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The diagnostics by portable systems as an alternative for the diagnostics by stationary systems

SUMMARY

In this paper a preliminary analysis of extending application (mainly in marine industry) of diagnostic strategy based on technical state assessment is presented. It is proposed to use portable diagnostic systems for implementation of this strategy which is hoped to be more effective than the service life strategy, widely and almost exclusively used in ship exploitation. Scope of necessary research to make using these systems possible and justifiable is also given.

EXPLOITATION STRATEGIES

The service life strategy is widely used in contemporary ships as almost unique out of five usually applied exploitation strategies [3]. The service life strategy (called also „diagnostic strategy") is applied to a very limited extent. Other strategies are used sporadically.

The service life strategy is used most often due to lack of alternatives, regardless of its low effectiveness and of many other problems connected with its use. No need of using any diagnostic instrument is in favour for that choice. Service life counters summing up operation time intervals of objects in service are the only instruments most frequently provided. This does not eliminate however the main drawback of the strategy which is no possible control of object's real wear-and-tear .

The diagnostic strategy eliminates disadvantages of the service life strategy. A diagnostically controlled object (shortly called "diagnosis object" here), exploited in line with that strategy, is controlled by a diagnostic system monitoring its technical state.

In a general sense, a ship, her mechanical or electric power system, cargo handling gear etc may be selected as a diagnosis object, but in a detail sense - main or auxiliary engine, electric generator, pump, compressor, crane etc.

A wider use of that diagnostic strategy is strongly demanded owing its positive features. However, some economic and technical obstacles, difficult to be eliminated, still stand against a wider application of the strategy.

The first of them is that its stationary version, in which each diagnosis object is fitted with its own permanent diagnostic system, is almost exclusively applied today . If the number of objects is large,wide application of individual diagnostic control is very costly.

The second obstacle is due to not fully solved technical problems connected with:

- selection of diagnostic parameters for an object
- measurements of actual values of the parameters as well as
- their classification, interpretation, and relation to object's technical state.

Such obstacles appear in every diagnostic measurement process, however to a different extent.

Substantial cost reduction may be obtained in individual diagnostic strategy by parallel application of stationary and portable diagnostic systems. An outline of this problem was previously presented in [1] and in further works of this author [5], [6], [7]. This paper is intended to serve as an introduction to new research works on this subject.

KINDS OF DIAGNOSIS-REPAIR PROCEDURE

A diagnosis-repair procedure for a diagnosis object consists of:

- technical state assessment
- fault location
- fault identification (in respect to its place, type, extent, causes and consequences)
- repair of the object and after-repair control testing.

All the operations (except of object's real repair), being dependent on diagnostic instrumentation of the object, are carried out in different ways dependent on kind of diagnostic strategy, its complexity and automation level. Along with real repair an apparent repair, in which object's functional redundancy is used, may be also distinguished; it consists in switching-off a failed element and switching-on a redundant element instead.

The following kinds of applied diagnostic methods may be distinguished in respect to diagnosis-repair procedure:

● ***Non-computerized diagnostic method*** (Fig. 1) in which all the diagnosis-repair operations are performed by a man equipped with necessary measuring instruments and using technical information contained in supporting materials such as service manuals, technical specifications, or working objects of the same type etc.

In this diagnostic method special ways for fault location-identification are used to shorten diagnosis-making time. They are aimed to limit the number of diagnostic steps required for object's technical state identification.

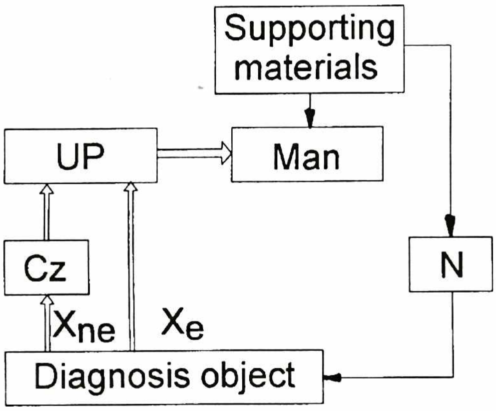

Fig. 1. Scheme of diagnosis-repair procedure in non-computerized diagnostic method
Cz - set of gauges, N - tools, UP - set of measuring instruments, x_e, x_{ne} - electric and non-electric diagnostic parameters

● ***Computer-aided diagnostic method*** (Fig. 2) in which all diagnostic and repair operations are also performed by a man using a computer equipped with a diagnostic and fault location algorithm suitable for the actually diagnosed object. Such algorithm contains a sequence of procedural steps which is specific for a given object.

In this diagnostic method it is the computer which controls diagnostic procedure giving instructions to the man who executes them. Having done these manipulations and measurements, he brings the conclusions yielded from these operations into the computer. The computer selects then the next procedural step on the basis of the memorized information. The operations are repeated until the lowest level of object's decomposition is reached, viz. the elements' level is achieved.

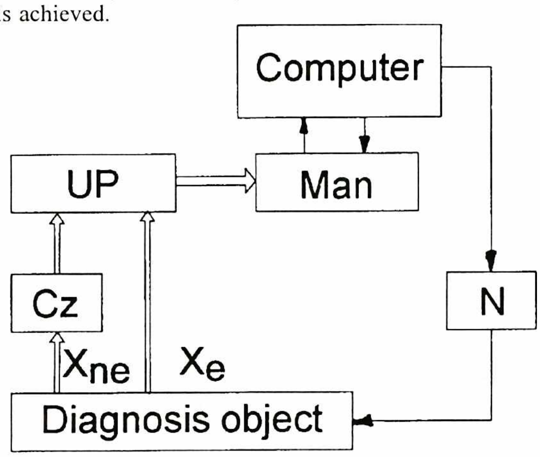

Fig. 2. Scheme of diagnosis-repair procedure in computer-aided diagnostic method
(Notation - see Fig. 1)

Schemes in Fig.1 and 2 differ from each other only by the substitution of „supporting materials" with „computer" and two-directional man-computer communication instead of the one-way connection.

● ***Computer-controlled diagnostic method*** in which all diagnostic and control operations and some repair ones (those in which the use of object's redundancy is made) are performed solely by a computer. The computer is permanently connected through a tester with a diagnosis object during the entire diagnosis-making time. Scope of diagnostic and repair operations performed by such system depends on its universality. One of its versions is shown in Fig. 3.

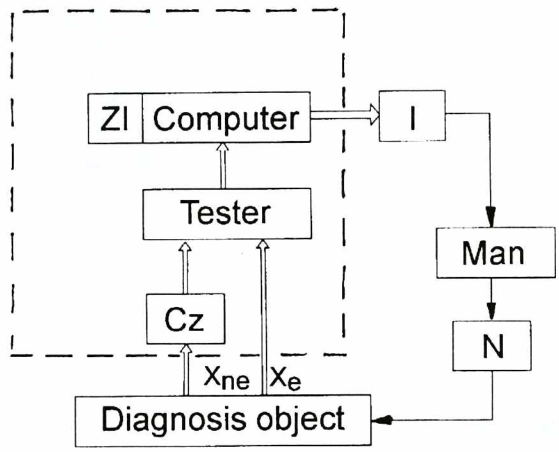

Fig. 3. Scheme of diagnosis-repair procedure of the computer-controlled diagnostic method in its measuring-assessing version.
ZI - set of information about diagnosis object, (for the remaining notation - see Fig. 1).

Almost all contemporary diagnostic systems are computerized. Therefore application of any strategy supported by a diagnostic system is connected with this diagnosis-repair procedure which is relevant to the computerized diagnostic method, regardless of whether diagnosis is made by using a stationary or portable system.

DIAGNOSTIC STRATEGY BASED ON STATIONARY SYSTEMS

When applying this diagnostic strategy a diagnosis object is fitted with an individual diagnostic system which performs object's technical state assessment, fault location and after-repair operations by itself. Fault identification and real repair is always assigned to man, but apparent repair may be assigned either to the system or to man, depending on needs.

Complexity of a diagnostic system currently controlling object's technical state depends generally on complexity of the controlled object and is characterized by special features resulting from demands and needs of the object and its higher-level structures. In these special features, demands resulting from object's type and even from a given object's copy, are often accounted for too. Therefore it is not possible to use a chosen version of stationary diagnostic system for diagnosis objects of a different kind or type, except of very special cases.

Stationary diagnostic system is permanently connected with the object controlled by it. Such system rarely forms a separate unit but usually it is structurally built into the diagnosis object. Diagnostic systems for complex electronic devices, especially digital ones (as e.g. computers), are particularly diversified and specialised.

Stationary diagnostic systems fulfil their functions relatively well in typical applications only, i.e. in the objects which they were designed for. This is a positive feature of the systems. They are not available however as universal market products due to their low applicability to other than typical cases.

Especially important objects are fitted today with stationary diagnostic systems exclusively (in ships - these are objects decisive for ship's ability to further voyage or for safety of life at sea). The remaining objects, less important or with enough redundancy are exploited in line with service life strategy.

SPECIFIC FEATURES OF DIAGNOSTIC STRATEGY BASED ON PORTABLE SYSTEMS

In the above described situation relatively less important objects are deprived of diagnostic control at all. Their exploitation in line with the service life strategy is far from optimum. To change the situation research works are recently carried out aimed at making it possible to diagnostically control such objects, from time to time at least. This could be accomplished today on the basis of portable diagnostic systems as it is not reasonable to apply a stationary diagnostic system in each case.

Providing a ship with a few special, programmable diagnostic systems would make it possible to perform cyclic or ad-hoc diagnostic measurements by ship's personnel. This concept could be considered as a realistic alternative for stationary diagnostic systems in the case of secondary objects, because it seems to be possible to design and manufacture such diagnostic systems in a better choice. These could be systems suitable for a wider scope of applications also in different untypical situations..

Systematic retrieval of information on technical state of a given diagnosis object is performed by connecting it with a diagnostic system. This is effected directly in the case of electrical magnitudes by connecting electric cables with spots chosen on the object, but indirectly - when non-electric magnitudes are concerned. In the latter case the cables are connected with the gauges, fixed in advance, which can measure magnitudes carrying information about parameters chosen for object's diagnostic control.

All information retrieval spots in a stationary diagnostic system are permanent. Cables running from these spots are usually connected with a computerized functional unit of the system through a tester. The spots can be selected in a relatively optimal way as information retrieval spots are unchangeable.

Due to this it is possible to maintain conditions of gauge-object contact unchanged for all the service life of the gauges in stationary diagnostic systems . It means that their static and dynamic characteristics are also kept unchanged which is fundamental condition for correct work of diagnostic system as the characteristics relate measured magnitudes to gauge output signals .

In diagnostics by portable systems, technical state assessment of a diagnosis object is carried out in a quite different way as one diagnostic system is provided for control of many objects. In this case the diagnostic system is connected with a diagnosis object only for the time needed to perform a control. When these operations are finished the connections (cables and gauges) are taken out and transferred to the next object.

PROBLEMS OF GAUGE-OBJECT CONTACT REPEATABILITY

The consequence of connecting-disconnecting operations of a diagnostic system is a necessity of connecting and disconnecting elements which retrieve diagnostic information from an object. Number of the operations is rather unimportant in the case of connections which conduct signals of electrical magnitudes. The problem is opposite however in the case of measuring non-electrical magnitudes.

When a large number of diagnosis objects is selected to be serviced by one diagnostic system, fitting each of the objects with independent gauges seems to be unrealistic and uneconomical also because of difficult working conditions in which many objects operate and which may influence destructively gauges fixed on the objects. Moreover it would be necessary to install again almost all gauges on an object in each case of using such a diagnostic system.

Each subsequent gauge installation is characterized by somewhat different features of gauge-object contact. In each case this is followed by a deviation of the characteristics relating measured values to gauge output signals,. When the differences are too large, the gauge calibration is not valid any longer. Achieving an acceptable repeatability of gauge-object contact is the most difficult obstacle to be overcome in implementation of portable diagnostic systems.

CALIBRATION PROBLEMS IN PORTABLE DIAGNOSTIC SYSTEMS

Diagnostic system calibration is not limited only to gauge calibration against magnitudes assumed as diagnostic parameters. Determination of relationships between current values of the parameters and an actual technical state of a diagnosis object is equally necessary and even much more difficult to be achieved.

In the stationary diagnostics the relationships are established during manufacturing process of the object. They are determined by making use of fragmentary observations and measurements and then calibrating them against prior service records of other units of the same object's type. The relationships obtained this way are valid during all service life of the given object.

One portable diagnostic system may be applied for diagnostic control of many objects (of the same or different type or kind) which are characterized by the diagnostic parameters possible to be measured with the use of the gauges of the same or similar type. The system application universality for different diagnosis objects is limited to computerized systems only which may be adjusted to control even very different objects.

The adjustment consists in re-programming of the system in line with diagnostic requirements of a new object, viz. by installing a diagnostic program, suitable for the new object, into the computer. Such an independent diagnostic program, averaged for objects of the same kind, may be elaborated on the basis of calibration of some or dozen or so objects of a given kind which are in some different, but nearly known, technical states. These should be objects selected not only from their manufacturing but also exploitation phase. It is possible however to limit the basis of calibration to objects in service only.

Each diagnostic program elaborated in this way would be valid for a large number of objects of the same kind, but it would be less exact than the programs prepared for stationary diagnostics.

Its exactness can be satisfactory for practical purposes if only calibration during programming is made relatively exactly. However calibration of the system based on data from a single object only is not acceptable because an actual, notexactly known technical state of the object used in calibration would be then decisive for its results.

CONCLUDING REMARKS

Application of diagnostic strategy is limited today to its version connected with the use of stationary systems only and therefore is generally limited. The situation may be changed for better by development of the diagnostic strategy based on portable systems.

An optimum solution would be application of both versions of the strategy: based on stationary and portable systems, in parallel. To bring this idea into effect it is necessary to carry out research on repeatability of gauge-object contact and on diagnostic system calibration methods based on diagnostic measurements of a limited number of similar diagnosis objects. Some of the research projects are under way.

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