WIZE: A KNOWLEDGE-BASED DOCUMENTATION AND DATABASE SOFTWARE SYSTEM IN THE FIELD OF FATIGUE AT HIGH TEMPERATURES

A. Jovanovic, K. Maile and P.M. Schäfer

Staatliche Materialprüfungsanstalt (MPA), University of Stuttgart, Germany

Abstract

The paper presents objectives and results of a research project the aim of which is the development of a knowledge-based ("intelligent") documentation and database system (WIZE) in the area of high temperature fatigue strength. The system is controlled by a module developed within the knowledge-based system (KBS) shell and it provides also an "intelligent user-interface". The database part is developed in a relational database system, but an upgrade towards object-oriented network-like database structure is being made. The part contains data for 30 groups of materials relevant for high-temperature power plant applications (e.g. turbine materials) and helps to derive the corresponding crack initiation curves. The documentation base is developed in a full-document oriented hypermedia system. The navigation through the information space of stored hyper-documents is controlled by the KBS-based part. Future development includes application of neural networks.

1. Introduction

Components in power plants are generally not subject only to statical but also to alternating loading, e.g. due to start-ups, shut-downs and changes in operation conditions. Typical examples of such components are boiler components, turbines, pipings, etc. Experimentally determined low-cycle fatigue behaviour of the relevant materials is essential for design and assessment of the state of current damage. This low-cycle fatigue behaviour of a material is especially influenced by several factors, such as temperature or material condition. This leads to the fact that the compilation of numerous test results is confronted with many problems related to crack initiation, failure curves, material laws, damage hypotheses and extrapolation methods for strength and fatigue calculations.

The engineer responsible for assessment relies often on results from literature which he uses for his special problem formation. Correct interpretation of these results is frequently connected with high uncertainties, and the published data are usually not directly usable for the component-relevant applications. In order to implement these data the user is required to know a great deal of the correlation between single results of a test series and the ensuing initiation and failure characteristic curves respectively, [1].
The paper presents an outline of the research project and the corresponding knowledge based system (WISE) currently developed at MPA Stuttgart.

2. Requirements to Documentation System

In the course of the recent years data bases have been set up on various scientific areas with the aim, to store data and to make them accessible to users. However, user from industry have only little practical benefit because of the following facts:

- Complexity of the set up of data bases
- Complexity of the data retrieval operational enquiry (extensive computer knowledge often required)
- No "in-depth" information about the applicability of data, about case studies, about limiting boundary conditions, etc.
- Often unreliable data communication when computer networks are used.

Because of these disadvantages modern developments deviate from a central system and change over to smaller, distributed ones.

On the other hand, various new possibilities (e.g. hypermediabased ones) and the corresponding tools have been created in order to record structured expert knowledge and present it to the user, due to the fact that in order to work successfully with the data base a multitude of expert data knowledge is required. With the help of hypermedia systems it is possible to link associatively information (expert knowledge), data, graphs, etc. Several knowledge-based documentation systems of the kind have successfully been developed at MPA Stuttgart [2-5].

The advantages of these systems are obvious:

- Independent data base on workstation computer without additional costs
- Guidance of the user through the system in dialogue form (EDP-knowledge is not required)
- Possibility to integrate the calculations according to engineering codes
- Easy upgrading possibilities with own results
- Possibilities to store large amounts of data on optical discs (CD-ROM and re-writable discs)
- Possibility of interfacing to external conventional data bases.

3. Conception of the knowledge-based system

On the basis of these technical possibilities the following described steps for the realisation of a knowledge-based EDP-documentation system were defined [6, 7].

3.1. System Architecture

The knowledge-based documentation system WIZE consists of two main parts which are linked with each other.

* WIZE: Wissensbasiertes Dokumentationssystem auf dem Gebiet der Zeitschwingfestigkeit
• Knowledge base part: Information on the material behaviour under alternating load, relevant codes, instructions for the performance of tests and their evaluation, etc.

• Data base part: Material behaviour characterised in form of tables, graphs and mathematical approximation form.

The set-up of the documentation system allows the user to link information on valid codes, material data and explanations with various application conditions. Thus, he will be able to compare, for example, material characteristics and codes from the former German Democratic Republic directly to data from the Federal Republic of Germany. WIZE has been developed according to the software concept KISS (Knowledge-based Intelligent Integrated Software System) of MPA Stuttgart [8], hypermedia and data bases.

3.2. Database Part of WIZE

This part consists of the system and the user's data files, of the user interface, of the set of macros and of auxiliary data files.

• Data files

The data sheets contain all material data characterising material properties and material behaviour. A survey is filed in four tables for 30 material groups with specifications and application fields, chemical analyses and results of the metallographical investigations, mechanical and technological properties as well as the compilation of influential parameters on the fatigue strength for finite life and experimental test results. An additional table contains the data and calculation parameters for the approximation of the crack initiation curves denoted as "Expert curves" in WIZE, see Fig. 1 and their extrapolation.

• User interface:

Five interface sheets oriented to the structure of the appropriate data sheets represent the front end. Buttons are integrated apart from the presentation of the individual data records for the purpose of selecting the picture detail shown on the screen and the change between the various interface sheets. Data selection can be made with the help of the WIZE criteria table. Experimental test results, approximation curves including extrapolation found within the framework of such data investigations are represented to the user on a diagram, Fig. 1.

Buttons in the area of the curve captions legend enable retrieval of additional information from the Hypermedia part of the system.

3.3. Hypermedia Part of WIZE

The hypermedia part consists of three modules, i.e. the information from MPA parameter study, case studies and documentation base (codes, guidelines). The expert knowledge from the parameter study was structured in hypermedia. Because of its improved clarity it is much more user-friendly and parts can be called as additional information. The texts are structured and can be expanded from a list of topics. Relationships between several information are also realised by hot links.
3.4. Expert System Part of WIZE

The priority task which has to be carried out by the expert system object-oriented (OOP) tool Kappa in WIZE is the control of the complete knowledge-based documentation system. It is present in the bottom of the screen during the complete program run. In the hierarchy of the realised expert system case objects are created controlling additional user programmes and showing their current status. These control objects allow highly-efficient parallel running of the three program parts data organisation and administration, hypermedia and expert system case including the realisation of topical cross-references from other program parts by simply clicking the appropriate click box, Fig. 2. For additional information on the topic "Temperature" the click box in the caption area of the diagram has to be activated according to the representation of the results of a data investigation in the diagram. Guide is instructed via Kappa-PC to overlay an expandable subject index on this knowledge area. Following the selection of the topic of interest the relevant text is shown.

4. Use of Neural Networks

Neural networks offer in the case of sufficiently broad data basis a good possibility of connecting input and and output variables in WIZE [9-11].

Neural networks will be used in future for automatic set-up of crack initiation curves. This is not possible with classical numerical methods, as for example in the case,
when only one or two experimental points are present. The "intelligence" of the system shall thus be improved by using neural nets. WIZE will thus become a model for "total-integrated" systems of the new generation, putting expert system, hypermedia and object-oriented data base technologies together with neural nets.

Figure 2: Example for an associative link in the WIZE-System

5. Conclusion - Possibilities for further development

The paper shows the advantages of the WIZE-System in comparison with conventional EDP-Systems. With the help of WIZE it is possible to obtain quickly and simply data necessary for the user's practical need and to support decisions related to the analysis of power plant components. This is of special importance to the small and medium-sized industry, because the system is set-up so that it is not necessary to have specialized EDP-knowledge.

The user obtains information through a user-friendly interface.

The complete project will contribute to the availability and safety of plants and it will enable the supplier to be more competitive in this field. The users from the former GDR are the main potential users of the knowledge-based documentation system.

Main objective of the future development of the existing system is improvement of the present data base structure. This will improve and extend the search and combination possibilities by using object-oriented, hardware-independent "complex" software tools for database development. This will enable the user-friendly quick treatment of large data amounts in the system in future.
6. Literature


