DEVELOPING OF KNOWLEDGE-BASED SYSTEM FOR REMAINING LIFE ASSESSMENT OF PRESSURE VESSELS

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This paper addresses the Knowledge-Based System (KBS) for remaining life assessment of pressure vessels, currently developing at TMF Belgrade. The generic idea is to estimate remaining life of pressurized component by efficient usage of large amount of available informations (standards and regulations, service informations and experience, calculations and, in the future, economy, ecology and safety related data connected with criteria for replacement of the component).

INTRODUCTION

Major investments in power and other industrial plants and significant hazards of catastrophic failures, which may result in high outage costs and put at risk population and environment induced development of sophisticated analytic techniques for predicting plant components behavior in normal and accidental situations (6). Considerable experimental efforts and accumulation of empirical knowledge about characteristics of materials and components in service also contributed to great increase of quantity of data relevant for component remaining life assessment, which is far beyond the capabilities of conventional computer programs. Knowledge-Based Systems seems to be the only alternative for effective usage of broad scope of knowledge and data related with structure integrity problems (5). One of such systems, a KBS for remaining life assessment of pressure vessels, is presently developing at TMF Belgrade.

KBS ARCHITECTURE

Our strategy toward KBS development is to face with the needs of end-users (power and other industrial plants), for reliable, proven and easy-to-use software (S/W) system, available in the near future under reasonable commercial conditions, which determined requirements and limitations imposed to the system (narrowing down studied sources of damage), sequence of development activities and KBS structure (2).

The consequence of this approach was modular architecture of KBS with large and carefully structured database and the highest possible application of proven, commercial available S/W tools and packages (2). KBS for remaining life assessment of pressure vessels presently consists of four modules:

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1) Materials, plant Structure and sErvice history Database (MSE Db);
2) Library of Numeric Routines (LNR);
3) Expert Reasoning Module (ERM);
4) The dialogue module.

Modular architecture of the system promotes problem of compatibility, which has to be solved by thorough full development and/or purchasing of modules, programs and tools and integration. In this particular case, integration of S/W modules is based on combination of three well-known, conventional levels:
1) exchanging data via documented intermediary files (specially for purchased S/W packages);
2) linking of common libraries;
3) executing processes from the main program.

MATERIALS, PLANT STRUCTURE AND SERVICE HISTORY DATABASE

MSE Db was first implemented (release 2.0 is in final phase of completing), for the task of systematizing, structuring and collecting experimental and service data, standards and regulations in the field of pressure vessels. During the MSE Db implementing structured system analysis (SSA) (1) and object-oriented prototype development approach have been applied. Although large scope of data relevant for remaining life assessment of pressurized components have been included and structured according to the semantics of real system, the major advantage of this model is possibility of simplified adding new data and database restructuring (4).

Entity - Relationship (ER) model of MSE Db is shown in Figure 1.

LIBRARY OF NUMERIC ROUTINES

The core of LNR module, which contains necessary numeric procedures (stress, fracture mechanics parameters and other calculations), is commercial Computer Aided Engineering (CAE) S/W system based of finite element model. For upgrading LNR, several CAE systems are now in the phase of comprehensive evaluation, according to the following criteria:
1) quality of the results;
2) open architecture;
3) hardware (H/W) and budget requirements.

Since there are presently several S/W systems more than satisfactory quality of the results, the second criterion will probably have decisive role, specially considering integration and development of pre- and postprocessors for parameters of fracture mechanics (e.g. J-integral analysis).

EXPERT REASONING MODULE

ERM provides "intelligent" behaviour of the system. Basic tasks of this module are:

1) activating appropriate routines and procedures according to input parameters
2) dealing with uncertain and incomplete informations
3) helping and navigating user actions in the interactive work - intelligent assistance
4) explaining results of calculations

ERM will be implemented in commercial knowledge engineering tool - KBS shell. Several KBS shells are presently objects of consideration and evaluation.

THE DIALOGUE MODULE

This module performs the dialogue with user, providing user-friendly interface (the condition imposed to every modern S/W system), and participates in executing intelligent assistance task.

KBS DEVELOPMENT PERSPECTIVES

This KBS clearly projected according to empirical axiom of artificial intelligence development: "Think big, start small". Considering main objectives of KBS project, resources, good background in conventional information systems implementing and limited experience in knowledge engineering, several important issues had to be left for future development.

First, ERM should capture deeper knowledge. Second, LNR presently does not contain procedures which are considering corrosion, erosion and creeping, and therefore KBS can be expected to give adequate results only in conditions where those mechanisms of structure degradation are not significant. Third, for the sake of minimizing development time, interface is not planned to be device independent, which will impose few H/W restrictions for executing KBS (in the PC environment). And finally, module for decision optimization, based on multi criteria decision making, which has to suggest an answer what to do with the component (use-as-it-is, minor repair, replacement e.t.c.) is not foreseen in this phase.

CONCLUSION

The main objective of this project is to develop efficient, effective and well balanced system, with the good human - computer interaction and powerful, semantically meaningful database, which is now central and the most important module of KBS. Although this system will obviously exhibit only limited "intelligent" behaviour, its reliable conventional routines and modules should provide a solid base for inference module upgrading and effective usage of expert knowledge and heuristics.

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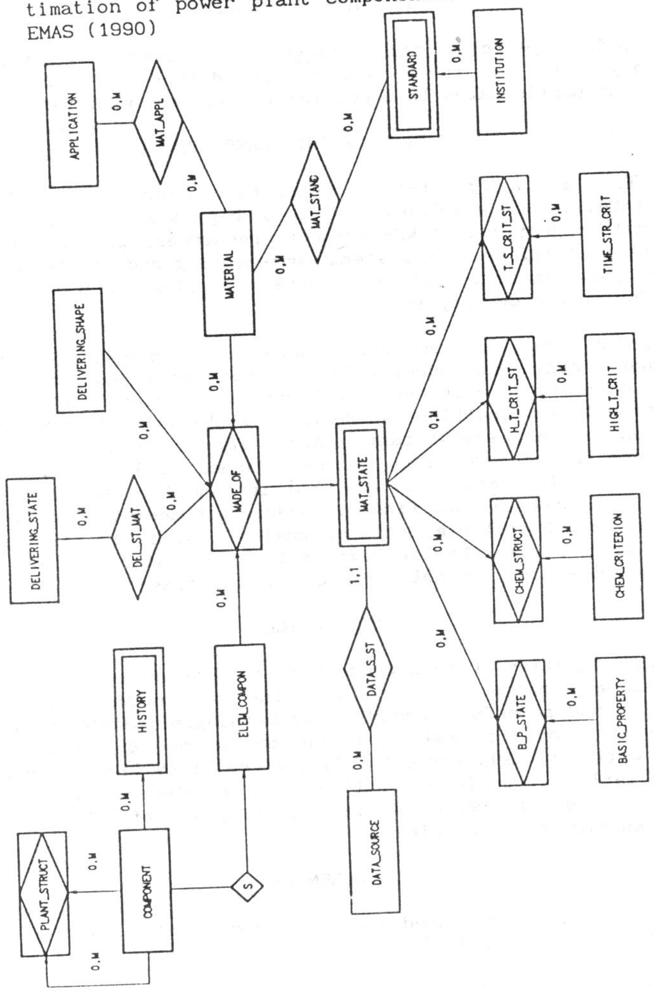

Fig.1 ER model for MSE Db