PROBLEMATIC ASPECTS OF BUILDING A KNOWLEDGE BASE IN THE TASKS OF FORECASTING OF THE DURABILITY OF CORROSIVE STRUCTURES

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Annotation: The paper discusses the main stages of building a fuzzy knowledge base in predicting forecasting of the durability of corrosive constructions. When solving this class of problems, it is necessary to formalize incomplete information (in particular, on the parameters of an aggressive environment) and structure multidimensional data arrays that are obtained as a result of the repeated solution of these problems. In this capacity, it is proposed to use fuzzy models of knowledge representation, which, in turn, are formalized in the form of fuzzy knowledge bases. The problematic aspects of their construction are considered, including: determination of the parameters of membership functions; methods for their building; number of terms-sets of a linguistic variable; assignment of semantic and syntactic rules; number of rules of fuzzy knowledge base; establishing the completeness of a fuzzy model and the linguistic completeness of the base of rules for model; accuracy of fuzzy model; coherence and consistency of rule base.

Keywords: fuzzy knowledge base, rule base, fuzzy inference, forecasting of durability, corroding structures.

The formalization of inaccurate data and the solution of applied problems with such data has a fairly broad practical character [1, 4]. The construction of mathematical models of these tasks should be given special attention. In fuzzy models, the rule base is a central element for the knowledge base, because it contains information about the structure of the model itself.

The rule base contains basic information about the simulated system and therefore the ability to correctly form it is a very important condition. This skill allows you to prevent errors that, given the importance of the rule base for a fuzzy model, usually belong to the category of “gross” [3].

Corrosive structures that function in an aggressive external environment are considered in the work [2, 4]. Input variables are: initial σ_0 and ultimate stresses in the element $[\sigma]$, corrosion rate v_0, area A_0 and perimeter P_0 of the core structural elements, the error $[\varepsilon]$ of the numerical solution of the system of differential equations, which describes the process of accumulation of geometric damage in the structural. The output variable is the integration step h_t to obtain the estimated predicted durability.

For each input and output linguistic variable, its term sets are written. For example, the permissible voltage: low (L), medium (M), high (H). The number of terms has a minimum and maximum value. As a rule, the minimum is equal to two, the maximum, of course, can be quite large, but quite visible. To construct membership functions of fuzzy sets of terms, indirect methods of their construction are used.

The next step in building a knowledge base is to define semantic and syntactic rules for defining each linguistic variable.

The number of rules in the knowledge base exponentially depends on the number of model inputs and the number of fuzzy sets contained in it [3]. Obviously, this leads to complication of the model (in some cases, to the so-called “curse of dimension”) and, as a result, to significant difficulties in setting it up.

As you know, a complete model does not need to be accurate, but the condition for achieving high accuracy of the model is its completeness [3].

A complete fuzzy model is a more accurate model of a real system than being incomplete models.

As noted in [3], the linguistic completeness of the rule base is not an absolute or necessary condition for the completeness of a fuzzy model. It is proposed to use a priori data to determine the number of terms of each linguistic variable.

According to the proposed approach for the formation of terms of linguistic variables in general, the rule of a fuzzy knowledge base can be represented:

$$R^{(k)}: \qquad IF \begin{pmatrix} \left[\sigma\right] = T_i^{j} \,\&\, v_0 = T_i^j \,\&\, A_0 = T_i^j \\ \&\mathrm{P}_0 = T_i^j \,\&\left[\varepsilon\right] = T_i^j \end{pmatrix}, \qquad THEN \quad h_t = T_i^j .$$

Here T_i^j – corresponding term-sets of linguistic variables; *i* – term number of each variable $\left(i = \overline{2,\mathrm{N}}\right)$, *N* – maximum number of terms ($N \le N_{kl}$), *j* number of variable $\left(j = \overline{1,5}\right)$, $R^{(k)}$ – corresponding *k*-rule of FKB ($k = \overline{2, N_{kl}}$); area A_0 and perimeter P_0; initial σ_0 and ultimate $[\sigma]$ voltage in it; parameters of the corrosion process v_0 and the maximum permissible error values $[\varepsilon]$; N_{kl} – maximum number of fuzzy knowledge base rules.

The results of numerical experiments suggest that the constructed rule base is linguistically completely. However, the last statement does not allow us to draw conclusions about the completeness of the fuzzy model itself, since the linguistic completeness of the rule base is not a necessary and sufficient condition for the completeness of the model.

At the same time, the constructed rule base allows us to calculate the value at the output of a fuzzy model, namely: each clear input state $(v_0, A_0, P_0, \sigma_0, [\sigma], [\varepsilon])$ leads to the activation of at least one rule. It should be noted that the constructed rule base is concordant and non-redundant.

Based on the foregoing, the following conclusions can be drawn: the rule base should provide the ability to achieve the required accuracy of the fuzzy model, in particular, after the parameters of the latter are determined.

At the same time, in order to reduce computational costs and present the model in a more intuitive way: the number of rules contained in the knowledge base should be as small as possible. In addition, reducing the number of rules in a model with multiple inputs may be a prerequisite for configuring its parameters.

References

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