ИЗМЕРИТЕЛЬНАЯ ТЕХНИКА

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NUMERICAL EXPRESSION OF ROBOT TEST

The problem of improving existing information systems by increasing their quality and operation are considered. The automatic testing and new evaluating method of a vehicle subsystem is proposed. The numerical simulation is realised on the base of automatic collection and systematic recording of commercial robot operation. The proposed information system of operation and testing allows verification according to specified criteria. Evaluation criteria were verified in laboratory conditions. The application of numerical simulation allows automation of the system operation with the regard for specified criteria and increases its operation quality.

Keywords: robot, information system, numerical simulation, automation

1. Introduction

Tendency to ensure car's high technical and operational parameters, and consequently successful realisation of any difficult technical system and mechanism comes out from perfect knowledge of operational conditions, knowledge of operation - technical characteristics and parameters of own system. This fact conditions to increase requests for technical level of measurement, actual time of measure results, precision of measurement results, possibility of measurement results processing, level of measurement automation i.e. measurement as method of objective quantification of physical values, or about relation between two or higher number of physical values. Analysis of achieved results from solving and car security area in whole scale of connectivity and relations confirms, that the role of laboratory verification is not replaceable in new quality management system. Complete access problematic to the test questions in new quality management system, continually to car production concept is getting necessary and logic part of car production process and, as analysis of development trends in car industry shows, effect of solution in testing automation has objective need.

It is necessary to concern about automation data gathering about component operation mode in real conditions. It is possible to define their reliability based on gathered data about operating and component failure accepting. It is possible to design device for test tracing of components and test method after defining critical elements. This way to gather data about component operation, as a difficult system is in accordance with science and developing principles; by this we prevent un-controlled production of non-verified elements in industrial production. Based on gathered data, it is possible to increase component reliability and to reach higher level in planned car production.

2. Gearbox quality problem

Current dynamic development of car industry, continuous increasing level of their technical parameters and characteristics confirms continually whole process speeding competition in the world.

Using the gearbox as a car decisive component is limited also by complex access level to quality assurance. Gearbox general function model and its accuracy analysis is possible to realise based on present ways of functional unit and devices accuracy. General accuracy of function units is understood as quality of approach function and operational dependencies, acted in mechanisms to requested dependencies, for which these function units were constructed and are chosen.

From point view of gearbox utility, i.e. gearbox using and ability, general criteria is its quality and its basic intention, divided into:

– *manipulation ability*, if we evaluate it in aspect of cont-rol and manipulation with gearbox within speed striking,

– *technologic ability*, if gearbox is evaluated in aspect of use in car as mean of realisation of chosen drive kind.

2.1. Problems with quality management

Today brings significant changes in product area, in all industry forwarded countries. Understanding of changes in quality is possible to characterise as a movement from clearly technical soundness to integral product quality. Pro-duct quality became significant criteria of science and research effect and big productivity reserve of common work.

This general definition of development in quality field and objective need to continually increase quality in application for cars, which reports to increasing requirements for high technical and operating parameters, requires:

– to direct systematically all related actions, i.e. arrange questions of quality management to whole creating process of gearbox,

– to complex evaluate quality, which requires to use quantitative evaluation,

– to identify quality, i.e. to evaluate reached quality level, which has basic importance to control whole creating process and innovation gearbox process,

– to compare objective gearbox parameters with comparable world level types directly by measuring of chosen parameters, or indirectly by data from progressive technical information.

Quality management is concerned as complex, if it is expanded to all fields, which can have influence the final gearbox quality, including user's operation. This system, which dominate today in all industry forwarded countries, leads to create conditions in flow pre-production, production and after production activities by using objective methods for apply testing [2].

2.2. Analyse of reliability influence to profitability and economic effect

Before analysis of gearbox reliability influence to economic effect, it is important to realise basic ideas of reliability theory and to check relation of coefficients quantitative reliability to economic coefficient and efficiency coefficient. Related basic ideas:

Quality of product is properties summary, expressing ability to fulfil functions, for which it is dedicated. We take into account also product economic coefficients, its outfit by accessories, spare parts etc., as well as premises, which producer creates to provide services connected to product use.

Reliability is general object attribute, reposing in ability to fulfil requested functions with keeping of values for specified operational coefficients in specified limits and in time according to technical conditions. Reliability is one of the most important groups of product quality marks.

3. Metrological assurance of automation testing

From point view of measuring accuracy technics for test managing mechanism, it is necessary to look, that measuring technical assurance is realised mostly on principles of electrical measuring of non-electrical values with appropriate automation measuring process level and evaluating process. This concept of automatic measuring systems creation is not secured very well in the metrological way yet [3]. This field significantly documents the current status, advance of technical practice before readiness of metrological assurance. That is why it is possible to define requirements needed to metrological assurance at least of individual parts of automation measuring system i.e. individual measuring strings used in measuring and tests.

3.1. Measuring string structures

Measuring string - devices set intended to measuring, transport and data processing about measured value in general form represent sensor set, measures, measuring instrument, converters, measuring channels, analogue and numeric technical devices, computing devices, sensors and registered devices attached to one function unit in order to requested measuring, processing of data about measured parameters. Measuring string block schema is generally showed on fig. 1. It is possible to characterise measuring string individual blocks in the way of functions by this description:

1. input block – is created by sensors set, which scan required measured parameters, ensure data entrance to measuring string.

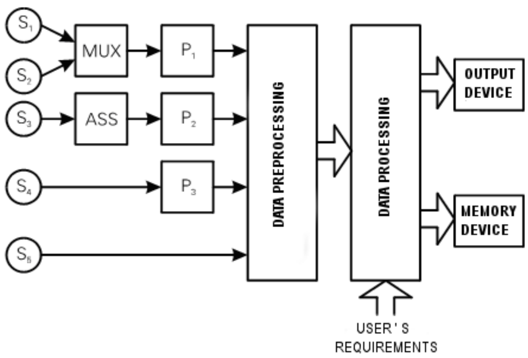


Fig. 1. Measuring string block schema:
S_1 … S_5 – sensors; MUX – measuring switchers, multiplexer; P_1 … P_3 – analog-numeric conventers, ASS – analog exekuting system

2. block of converters - ensure data processing from entrance block to suitable form for following processing, mostly to the numeric form.

3. pre-processing block- is used to data pre-processing (check, filtration etc.)

4. processing block- ensure data processing by specified algorithm, it is composed with suitable computing devices including particular software.

Output block- ensure data output in required form. Printers, recorders, control panels etc belongs here. Following memory device, where it is possible to store reached data for following processing.

Measuring string does not have to contain all involved parts, it is possible to drop some of them, or to expire some parts and to complete according to requirements of concrete application [1].

3.2. Follow component results in running

Numbers of several speed degree exploitations are written in table 1. After mathematic counting of individual speed strikes, coefficient of exploitation has been stated for individual speed as well as for all gear system. To emphasize difference, measuring results of both modes are drawn to one graph 1. This result proves arguments of earlier car abrasion in city traffic. Values are concreted. After measuring results summary, it is possible to express also gear mechanism use in percents. Result is in graph 1.

4. Technical means of Automation test system

The role of technical devices is getting important meaning in accordance with increasing technical level of developed devices and with motoring research trends, as well as with high requirements and method severity of their testing and evaluation.

Table 1. **Control mechanism and speed degrees of 5 speed degrees gerbox use**

Geared speed degree	Number of gear n	use [%]	coefficient f_j [%]
1	97555	20,4	8,49
2	114100	23,8	12,44
3	154050	32,1	26,06
4	91300	19,1	36,70
5	18805	3,9	15,80
R	3350	0,7	0,47
TOTAL	479160	100,0	100,00

Technical assurance of car components measuring, i.e. difficult devices must fulfil these limits and conditions:

– tests technical severity on moving car with big lack of place to install measuring and testing equipments to the car require to apply measure signal remote transmission on analogue or discrete signal level, analysis provide following data perfect overview and is used as a base for development designers team.

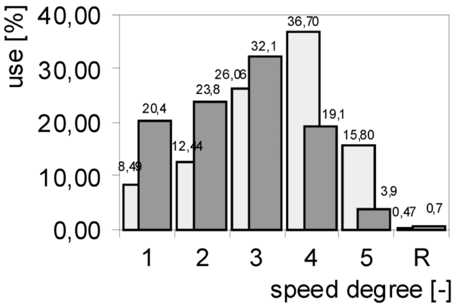
it is necessary to measure mechanical values by transformation of physical parameter to electrical signal, i.e. with measuring method of no electrical values by electrical way. It is necessary to correct signal from sensor and store it so that it will be available for direct processing, or for analyse,

– test system must be able to automatic function, i.e. automatic scanning of measured values, their processing, storing and editing in suitable form for next using,

in tests realisation, there must be connectivity between gear mechanism movement and measuring system control, that means test system must be automatic and connected to test cycle managing via control inputs of gear mechanism.

4.1. Configuration of automatic test system devices and their connection

As a result from present possibilities and the most necessary needs, configuration for ATS, which is drawn in fig. 2 was proposed. Individual measuring equipments and control devices are connected to control system by system bus, which fulfil requirements for adaptability of devices configuration for individual measuring and testing tasks and for eventual configuration expansion.



Graph 1. Control mechanism total use

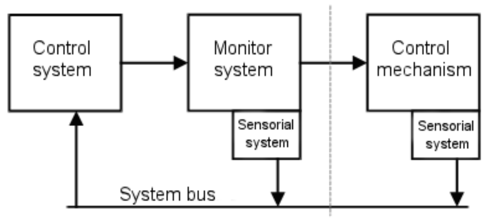


Fig. 2. Block schema devices ASS

4.2. Automatic test system project

It is possible to create concrete project solution of automated test system accepting results reached by now, according to fig. 3. As it comes out from gear mechanism test conditions, flyer system, evolve controller and starting clutch connec-tion is not needed. These parameters are necessary to take into account in speed degree gear (related to handle gear arm). This is test condition in laboratory conditions:

1. control power of default Fp= 50N
2. control power of gear Fr=70N
3. path length by default lp=30mm
4. path length by operation lR=55mm
5. time of default sP=1sec operate of gear sR=1 sec

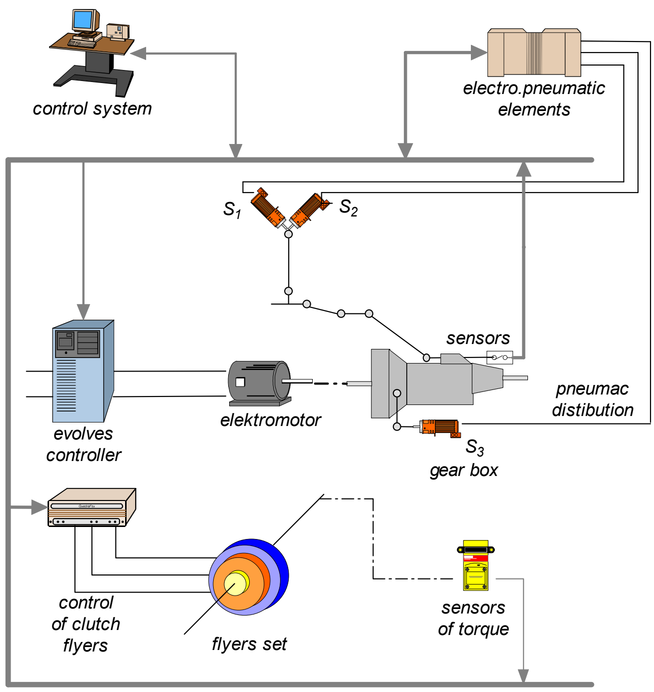


Fig. 3. Insertion ASS schema

Pneumatic rollers S1 and S2 do speed gearing process. Double acting pneumatic roller S1 assure pre-selection of speed degrees directly at gear arm and double acting pneumatic roller S2 assure speed degrees gearing.

4.3. Motive system acts description

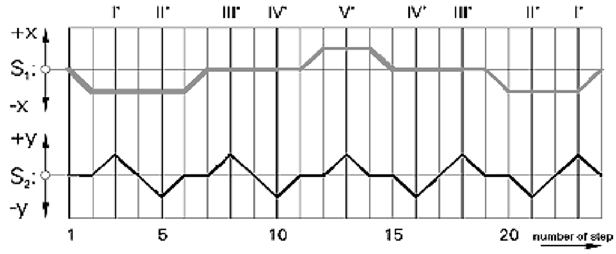
Algorithm of charging whole gear control mechanism is specified by pneumatic rollers synchronisation. One trial cycle is in table 2. It result speed degrees gear process-graph 2. This material is base for control system programming. Gear mechanism trial process depends on its used level. The base of test is to repeat speed degree gear process. From 1 speed degree to 5 speed degree and inside out from 5 speed degree to 1 speed degree. Concrete algorithm of test pass includes methodology part.

5. Reliability trials methodics propose

Automated reliability verifying and gear mechanism life cycle is the goal of test. It is necessary to change dimensions, eventually construction nodes of least reliable elements before test. Test methodology is deduced from the way of speed degree gearing during car running. Speed degrees gearing flow is introduced in previous part. The flow repeats always the same way with aspect to chosen speed degree.

Table 2. **Pneumatic rollers synchronisation**

Number of step	***Description***	***Roler S_1***	***Roler S_2***
	A C C E L E R A T I O N M O D E		
1.	***Roler*** 1. defaul 1. speed degree	✓	
2	***Roler*** 2. gear 1. speed degree		✓
3	***Roler*** 2. moves gearbox to neutral position		✓
4	***Roler*** 2. gear 2 speed		✓
5	***Roler*** 2. moves gearbox to neutral position		✓
6	***Roler*** 1. moves gearbox to neutral position	✓	
7	***Roler*** 2. gear 3 speed degree		✓
8	***Roler*** 2. moves gearbox to neutral position		✓
9	***Roler*** 2. gear 4 speed degree		✓
10	***Roler*** 2. moves gearbox to neutral position		✓
11	***Roler*** 1. defaults 5 speed	✓	
12	***Roler*** 2. gear 5 speed degree		✓
13	***Roler*** 2. moves gearbox to neutral position		✓
14	***Roler*** 1. moves gearbox to neutral position	✓	
15	***Roler*** 2. gear 4 speed degree		✓
16	***Roler*** 2. moves gearbox to neutral position		✓
17	***Roler*** 2. gear 3 speed degree		✓
18	***Roler*** 2. moves gearbox to neutral position		✓
19	***Roler*** 1. defaul 2 speed degree	✓	
20	***Roler*** 2. gear 2 speed degree		✓
21	***Roler*** 2. moves gearbox to neutral position		✓
22	***Roler*** 2. gear 1 speed degree		✓
23	***Roler*** 2. moves gearbox to neutral position		✓
24	***Roler*** 1. moves gearbox to neutral position	✓	



Graph 2. Speed degrees gear procces

It is necessary to assure handle control power, path length of default and path length of speed degree gear. Gear mechanism lines effort by power intensity, which is prescript in tolerances during car running and followed construction nodes, ensure fulfil these conditions. Whole system is specified to follow up gear mechanism in aspect of car reliability during car running. From table 1 is deduced that in aspect of number speed degrees gears the most used is 3 speed degree (32,1%), and (26,06%) in short path. 4 speed degree is geared in small number (19,1%), but it is geared on longer path (36,70%). It is not possible to follow this reality in one aspect, because:

if we want to follow results in aspect of number of gears, than it is in gear mechanism field

if we want to look and follow the parameters change in aspect of gear length, than problem elements are gear-wheel, winches and their installing in gear box.

Test commerce car measuring results are base to propose the test method about control mechanism use in aspect of number of individual speed gear. Graph1 deducing from table 1 shows the ratio of gear mechanism use. This ratio must be keep during test and gear mechanism test in number, what is used and record in tables. Proposed ratio method seems to be the most suitable.

5.1. Ratio method

Ratio method comes from distribution of percentage ratio elements use of gear mechanism during speed degrees gearing. Values of use from table 1 are the base of distribu-tion. Maximum level is reached when each component of gear mechanism will be running by distribution in table one during follow-up. Mathematic interpretation of number of gear zu in one level and trial process is:

$$z_u = \frac{1}{u} \times \left[\sum_{i=1}^{n} n_{1i} + \sum_{i=1}^{n} n_{2i} + \sum_{i=1}^{n} n_{3i} + \sum_{i=1}^{n} n_{4i} + \sum_{i=1}^{n} n_{5i} \right]$$

Where: n1-n5……number of gear in u-level

u…….. dividing level of max. number of gear

z1i-z5i.…number of gear of individual speed degrees

n………maximum number of speed degrees gear of related speed

Example: if we want to follow-up gear mechanism element reliability in speed degree 5, then number of individual speed degrees gears will be:

n1 = 97555 / 5 = 19511 times

n2 =114100 / 5 = 22820 time

n3 =154050 / 5 = 30810 time

n4 = 91300 / 5 = 18260 time

n5 = 18805 / 5 = 3761 time

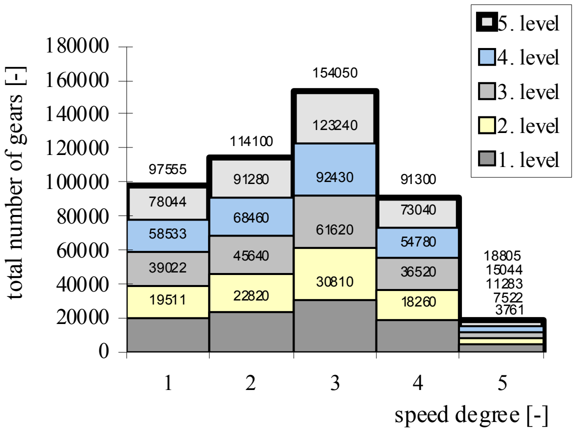
Ratio method data are in graph 3.

Use coefficient estimate exactness or gear mechanism element reliability is higher, when dividing level is higher. It is important to know, same number of gears ratio in every level is kept in ratio method. We can see on graph 3, that there is an area in the bottom, which is showing ratio number of gears of speed degrees of one level. Level 5 has 5 times smaller number of gears in same ratio as a basic level. It is possible to fill this area by trial in 2 ways:

1) vertical classification, 2)horizontal classification.

5.2. Vertical classification

The level of test according to vertical classification is divided in sequence according to speed percentage use. It means, that control program give command to gear speed degree 5 and then 4, 1, 2, and 3 as the last one. It is because all gear mechanism elements would be follow-up from the speed degree which use is the smallest. We have the biggest chance, that we verify biggest number of gear mechanism elements. We can see logical flow of gear mechanism test in graph.



Graph 3. Testing according to ratio method by 5 levels

Mathematic total number of gear zuV in vertical classification, is expressed by relation:

$$z_{uV} = u \times \left[\sum_{j=1}^{n_5} z_{5j} + \sum_{j=1}^{n_4} z_{4j} + \sum_{j=1}^{n_1} z_{1j} + \sum_{j=1}^{n_2} z_{2j} + \sum_{j=1}^{n_3} z_{3j} \right]$$

Where: n1-n5……number of gear in u-level

u…….. dividing level of max. number of gear

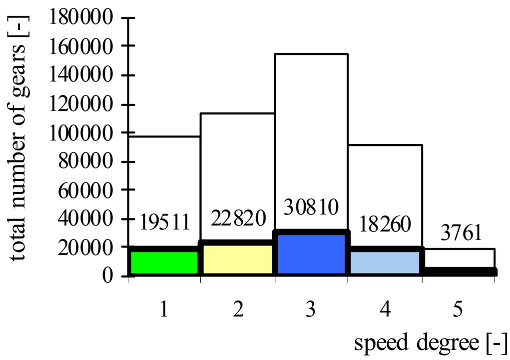
z1i-z5i... number of gear of individual speed degrees

Vertical classification is risky, because rest parts of gear mechanism will stay untested for example by testing 4 speed degree by failure. This negative solves trial according horizontal classifi-cation.

5.3. Horizontal classification

The test of gear mechanism elements by horizontal classification is equable according to graph 5. All speed degrees gearing are in phase one. After that, control system gives command to test control mechanism from 4 speed degree. Test till 3 speed degree is done the same way. It is gear separately from neutral position. We can mathemati-cally interpret the number of gears ZuH by horizontal classification test like this:

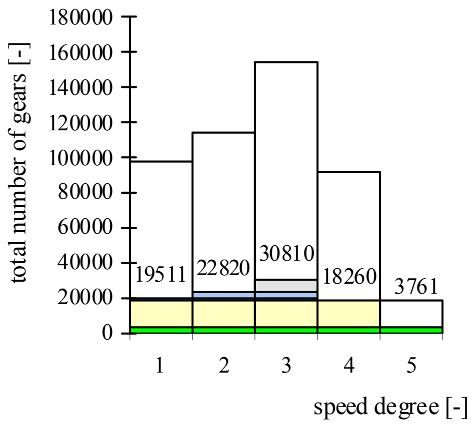
$$z_{uH} = u \times \left[z_u - \sum_{j=1}^{n_5} z_{5j} - \sum_{j=1}^{n_4} z_{4j} - \sum_{j=1}^{n_1} z_{1j} - \sum_{j=1}^{n_2} z_{2j} - \sum_{j=1}^{n_3} z_{3j} \right]$$



Graph 4. Level of test according to vertical classification

Where: n1-n5… number of gear in u-level, u - dividing level of max. number of gear, z1i-z5i - number of gear of individual speed degrees.

Cycle is repeating after one level of test is finished according to proposed method.



Graph 5. Level of test according to horizontal classification

6. Conclusion

The contribution was elaborated within the research project KEGA project No. 3-7285-09 Contents Integration and Design of University Textbook "Specialised Robotic Systems" in Print and Interactive Modules for University of Technology in Zvolen, Trenčín University and Slovak University of Technology in Bratislava.

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Численное моделирование испытаний робота

Разработана информационная система качества управления и автоматизации испытаний роботехнических средств. Численное моделирование реализовано на основе системы автоматического сбора и анализа данных промышленной эксплуатации роботизированных средств. Предлагаемая новая информационная система эксплуатационного и испытательного процессов позволяет осуществлять контроль в соответствии с заданными условиями. Критерии оценки подтверждены в лабораторных условиях. Применение численного моделирования позволяет автоматизировать процесс оценки функционирования системы с учетом установленных критериев и повысить качество ее функционирования.

Ключевые слова: робот, информационная система, численное моделирование, автоматизация

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IDENTIFICATION OF THE VEHICLE ACCORDING TO MAGNETIC TRACK

Identification, control and evaluating system for analysis of the object magnetic signatures is presented. A measuring unit with HMR sensor and control and evaluation system are described. The results achieved during measurements with their interpretation are given.

Keywords: magnetic sensor, object identification, magnetic field, measurement system, automated system

1. Introduction

The object´s magnetic signature is combination of disturbances caused by the presence or by the movement of the object in magnetic field. These signatures we can measure, record an this record can be analysed.

Every object, which is in the magnetic field causes its disturbance. This disturbance is called as a object magnetic signature. Depending on material permeability and geometric sizes of the object, batch off the largeness of the magnetic field disturbance.