorithm Development

Step 1: A set of questions is displayed before the user so that program can proceed in some direction depending on the choice of the user.

Step 2: The choice made by the user is being searched in the entire working memory by decision making statements such as If-else or switch statement.

Step 3: The search is to be done in

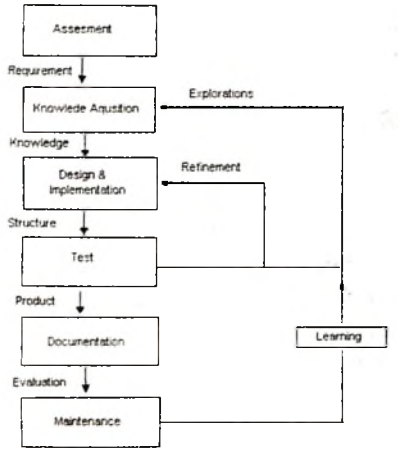

Fig.3 Alogrithm for Expert System Program

such a way that it is completed for each stage then goes to the next stage.

Step 4: After eliminating some of the possibilities in previous stages; proceed in the specific direction by asking the user with another question(s).

Step 5: Stage where the answer to the user's query is obtained; program displays the photograph of

Step 6: Then the user is asked if he wants to see the causes and remedies for that particular (displayed) defect.

Step 7: Cause-effect diagram for that particular defect is displayed.

Step 8: In case if the program cannot proceed further at some stage; more information is required.

Step 9: If user wants to again use the program right form the beginning then go back to step!.

Sample Code for The Identification of Cracks Rule 3:

If

Defect type= crack

and its location = on weld metal and occurs during= solidification and its orientation=along the centerline.

Then defect=hot crack Inference Engine uses Rule 3 as follows:

Have you seen any crack in the weld metal (y/n)? >Yes

Were the cracks developed only in the weld metal? (y/n) >Yes

Did it develop during solidification of weld metal? (y/n) >Yes

Were the cracks spread along the centerline of the weld? (y/n) >Yes

The defect you have observed is hot crack (Longitudinal crack) (Because of Rule 3).

Similarly, same algorithm follows for the other welding defects.

The details of CDAD program:

Have you seen any of these defects?

1. Have you seen any crack in the weld metal?
2. Have you seen any holes on the weld surface that may be clustered?
3. Incomplete Fusion

1) The weld deposited did not completely fill the joint preparation.

2) There is space in between the beads or passes.

3) Space at the root of the joint.

4. Have you see any non-mettalic solid material entrapped in weld metal or between weld metal or base metal
5. Have you see any groove in the parent metal along the edges of Parent metal?
6. Have you seen fine particle of metal on the plate surface adjoining the weld area.
7. Too wide or too narrow ends that are excessively convex or concave
8. Have you seen any crack transvrese to the welding direction and non branching
9. Is there any bending or buckling in the wokrpiece ?

Enter your choice from 1-9: 1

Fig. 4 Longitudinal Crack

Were the cracks developed only in the weld metal?(y/n)

Y

Did it develop during solidification of weld metal?(y/n)

Y

Were the cracks spread along the centreline of the weld?(y/n)

Y

The defect you have observed is HOT CRACKS

Do you want to see the causes and remedy for this defect?

THE POSSIBLE CAUSES ARE:

1. Insufficient weld bead size or shape
2. Welding under high restraint
3. Higher carbon content of weld metal and/or hardenable base material
4. Presence of elements like sulphur leading to embrittlement of grain boundary
5. Temperature gradient within the weld zone that causes thermal stresses to develop

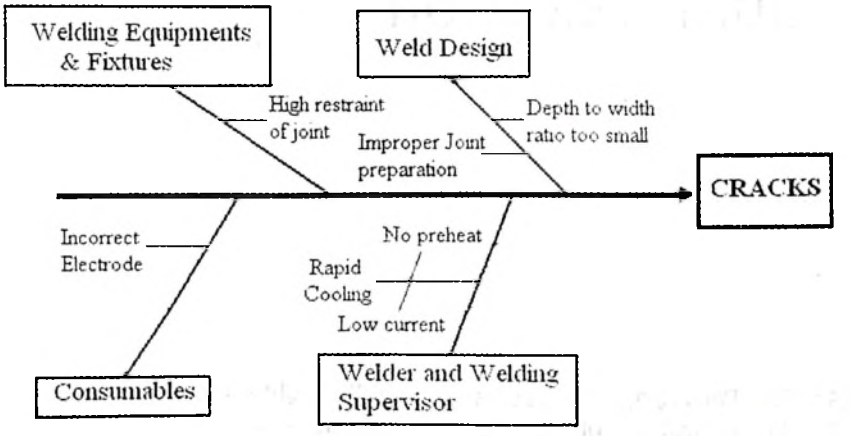

Fig.12 Cause - effect diagram for cracks

6. Welding with contaminants such as cutting oils on the surface of the parent metal

THE SUGGESTED REMEDIES ARE:

1. Prefer an elliptically shaped weld pool over a tear drop shape
2. Use filler rods with low carbon and impurity levels and relatively high manganese content
3. Select welding parameters so as to give weld beads with a depth-to-width ratio lying between 0.5:1 and 2:1
4. Avoid high welding speeds (at high current levels) and increase the electrode size
5. At the run stop, ensure adequate filling of the crater to avoid an unfavorable concave shape
6. Adopt back step or block welding sequence
7. Reduce the heat input
8. Allow minimum joint restraints

7. Conclusions

The procedure followed in developing a comprehensive welding defect analysis and diagnosis (CDAD) program have been developed.

Expert systems are gradually establishing themselves as powerful tools in all fields of engineering. An expert program tries to match facts with which it is supplied, to possible symptoms or conditions that it knows about. The program uses such evidence to either recommend, or take a course of action.

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