INTELLIGENT SYSTEM TO PROVIDE PRECISION OF ASSEMBLY PROCESSES IN MANUFACTURING AND MAINTENANCE

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The system suggested was developed to make the assembly processes in manufacturing and maintenance of aggregates more precise. The auxiliary surfaces, components, units and their couplings, that are in contact with replaceable or other component parts are taken into consideration. The system based on tracing the speed changes in wearing-out during the operation process, the couplings conditions produced by the parts in aggregate or units. The methods of decision-making when kitting-up the whole list of aggregate items for assembly from the view point of providing the necessary precision of the coupling parameters are employed. All geometrical parameters as they were given in the original aggregate design are restored. The correlation and interdependence of the dimensions of parts in aggregates or in the vehicle can be showed up with assembly dimension lines.

At present a prototype of the program has been developed. It enables to realize the advantages of the suggested system in providing the precision of assembly processes in manufacturing and maintenance.

On the basis of the method suggested it will be possible to create the on-line sources, which allow to make the system more flexible, universal and useful for enterprises and organizations dealing with complex aggregates maintenance.

Key words: dimension analysis, assembly precision

One of the major problems of auto-repair industry is economically efficient restoration of automobile working ability for most fully usage of remaining life-time of their parts.

Economic effectiveness in repair lies in the fact that the parts used and obtained after disassembling and cleaning the automobile are much cheaper than the ones produced by machine-building industry manufactured by stamping, casting and forging. In addition, less number of surfaces are machined during the repair works, therefore processing content is much less labourous as a result. Thus, implementation of rational technological repair works provides restoration of the component properties close to those of a new one.

The common approach in the repair technology is mere replacement of the considerably worn out components if the wearing out signs are clearly seen. Empirical observations caused by frequent failure occurrence of a part or a group of parts are usually the reason to replace them or control their dimensions [1].

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Additional surfaces, components and units and their junctions are not considered in the method described above. Changes in wearing out intensity during the life-time, conditions of dimensional chains contact links are missed either. Modern auto-repair industry lacks the clear reasoning for making decisions on forming the components list (inventory) of an aggregate under assembly, which provides accuracy of contact links. The integration junctions parameters designed at a project stage are not restored. All the issues mentioned above result in overall aggregate accuracy reduction, which leads to increase of repair expenses and operating life decreasing.

A perspective trend in auto-repair branch is dimensional analysis. Optimum permitted parts and connection joint wearing out must be calculated according to their influence on the operating capacity of the unit under assembly limiting its life-time. The only solution of this problem is to consider dimensional parts parameters as parameters of dimensional chains, which determine aggregate or unit reliability.

An aggregate, a unit or an assembly unit may consist of some hundred parts, each of which depending on its configuration has a rule from 2 to 10—15 different geometric parameters. Optimal parameters formation for dimensional chain links to provide given parameters of the contact dimensional chain links is connected with the necessity to solve dimensional chains equations for the all aggregate. That produces massive data amount, which is significantly time-consuming, therefore using information systems allows to improve repair work quality and to shorten creation time for technological processes.

Any aggregate — is a complex thing and to improve its accuracy control the following criteria are established at the stage of repair works: increasing of operating time, reduction of human factor and maintenance expenses.

For the aggregate operating time control process functioning — both a goal of control Z* and an algorithm of control φ must be determined. The algorithm —is an instruction how to achieve a goal having information about conditions of medium X, aggregate Y and goal Z*:

$$U = \varphi\left(X, Y, Z^{*}\right). \tag{1}$$

The stage sequence of dimensional links accuracy control method in auto-aggregates repairing is shownr in Fig. 1.

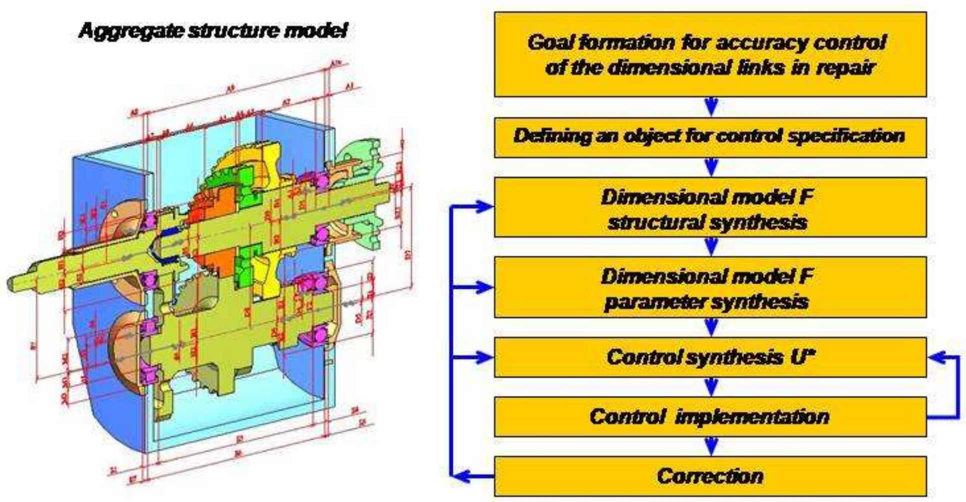

Fig. 1 — The stage sequence of dimensional links accuracy control method

Automobile aggregates dimensional links operating time control goals {Z*}: increasing of life-time, the desired assembly accuracy providing, reduction in repair expenditure and spare parts with reasoning their replacement. The objects for control are the contact links of aggregate dimensional chains and an assembly control process. Model F structural synthesis is to form algorithm, which allows to evaluate conditions of dimensional chains Y contact links, knowing data about internal links of aggregate X dimensional chains: X→Y; F= (St, C), C – a number of parameters , St – a model F structure. Parameter model F synthesis is to define and plan experiments with the aggregate and observation of the object without experiments and controlling actions. Control synthesis U* is to make a decision about parameter U so that in current situation to achieve the desired goal Z*of controlling aggregate assembly process. Moreover, the control must be optimal in terms of management goals and be presented by program of controlled parameters time changes. Control implementation is to coordinate and check decisions from previous stages. The automobile aggregate operation time control as suggested requires development of the described cycle with introduction of a correction stage. The Correction stage plays role of a feedback improving the control process: $U = U(u_1,\dots,u_q); \quad Q(U) \to \min \to U^*$.

To implement the control process mentioned above bundled software (BS) was developed. Its structure illustrates the main stages of auto-repair quality control method. BS consists of the structure model module and the aggregate dimensional links model, the algorithm of components and units quality classification; the selection algorithm for an optimum dimensional links restoration and size checking strategy; a simulating algorithm for composing links wear out rate intensity and dimensional links operating time; an algorithm of dimensional links arrangement according to their ranks.

Suggested method of repair process using BS is shown in Fig. 2.

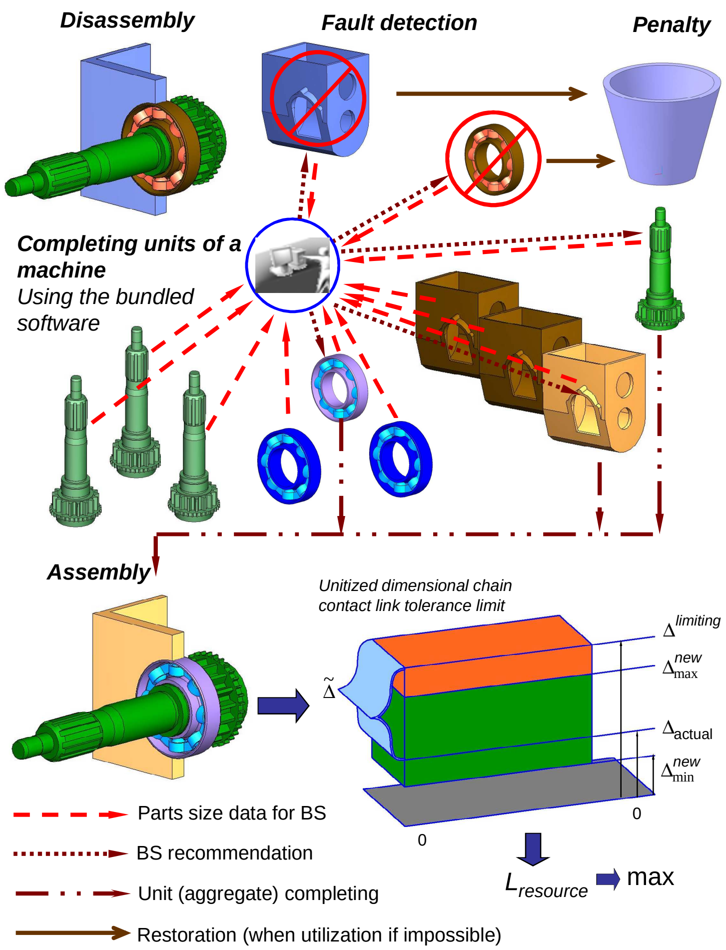

Fig 2 – Suggested aggregate repair process method

The components surface fault detection is taking place during the repair process. The data is processed and input into database. The components are classified according to their surface parameters and sorted intothe following groups: “fit without restoration”, “restoration required” and “unfit”. The assembly components for from groups “restored”, “fit without restoration” and “new” are made up a full set by BS using dimensional analysis and simulating of dimensional chain links wear out rate intensity. In this case initial data are taken from real surfaces ware out values in case of a fixed operating time.

To estimate dimensional chain conditions a comparison base is required, which is obtained as a result of the dimensional analysis of a new aggregate by checking contact links parameters. Accuracy which is to be reached by restoration dimensional chains is the accuracy of new aggregate contact links.

Experimental and simulating results demonstrate efficiency of the suggested dimensional links control accuracy method, due to which operating time of every single dimensional chain and overall aggregate is increased.

The essence of the described method lies in estimation of operating time of repaired automobile aggregates based on component surface ware rate values obtained during simulation experiments. Knowing the tolerance of the dimensional chain contact links of repaired aggregate we use it as a maximum permitted wear out level for a new aggregate. The latter consists of composing links wear out values, which are determined by wear out intensity. This is the remaining accuracy value for the restored dimensional links, the operation life is defined by the following:

$$L_i = \frac{\tilde{\Delta}_i}{\sum_{j=1}^{n-1} I_j}, \qquad (2)$$

Where L_i — is operating time i-th chain under consideration (i varies from 1 to m, where m — is the number of dimensional links); I_j — wear out intensity of a j-th link (j varies from 1 to n, where n — is the number of composing links) of i-th chain; $\tilde{\Delta}_i$ — the value of residual accuracy of contact link of i-th chain under consideration in comparison with the value of a new one.

The results of model experiment (fig.3) on modeling life-time of new aggregate dimensional links that were restored according to the existing methods and according to the method suggested show the using the suggested solutions on restoring accuracy of contact links dimensional chain life time increases. The average value for remaining accuracy of dimensional chains contact links increase as well.

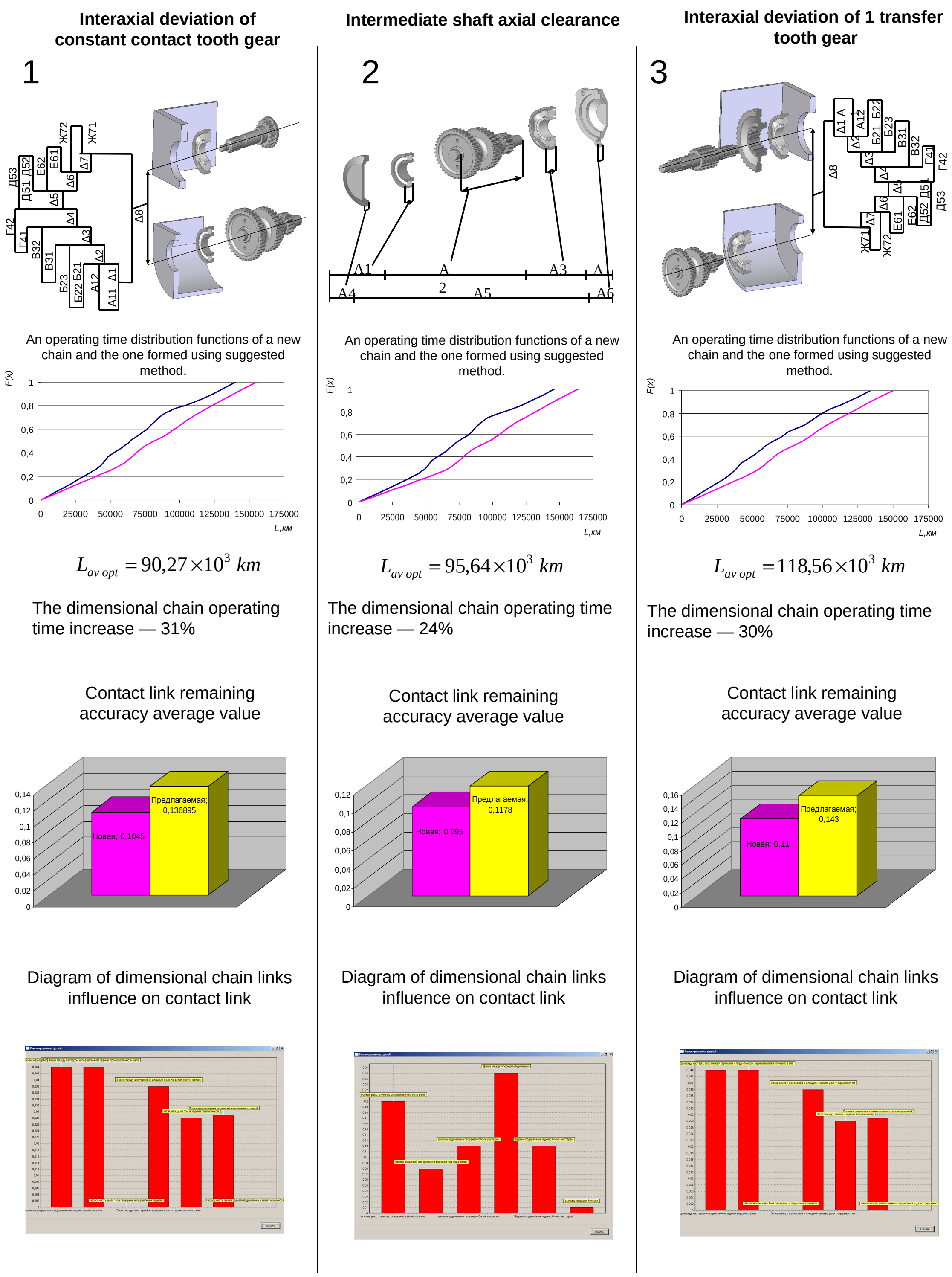

Fig. 3 — Modeling results

Application of the suggested method for dimensional links accuracy restoration allows to reach operating life increase up to 30 % in average (24 %—32 %). This proves low efficiency of conventional auto-repair methods, which can not provide the maximum accuracy level rated by manufacturer.

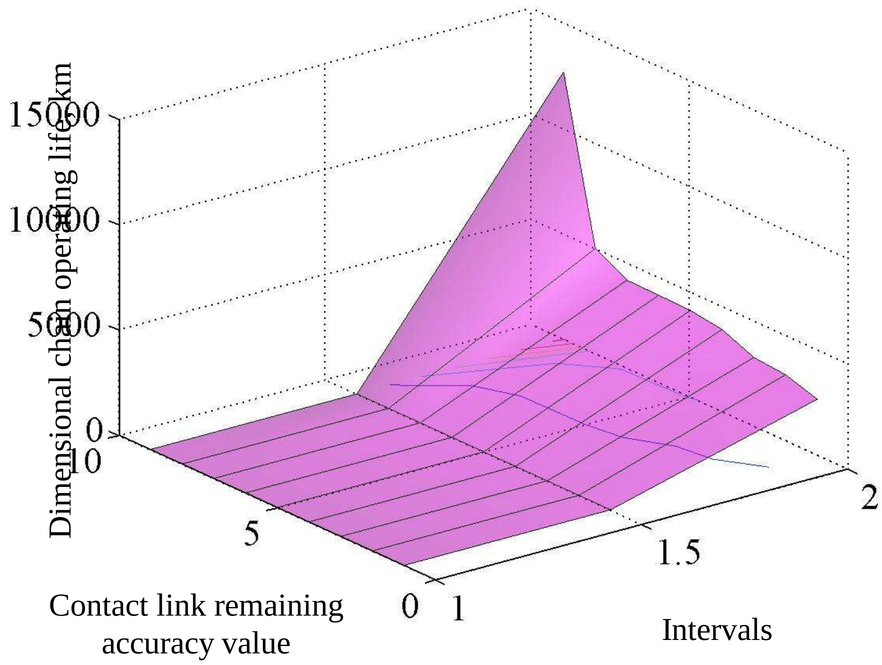

Fig. 4 — dimensional chain “bearing-case” operating life changes behavior according to modeling data

Pattern shown on fig. 4 confirms theoretical aspects on possibility of dimensional links operating life regulation by regulation of contact link remaining accuracy. Insignificant increase of dimensional link lifetime approaching maximum permitted value of remaining accuracy allows improving economical and repairing efficiency.

According to the experiment results the distribution values of aggregate dimensional chain life time are shown in fig 5. It shows the increase of average life-time for each chain and as a result the increase of average life time of the whole aggregate.

The suggested method is modern and multi-purpose. It should be noticed it might be applied to any aggregate.

The advantages of the suggested method of accuracy control of aggregate dimensional chains, the component size control, a controllable process at completing stage, increase of post-repair lifetime in comparison with new aggregate.

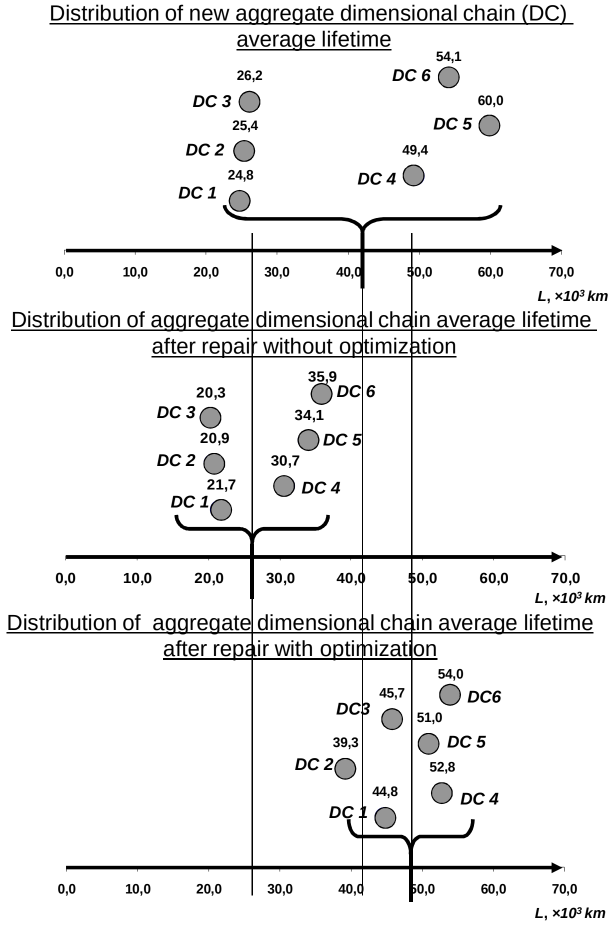

Fig. 5 — Comparable analysis of aggregate dimensional chains average lifetime distribution under different strategies

Reference literature

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