PREDICTION OF INSTALLABILITY OF COMPLEX MACHINE-BUILDING SYSTEMS WITH PERIODICALLY REPEATED ASSEMBLY AND INSTALLATION WORKS

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For many complex mechanical engineering systems, including oilfield equipment, one of the characteristic features is the specificity of the installation of machines and units at the site of operation. Installation works include: assembly of machinery and equipment at the site of operation, installation of them in the working position at the design site, connection of mechanisms into technological lines, as well as the performance of auxiliary, fitting and other operations. Particularly specific are the requirements for the installation suitability of engineering objects, which are characterized by repeated dismantling and assembly and dismantling and assembly work with periodic relocation of equipment to new points of operation. So, for example, in accordance with the specifics of well drilling, drilling rigs go through the following stages of the operation cycle: construction and installation of drilling rigs, testing of a set of equipment, drilling, installation and testing of wells. Then dismantling and transportation of units to a new place of operation. [Kerimova, 2000]

Periodic re-dismantling with transportation of equipment from point to point has significant organizational and technical developments not only in the technological process of equipment operation (compared to stationary installation), but also in the accepted systems of maintenance and repair. These differences are especially evident during the dismantling of equipment, its transportation and installation at a new point. During dismantling, existing damages and failures are detected, which are eliminated during installation at a new point of operation by current or assembly-assembly repairs.

Upon completion of the installation, the equipment is run-in and tested, as well as pre-operational maintenance. To assess the install ability of oilfield equipment, a guidance document has been developed [AGNA, 1997], according to which the proposed quantitative indicators are divided into main ones - for a general assessment of install ability - additional - for assessing the particular properties of an object.

The composition of the main indicators includes: the total and operational complexity of the installation of the product, the total cost of installation, the coefficient of installation suitability. The composition of indicators for evaluating the particular properties of the product includes: the probability of performing installation work at a given time; average installation time; installation frequency; indicator of manufacturability of the object during installation; collection rate; collection factor; ease of installation factor; coefficient of complexity of the design during installation.

However, the results of using the guidance document show that the composition of these groups of quantitative indicators for evaluating the install ability for the case of periodic re-installation with the transportation of equipment to a new point of operation is sufficiently reasoned and requires some clarification.

Since it is difficult to assess the influencing factors by quantitative methods in this case, an attempt was made to characterize them qualitatively. Of the well-known methods of mathematical processing of qualitative information, the rank correlation method deserves special attention. The essence of the method lies in the fact that a certain circle of specialists (experts) is invited to evaluate the comparative degree of influence of each of the factors on the phenomenon under study by assigning appropriate ranks to the factors. The most strongly influencing factor is assigned the rank of 1st, other factors in descending order - ranks of the 2nd, 3rd, etc.

If the expert finds it difficult to indicate the sequence order for two or more adjacent factors, then he assigns the same rank to them, and introduces fractional ranks during the calculation.

There are several ways to conduct an expert survey. The most common of these is the method of coordination, which consists in the fact that each expert gives an assessment independently of the others, and then the information received is summarized to make an informed decision.

Preliminarily, based on the need for an individual assessment of the significance of quantitative indicators of assemble ability for mechanical engineering systems with periodically recurring assembly and installation work, a questionnaire was developed for experts. The questionnaire included the main and additional quantitative indicators of install ability in the following sequence:

The total labor intensity of installation includes the labor intensity of the main, auxiliary, fitting-finishing and preparatory-final works carried out during the installation of the object.

The operational complexity of installation includes the complexity of the main, auxiliary, fitting and finishing works carried out during the installation of the object.

The total cost of installation of the main, auxiliary, fitting and finishing works carried out during the installation of the object.

Mount ability coefficient is the ratio of the wholesale price of an object to its total cost, including the cost of installation work.

The probability of performing installation work at a given time. The probability of performing installation work at a given time is the probability that the installation time of an object will not exceed a given value.

Average installation time - the mathematical expectation of the installation time of the object.

Mounting frequency - the mathematical expectation of the number of cycles (mounting, operation, dismantling, repair, reserve, etc.) performed by the object during the considered calendar time.

Manufacturability of the design during installation - the ratio of labor costs to perform basic installation work. To the total cost of installation of the object, excluding labor costs for fitting and finishing work. Collection coefficient - the ratio of labor costs for the implementation of the main installation work to the total labor costs for the installation of the facility, excluding labor costs for the performance of auxiliary work.

Assembly coefficient - the ratio of labor costs for assembling an object at the manufacturing enterprise to the total labor costs for assembly and installation.

Coefficient of ease of installation - the ratio of the number of comfortable working positions of the performer during the installation of the object to the total number of characteristic positions.

Coefficient of design complexity during installation - the ratio of the total labor intensity of installation, assembly and adjustment work to the labor intensity of installation work during the installation of an object.

To determine the degree of significance of the listed quantitative indicators of the assembly suitability of mechanical engineering systems with periodically recurring assembly and installation work, the opinions of eight experts competent in this matter were collected. Based on the results of the questionnaire survey, a rank matrix was compiled (see table) with the number of experts m=8 and the number of analyzed factors (quantitative indicators of install ability) n=12.

The degree of agreement between the opinions of experts was checked using the concordance coefficient:

Factor ranking results

Number expert	**FACTORS**											
	1	2	3	4	5	6	7	8	9	10	11	12
1.	1,5	12	5	8,5	8,5	1,5	3	7	10	11	6	4
2.	2	12	4,5	7	8	1	3	11	9	10	4,5	6
3.	1,5	12	6	8	7	1,5	3	10	9	11	5	4
4.	2,5	12	5	8	6	1	2,5	9	10,5	10,5	4	7
5.	3	10	5	8,5	8,5	1	2	7	12	11	4	6
6.	2,5	12	4	7	8	1	2,5	11	9	10	5	6
7.	1	11	4	8	7	2	3	10	12	9	5	6
8.	1	10	4	8	7	2	3	9	11	12	5	6
∑	15	91	37,5	63	60	11	22	74	82,5	84,5	38,5	45

$$W = \frac{S}{\frac{1}{12} m^2 \,(n^3 - n)};$$

Where m is the number of experts; n is the number of ranked factors: S is the sum of the squared deviations.

$$S = \sum_{i=1}^{m} \left(\sum_{i=1}^{n} r_{ij} - \frac{\sum_{j=1}^{m} \sum_{i=1}^{n} r_{ij}}{n} \right)$$

Where r_{ij} is the rank of the j-th factor of the i-th expert.

When the opinion of experts completely coincides, then W=1, if there is a discrepancy, W=0. Thus, the value of the coefficient of concordance lies within 0≤W≤1. The coefficient W calculated according to the table is 0.936. This shows that the average degree of agreement among all interviewed specialists is quite high. To assess the significance of the concordance coefficient, the chi-square test is used:

$$\chi 2 = \frac{S}{\frac{1}{12}} \cdot m \cdot n(n+1)$$

The calculated value of the chi-square test is compared with the tabular value of the test taken for a confidence level of 0.95. The most probable value of the considered event is estimated by the smallest sum of ranks. The calculated value of χ2 (97.36) turned out to be higher than the table value (19.7), so it can be argued that the agreement in the opinions of the interviewed specialists is not accidental.

The results obtained make it possible to make the necessary adjustments to the current guiding document “Mountability of oilfield equipment. Terms, definitions, nomenclature of indicators and evaluation methods”, extending it to mechanical engineering systems with periodically recurring assembly and installation work.

References

Chen, R.W., Navin-Chandra, D. et al. (1994) 'A systematic methodology of material selection with environmental consideration', IEEE Int. Symposium on Electronics & Environment.

De Fazio, T.L. and Whitney, D.E. (1993) 'A prototype of feature-based design for assembly', Journal of Mechanical Design, Vol. 115, pp.723-734.

Dong, T., Zhang, L. et al. (2006) 'A hierarchical approach to disassembly sequence planning for mechanical product', International Journal of Advanced Manufacturing Technology, Vol. 30, Nos. 5-6, pp.507-520.

Guiding document “Mountability of oilfield equipment. Terms, Definitions, Nomenclature of Indicators and Methods of Evaluation”. RD 26-16-45-97. - Baku: AGNA, 1997.32 p..

Herrmann, C., Frad, A. and Luger, T. (2008) 'Integrating the end-of-life evaluation and planning in the product management process', Progress in Industrial Ecology - An International Journal, Vol. 5, Nos. 1&2, pp.44-66.

Holbum, D.M., Anstey, M. et al. (1995) 'A novel architecture to facilitate disassembly and reuse of electronic components and sub-assemblies', Proc. of Int. Coriference on Clean Electronics Products and Technology

Kerimova L.S. Functional model with periodic dismantling and reassembly. Mechanical Engineering. 2000, T 4. P. 4-7.

Li, F-Y., Liu, G. et al. (2000) 'A study on fuzzy AHP method in green modularity design', China Mechanical Engineering, Vol. II, No.9.

Mascle, C. (1998) 'Automatic a priori, a posteriori or appropriate determination of subassemblies', International Journal of Production Research, Vol. 36, No.4, pp.l 001-1021.

Seaver, W.B. (1994) 'Design consideration for remanufacturability, recyclability and reusability of user interface modules', Proc. of1994 IEEE Int. Symposium on Electronics and Environment.

Shah, U. and Tadepalli, R. (1992) 'Feature based assembly modelling', Computers in Engineering, Vol. I, pp.253-260