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DEVELOPMENT OF MICROCOMPUTER-AIDED VIBRATION DIAGNOSTIC SYSTEM

Summary. The paper presented development of microcomputer-aided vibration-diagnosing system offered by Poltegor Institute, Poland. Three levels of development of the system are distinguished. Description is given for analog diagnostic devices and utility features of a program for microcomputer compatible with IBM PC AT or XT, capable of being used in conjunction with the system DOS III and hard disc 20 MB. The utility program enables to provide a data base for five hundred drive units (motor-gear-unit).

Data on the object can be gathered during three year period. Also, microcomputer-aided diagnostic infering system has been used. The program is controled through menu.

1. INTRODUCTION

The paper presented development of vibration diagnostic system, taking its use for driving units (electric motorgear-unit) as example. The development on a given level is distinguished from the vertical one associated mainly with the introduction of new technical means.

The system and its development based on the theory and practice was created owing to the co-operation between Poltegor Research Institute and largest Polish Surface Mine Bełchatów. The development has been pursued over a span of about seven years of the Institute's activities and some five years of industrial application when the diagnostic method and measures, diagnostic devices, utility software were continuously refined. The system is mainly used for the diagnostics of gear-units.

First approach to the diagnostic method, and preparation of initial points for selection of features of the diagnostic devices, was based on [1, 2] and references cited in [1].

The development of diagnostic method is presented in [3-6]. Problems associated with the classification of toothed gear condition are considered in [4]. The method to evaluate selection of diagnostic parameters and diagnostic signalreceiving points is suggested in [5].
The technical deseription of analog diagnostic devices is given in [7].

2. DESCRIPTION OF DIAGNOSTIC SYSTEM DEVELOPMENT

In the development of diagnostic system, one can distinquish the development on a given level, as shown in fig. 1.

In general, aparat from the horizontal development, the vertical one can be distinguished which consists mainly in the introduction of new diagnistic means to give rise to the vertical development on a higher level.

To develop a diagnostic method on a given level, fig.1, certain features of a diagnosed object must be determined and changes in these features, as those reflecting its technical condition, will be followed-up by measuring physical quantities. Keeping in mind the features of diagnosed object and the hitherto knowledge in the field of diagnostics, a diagnostic method is developed for which most simple means of technical diagnostics are selected. As per principles of the method, diagnostic experiments tests are made using means intended for the diagnostics in order to determine a correctness of the developed method, and correct selection of diagnostic means as well.

After experiments carried out, it is likely to be necessary to find (to discover) new features of the object, to improve the method; this is illustrated by the arrows of feedback shown in fig. 1. After having made experiments and verified method, the user can start with gathering diagnostic data. In the first time-period after introduction of the method, the diagnostic data can also be gathered by a research center.

If the user is at disposal of a large number of the objects of the same type, statistic handling of results follows after having gathered data concerning all the objects at a given time interval. In [3], there is shown how to reduce a number of diagnostic parameters, basing on a definite statistic handling of results. On the lowermost level of the development, statistic handling of results is carried out with the use of traditional manual input through the keyboard computers for measuring collections gathered in the note-books. As already mentioned, a decisive effect on the development of diagnostics have selected diagnostic means and their coherent constraints. In the veritcal development of diagnostic means, there is possible to distinquish analog, hybrid (analog-digital), and digital diagnostic devices. In the vertical development of a method of diagnostic data gathering on the lowermost level, there is used notation of data obtained from analog device readings to be written down in the note-books and on this basis, graphs of changes in data values are plotted. A higher level of data gathering can be represented by data storing in the microcomputer, readings taken from the analog devices through the keyboard.

Essentially new quality in the method of diagnostic data gathering is the use of microprocessor based diagnostic data collector which

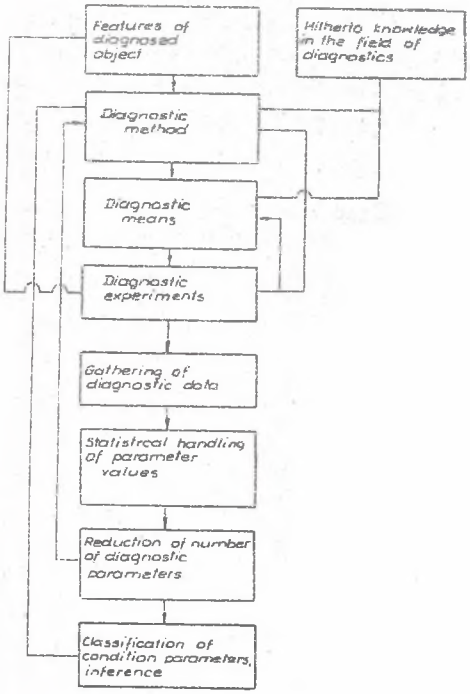

Fig. 1. Development of technical diagnostics on a given level

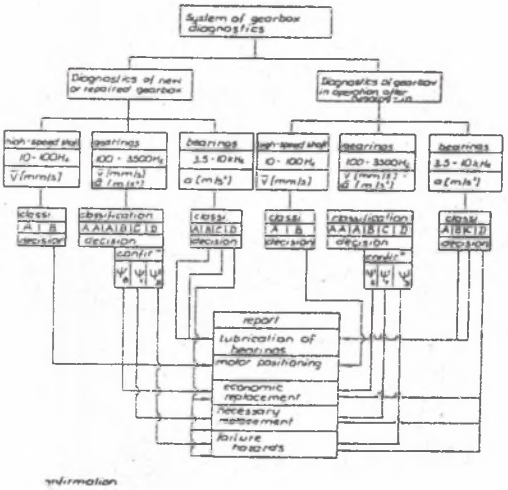

Fig. 2

memorizes properties of the entire diagnostic signal in the digital form. The signal is transmitted then, trough the interface, to the microcomputer. The latter makes a signal analysis like that in the analog devices and besides, the signals are analyzed further, depending on the software. The statistical data handling is subject tothe vertical development. The loaremost level of data handling has been already mentioned. A higher phase is to prepare a specialized softwere for the microcomputer and to make use of data base of the diagnostic system. There are used data gathered manually through the keyboard or data fed with the use of collector which is connected with the microcomputer throught the interface.

The specialized software relating to the statistic handling of results can also be fed into the diagnostic system, thus forming an integral whole.

3. ELEMENTS OF DIAGNOSTIC SYSTEM

3.1. Analog, hybrid (analog-digital) diagnostic devices

A basis for the development of engineering diagnostic system are diagnostic devices and their coherent constraints. There is a variety of portable diagnostic devices enabling measurement of physical quentities to be made according to ISO [10] or Canadian standards [11]. As per principles of the method presented in [3, 6]. The device PPD1 has been developed under consideration in [7] and in [6], reasons are given for construction of a diagnostic device whose characteristic differs from that used so far. The device PPD1 is shown in fig. 3. For further analysis of the signal, the analog device UPD1 has been developed. It is a vibration analyzer enabling narrow-band analysis to be mede in specific reasonable cases after having made measurements with the use of device PPD1. The latter makes also possible to evaluate rolling

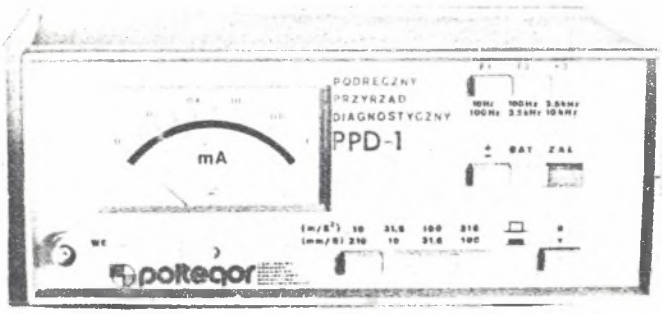

Fig. 3

bearings condition, making use of resonant properties of a housing of the object where rolling bearings are built in. The bearing condition is evaluated basing on the rms value of wall vibration acceleration for a bend width 3500-10 000 Hz. A similar principle relates to the commonly used meter for bearings diagnostics called SPM (Shock Pulse Method) where the bearing condition is determined by measuring ultrasonic wave intensity corresponding to the resonance frequency of a piezoelectric sensor. The device PDŁ for bearings diagnostics shown in fig. 4, apart from being capable of measuring intensity like devices PPD and SPM, enables percentage of the depth of modulation to be measured. The depth of mo-

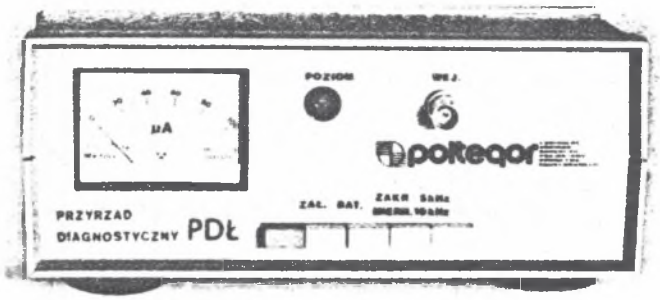

Fig. 4

dulation is a supplementary important feature of the diagnostic signal, and enables an additional interpretation associated with the rolling bearing condition. In practice the device PPD1 proved very suitable to be used for the diagnostics of toothed gears. At present, a fundamental standard of a hybrid (analog-digital) diagnostic device called MKDD-1 microprocessorbased diagnostic data collector is being developed, which enables, apart from being capable of making diagnostic measurements (analog part), features of the signal to be recorded in digital form. The signals recorded in digital form are transmitted through the interface to a microcomputer compatible with IBM in order to be handled further.

3.2. Microcomputer-aided diagnostics

On a definite level of the development of diagnostics, findings from readings in devices PPD1 and PDŁ are transfered through the keyboard to the microcomputer.

A regular gathering of diagnostic data results from a need of afficti-ve use of the diagnostics. At Poltegor Institute, an original program for

microcomputer compatible with IMB PC-XT or AT was developed, enabling diagnostic data to be gathered along with their adequate processing which makes it possible to aid the diagnostic inference. The data base allows to gather data during three-year period, namely those for 500 nos. of drive units (gear-unit - electric motor).

Owing to the use of computers to aid the diagnostics, a report is obtained in form of a printout which gives preventive recommendations concerning necessary check of bearings lubrication as a catchword "lubrication of bearings. A further instruction in the report is watchword "position motor", including value of a diagnostic parameter being indicative of an incrorrect positioning of the motor relative to the toothed gear. The above watchwords give instructions to take preventive measures in order to maintain a suitable technical condition of toothed gears.

The hazardous states of toothed years as a whole are given in the report in form of three conditions recorded as economic replacement, necessary replacement, failure hazard. It is suggested to replace the gear in such technical condition which is adequate to the catchword "economic replacement". Keeping in mind a required rate of production, decissions on the gear replacement can be taken on all three levels of gear condition. Of course, it is possible to make up report on a definite process line, or corresponding section of the report concerning preventive recommendations or degree of hazard.

The diagnostic program is controlled by means of menu. Fig. 5 shows menu of catalogue "Analysis" against a background of the main catalogue. After selection of item 1 of the main catalogue - feeding measurements - table shown in fig. 6 is displayed. After having selected item 2 from the

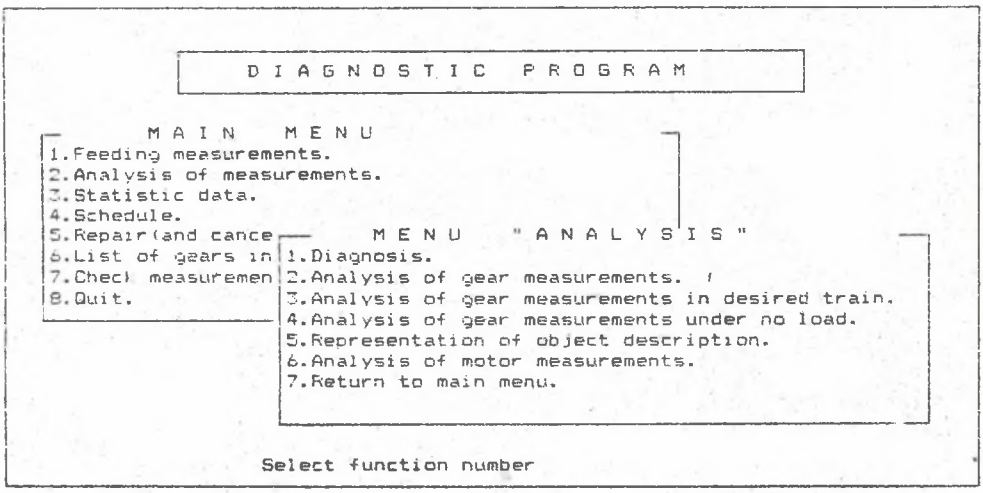

Fig. 5

ROUTINE MEASUR. 1.RP TYPEKA16 Conv.62.06N Date88.11.16 Load 85.0

M	10-100Hz v[mm/s]	100-3500Hz v[mm/s]	100-3500Hz a[m/s2]	3500-10000 a[m/s2]	M	10-100H v[mm/s]	100-3500Hz v[mm/s]	100-3500Hz a[m/s2]	3500-10000 a[m/s2]
1	4.5	2.6	12.0	2.0	7				
2	4.7	2.6	8.0	4.0	8				
3	2.6	5.5	12.0	1.5	9				
4	4.2	3.5	11.0	2.0	10				
5	0.0	0.0	0.0	0.0	11				
6					12				

Annotation

Is it to be printed out?(Y/N)

Fig. 6

main catalogue, a full screen illustration will appear in the display unit, as shown in fig. 5. If item 1 is selected from the catalogue "Analysis", the system shall request to designate the object which can be distinguished by a place of its actual use or by inventory number. After having fed data on the object, the diagnosis will be displayed, as shown in fig. 7.

```
Gear  1.RP        Date of last measurement88.11.16
Within  10-100Hz v-av.in cl.A.
Range II pnt3-cl.A;
Within 100-3500Hz a-av..v-av.in cl.AA.
Range III:
Pnt.1 in cl.A
Pnt.2 w cl.A
Pnt.3 - cl.A
Pnt.4 - cl.A
Pnt.5 - cl.A
```

Do you want graphical classification of rolling bearings ?(Y/N)

Fig. 7

The diagnosis relates to the gear numbered 1RP and speaks about a correct running of hight-speed shaft of the gear (class A) and incorrect running of the gearing (class D). The condition of rolling bearings operated within area of points 1-4 is correct (class A). The interpretation

of classes A-D is explained in [4]. In order that a diagnosis might be made basic technical data on the object must be fed, apart from the values of parameters, as shown in fig. 8. The whole menu of diagnostic

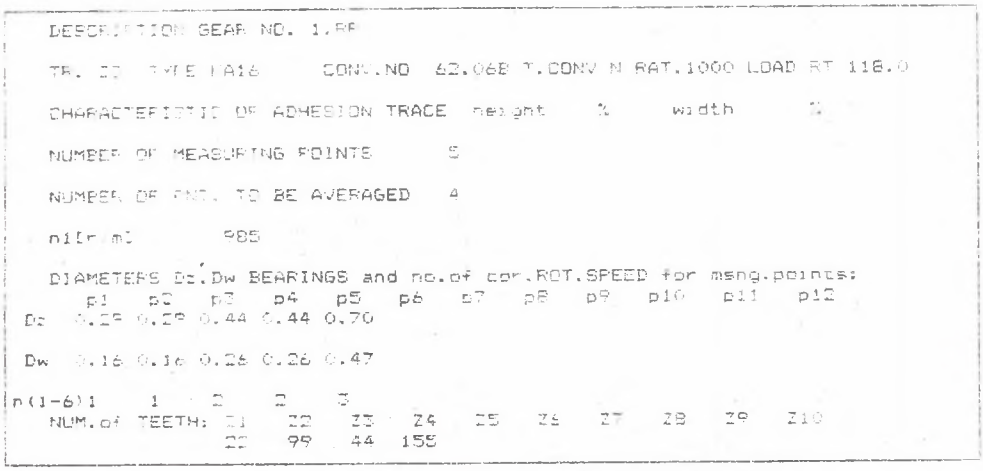

Fig. 8

system has five sub-catalogues comprising 3-6 catchwords which enable to control software as a whole. Particular catalogues are arranged as shown in fig. 5. An effect from using the method and system is presented in form of a report. The report is controllable by menu fig. 9. The exemplary report on a preventive recommendation concerning lubrication of bearings is shown in fig. 10. Apart from the utility program enabling data to be gathered and diagnostic inference to be made, a research pro-

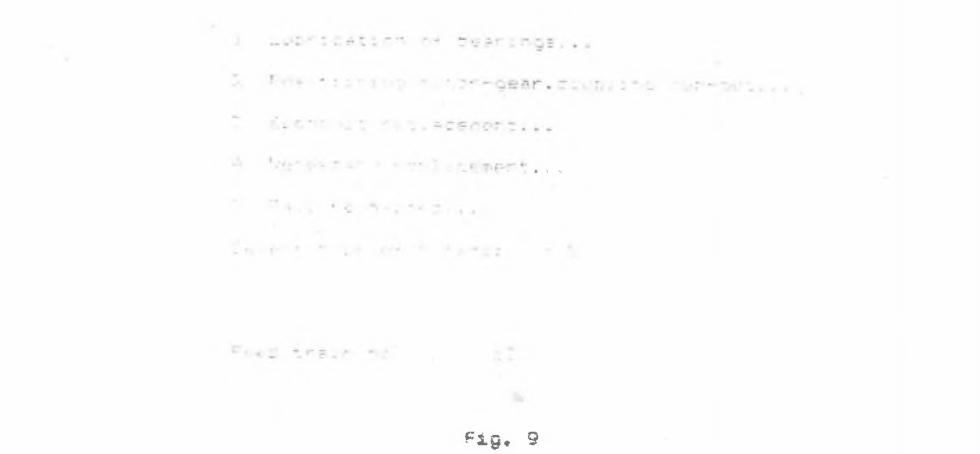

Fig. 9

gram has also been developed which makes it possible to realize the suggested method acc. [5] to be used for evaluation of the correct selection of measuring and diagnostic signal-receiving points.

```
          "LUBRICATION OF BEARINGS..."
 1.02C   4Z          87.09.28 - occurred   1 time(s)
 a3-k1.B:
-------------------------------------------------------------------------------
 1.04A   762/MR      88.10.31 - occurred   1 time(s)
a1-k1.B:
-------------------------------------------------------------------------------
 1.04A   763/FZ      88.06.10 - occurred   3 time(s)
 a2-k1.B:

 88.06.10    - previous msr.
 a2-k1.B:
 II zakr.-a,v k1 B:
 IIzakr.pkt3-k1.D:
-------------------------------------------------------------------------------
 1.04C   740/FZ      89.01.10 - occurred   3 time(s)
a1-k1.B:a4-k1.B:


                press any key ...
```

Fig. 10

CONCLUSIONS

In the development of diagnostics, three essential levels can be distinguished which are possible to be used for the mines depending on their size.

First level relates to the use of analog diagnostic devices PPD1, UPD1, PDŁ, with collection of diagnostic data in the notebooks. This level is recommended for small mines when cheap manpower is available.

Second level relates to the use of above analog devices, with collection of diagnostic data in a microcomputer compatible with IBMPC AT or XT provided with operating system DOS III and hard disc 20 MB.

Third level relates to the use of a hybrid analog-digital device capable of being operated in conjunction with IBM PC through the interface, besides, DOS III with hard disc 40 MB is utilized. This level is recommended for large mines.

The Poltegor Institute, Wrocław/Poland, is now able to supply analog devices and utility software for the first and second levels.

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POSTĘP WE WSPOMAGANYCH KOMPUTEROWO WIBRACYJNYCH SYSTEMACH DIAGNOSTYCZNYCH

S t r e s z c z e n i e

W artykule przedstawiono opracowanie układu do wibracyjnego diagnozowania wspomaganego mikroskomputerem, a oferowanego przez Instytut "Poltegor", Polska. Wyróżniono trzy poziomy układu. Podano opis analogowych urzędzeń diagnostycznych i cechy użytkowe programu dla mikrokomputera kompatybilnego z IBM PC AT lub XT, który można zastosować łącznie z układem DOS III i dyskiem twardym 20 MB.

Program użytkowy pozwala na dostarczenie bazy danych dla pięciuset zespołów napędowych (silnik - przekładnia zębata - zespół). Dane na temat obiektu można zbierać przez okres trzech lat. Ponadto zastosowano też diagnostyczny układ wnioskujący, wspomagany minikomputerem.

Program kontrolowany jest poprzez menu.

ПРОГРЕСС В КОМПЬЮТЕРНО ВСПОМОГАТЕЛЬНЫХ ДИАГНОСТИЧЕСКИХ ВИБРАЦИОННЫХ СИСТЕМАХ

Р е з ю м е

В статьи представлено разработанную схему для вибрационного диагноза, подлитываемую микроЭВМ, а предлагаемой институтом "ПОЛЬТЕГОР" - Польша. Выделено три уровни схемы. Указано описание аналогичных устройств для диагноза и потребительные свойства программы для совместимого микроЭВМ с IBM PC AT или XT. который можно использовать вместе со схемой DOS III и хард-диском 20 мегабайтов.

Рабочая программа позволяет передать базу данных для 500 силовых установок двигатель - зубчатая передача - установка . Данные на тему объекта можна собирать три года.

Кроме того применененно также диагностическую схему выводов, которую подлитывает микроЭВМ.

Программа контролирована меню