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**Production group management of aviation equipment service
for personnel errors decrease****Abstract**

The problem of production group management of aviation equipment service for safety by algorithm and procedure development of control system actions is considered. Based on the production group (also two and more production groups) staff interaction models developed earlier, the procedure of a production group weak link compensation at of aviation equipment maintenance is offered. During the work between workers and various groups of the personnel there are various communication acts, that's why the production group essence is presented in total production relationship as an allocated center of responsibility. Process of production group formation and organization of aviation equipment maintenance is analyzed. Procedure algorithm is based on mathematical models: square display and ostillyatorny. It includes 6 main steps: collecting and data processing about the previous production group behavior and its components; entry conditions and parameters of displays discrete model forecast for definition of the stationary modes of each couple of group staff interaction; expected parameters numerical study and the model of displays analysis; making decision on preservation or operating of change parameters for substitution it in ostillyatorny model; the ostillyatorny model analysis with new parameters and their adjustment; collecting and processing of new actual data for the condition of system forecast in the following period. The procedure is realized at the enterprise serving aviation equipment by means of specially developed algorithms and

programs complex. Research results may be used for of administrative decisions adoption at the other types of productions organization on air transport.

Key words: production group, weak link compensation, maintenance, aircraft equipment, personal mistakes

Introduction

The maintenance (M) of the aircraft equipment is the complex of productions providing the air transport (AT) functioning [1]. In spite of the fact that mistakes of the person, but not equipment refusals constitute the greatest potential danger to civil aviation, aspects of a human factor at M AT in researches on organizational structures modeling, optimization and productions on air transport are not rather considered in detail [2]. The production group represents system as which elements people and the relations of production arising between them act, participants of production group are united with each other by responsibility for the work result.

Now doesn't raise doubts that organizational structures and productions, production groups, including, are open and nonequilibrium, their behavior is characterized difficult predictable (or at all casual) by the external and/or internal environment and output results entrance influences. Instability and ambiguity emergence involves essentially new type of system behavior. On bifurcations size and direction depends on what of possible trajectories the system will leave a condition of instability. At this moment it is impossible to predict, in what direction there will be a further development: whether there will be a condition of compound system chaotic or it will move to the new, higher level of orderliness. In a similar situation it is correct to speak about the probabilistic forecast of system behavior.

Production group management processes

Between workers and personnel various groups there are various acts of work communication. That is why the production group essence is presented in total production relationship of elements in the form of the allocated responsibility center which possesses the emergzhentny properties which are absent at the elements and the relations forming production group. In fig. 1 the scheme of the maintenance organization process of the plane by production group as result of the analysis of information on an order of service production group (crew) formation for the airbuses A-320 is offered.

Fig. 1. The scheme of production group formation at aviation equipment maintenance

The production group, in the narrow sense of the word, is small (discretely changing in number) set of elements people and their production relationship, naturally connected in a whole by means of the Allocated Responsibility Center (ARC), which possesses the emergent properties which are absent at the elements and the relations forming group [3]. The ARC of production group possesses dualism. On the one hand, it is the purpose, result; on the other hand is the conflict. The condition of ARC doesn't give us a picture of behavior of the certain individual, it acts as result joint, let and inconsistent, actions of production group members.

For determination of these parameters use program-production group is expedient, in the broadest sense, is a set of subsystems, each of which is also production group in broad or narrow sense [3]. The production group unites in itself some crews interacting among themselves. Thus, each crew can be also divided into personnel small groups. The structure of the plane production group is structured as shown in fig. 2.

Fig. 2. Structure scheme of production group formation for periodic maintenance

In the previous works [4, 5] need of an assessment of interactions influence for production group on an indicator of competence of all groups of the personnel is proved. In the course of work between workers and various personnel, groups there are various acts of communication. In this case the information and communicative mechanism of interaction between members of production group where the key role is played by information transfer, experience and other influence from one person to two another, and also from two people to the third is considered.

Influence of employees (members of group) arises at different competence if the employee A competence is higher, than of the employee B competence, the employee A can have positive impact on the employee B, and the employee B can have negative impact on the employee A. Interaction distribution is considered through "influence triangles".

Compensation of a production group weak link

The general algorithm of a weak link compensation technique in production group at maintenance of AT is presented by the scheme in fig. 3. Object of management is the production group, and the operating body – the decision-making person (DMP) and/or the group of experts.

Fig. 3. Procedure algorithm of a production group weak link compensation

Stages (steps) of compensation algorithm are the following.

Step 1. Collecting and data processing about the system and its components previous behavior. At the enterprise the constant monitoring and an assessment of each worker production competence and knowledge is conducted. All data are collected in specially created database where, in particular, all cases of employees collaboration (for each earlier being found couple), all cases of the mistakes and conflict situations taking place for this combination of workers are noted. The program complex on the following steps addresses to a database.

Step 2. Forecast of discrete model entry conditions and parameters for definition of each employee's couple the interaction stationary modes. The database serves as entry conditions for each employee's combination.

The following stages (steps) of a technique are based on two mathematical models.

Step 3. Numerical experiment in expected parameters and the analysis of displays model [6] in phase space. Search of employees all possible combinations for the serving equipment crew demanded structure is carried out. For each combination to the treelike scheme help of matrixes convolution, similarly offered in [2], the integrated indicator of the production environment dangers is calculated, convolution is carried out by the special program for the algorithm chosen by experts.

Step 4. Making decision on preservation or the operating change of model parameters. The received parameters are substituted in ostillyatory model [3] which numerical analysis allows to define efficiency of each employees combination interaction at the received integrated indicator. The employee's combination to optimum indicators gets out and the production team for the next task performance is formed.

Step 5. The model analysis with new parameters and their adjustment. It is carried out in the course of crew work.

Step 6. Collecting and processing of new actual data for the forecast of a system condition in the following period. Results of crew work are brought in a database, all cases of mistakes and/or the conflicts are noted. The result of the aircraft equipment maintenance at further operation is traced.

Displays model for production group

Let the group consist from rather big (for division into subgroups) numbers of N participants. Some subgroup one participant, which made a certain decision, through communication generates two pressure units (mutual influence) upon other participants, their distribution is presented in fig. 4. We will consider that for the same decision adoption any other participant has to receive two pressure units, that is receive two acts communication.

Fig. 4. The scheme of movement between subgroups under the influence of participants mutual influence: N – number of participants in group, M – total number of pressure units, which is generated by all participants who already joined the made decision

We will designate for x number of participants who do not possess pressure units (are not subject to influence of other participants), y – number of the participants having 1 pressure unit (are subject to influence of one of other participants). Two-dimensional display after a normalization of variables x and y (according to [5, 6]) has an appearance:

$$u_{n+1} = u_n^2 + u_n v_n - u_n; v_{n+1} = v_n^2 - u_n^2 - v_n + 2u_n, \quad (1)$$

where: u and v – new variables, $x \rightarrow u$, $y \rightarrow v$;
 n – iteration number, time discrete analog.

The numerical experiments made with mathematical model (1) which example is presented in fig. 5 allowed to draw the following conclusions.

1. Both variables aspire to zero at iterations small number, however at zero values achievement variables are subject to fluctuations about zero.

Fig. 5. Numerical experiment results for model according to (1)

2. If to assume that the group is open for an participants exchange with environment, the results received for a iterations large number get physical sense: variables negative values mean that participants from the outside join system.

3. Limited fluctuations amplitude testifies to need of some quite limited "personnel" reserve.

Generally the elementary one-dimensional (for a variable x) displays model [6, 7] with two parameters a and b has an appearance:

$$x_{n+1} = ax_n - bx_n^2 \quad (2)$$

The model (2) was analyzed analytically and in number. The following conclusions are drawn.

1. Parameter b has no impact on a special point stability, however the special point arrangement depends from b , without being strictly determined by the first parameter. The variable x during iterations can accept the values which are going beyond an interval $(0; 1)$.

2. The cycle of the period 2 (2 cycle) appears at $a=3$ through bifurcation and is steady at $3 < a < 1 + \sqrt{6}$. Further, there is a bifurcation of the period doubling. Parameter b at nonlinear composed again does not influence stability of system, however it determines self-oscillations amplitude: the more parameter b , then it is less dispersion between two system conditions.

3. Further increase in parameter a brings to cycle period doubling. Transition to the mode of dynamic chaos happens through sequence of the period doubling at parameter a approach to 4.

Two-dimensional display which analysis is similar and submitted in [6] earlier gives fuller interaction picture between production group employees.

Production group oscillatory model

We will consider model which numerical analysis allows to define efficiency of each combination interaction of production group participants. In this case the group behavior according to [3, 5] is described by the following equations system:

$$\begin{aligned} \ddot{x}_1 - (\lambda_1 - x_1^2)\dot{x}_1 + x_1 + \beta_1 x_1^3 + \sum_{k=2}^n \varepsilon_{1k} (x_1 - x_k) + \sum_{k=2}^n \mu_{1k} (\dot{x}_1 - \dot{x}_k) &= 0 \\ \ddot{x}_2 - (\lambda_2 - x_2^2)\dot{x}_2 + (1 - \Delta_2)x_2 + \beta_2 x_2^3 + \sum_{\substack{k=1 \\ k \neq 2}}^n \varepsilon_{2k} (x_2 - x_k) + \sum_{\substack{k=1 \\ k \neq 2}}^n \mu_{2k} (\dot{x}_2 - \dot{x}_k) &= 0 \end{aligned} \quad (3)$$

$$\ddot{x}_n - (\lambda_n - x_n^2)\dot{x}_n + (1 - \Delta_n)x_n + \beta_n x_n^3 + \sum_{k=1}^{n-1} \varepsilon_{nk} (x_n - x_k) + \sum_{k=1}^{n-1} \mu_{nk} (\dot{x}_n - \dot{x}_k) = 0$$

Here λ_j – excitement parameter of the oscillator j , Δ_j – a frequency detuning of the oscillator j relative to the first, the parameter β_j is responsible for not an isochronism of small fluctuations, ε_{jk} – coefficient of inertial communication of oscillators j and k , μ_{jk} – coefficient of dissipative communication of oscillators j and k .

Frequency of the first oscillator is taken for unit. In comparison with works [8 ... 10] into system (3) are entered the equations composed, responsible for oscillators each pair interaction.

The method of slowly changing amplitudes was applied to the presented system analysis. Interaction in the form of synchronization happens in a phase or an antiphase: the actions are co-directed (attracting interactions, a common goal) or oppositely directed (repellent interactions, the conflict).

Various mechanisms seek to lead system to synchronization with different phase shift between oscillators, thus the dual nature of the allocated interaction center proves most brightly. Interaction with shift of the phases $\pi/2$ is represented to the most

interesting, at this ARC shows both parties at the same time, that is the common goal at the conflict of personal interests is available.

The presented system of the equations (3) was analyzed in [9, 10] for the model consisting of 3 connected oscillators with periodic modulation of the operating parameter in more detail earlier. In this case an innovation is introduction to system of the fourth fictitious oscillator completely identical to the third unpaired [3]:

$$\begin{aligned}
 \frac{da_1}{dt} &= a_1(\gamma_0 + \gamma_1 \cos(\Omega t) - |a_1|^2) + \varepsilon a_3^\alpha (a_4)^{1-\alpha} \\
 \frac{da_2}{dt} &= a_2(\gamma_0 + \gamma_1 \cos(\Omega t) - |a_2|^2) + \varepsilon a_3^\beta (a_4)^{1-\beta} \\
 \frac{da_3}{dt} &= a_3(\gamma_0 - \gamma_1 \cos(\Omega t) - |a_3|^2) + \varepsilon a_1^\beta (a_2)^{1-\beta} \\
 \frac{da_4}{dt} &= a_4(\gamma_0 - \gamma_1 \cos(\Omega t) - |a_4|^2) + \varepsilon a_1^\delta (a_2)^{1-\delta}
 \end{aligned} \tag{4}$$

Here a_1, a_2, a_3 the complex slowly changing amplitudes of oscillators; γ_0 – the operating parameter; γ_1 and Ω – respectively amplitude and frequency of periodic modulation of the operating parameter; ε – the communication parameter accepted for a statement simplicity identical to all oscillators. Parameter α – an integer, describing nonlinear communication between oscillators.

Periodic modulation of the operating parameter leads to that oscillators serially pass through active and passive stages. Oscillators are excited serially by couples; thus communication between oscillators is carried out in a resonant way.

The general principle of research of model (4) consists in manipulation with phases of fluctuations by transfer of excitement between partial oscillators which become active alternately, so that transformation of phases answered iterations of display with chaotic dynamics. Signals at a frequency of fluctuations which influence passive couple during its transition through bifurcation of a limit cycle are formed of active couple signals and impose it the corresponding phases.

The presented model is used for making decision on preservation or the operating change of the model parameters of displays considered above. The numerical analysis of oscillatory model allows to define interaction efficiency of each employees combination at the received competence integrated indicator. On the basis

of it the employees combination to optimum indicators gets out and the production team for the next task performance is formed.

Recommendations for a technique practical realization

The analysis of special literature [1, 11, 12] and the organizations of productions at the MAT enterprises allowed to develop the technology of production group formation presented in fig. 6 at receipt of the demand for the aircraft service.

The practical realization of a technique of production group management is enabled by means of specially developed program complex for which the set of inquiries algorithms to a database is previously developed. The main result of a program complex work is the choice of crew optimum structure for the immediate production task performance according to the set professional requirements.

The head of production group needs to analyze structure of group, to reveal the most significant participants and to organize interaction with them.

On the basis of the production groups dynamics analysis recommendations about production groups management are formulated:

1. When forming group it is necessary to attract as much as possible different participants, to watch that the group wasn't uniform in any sign.
2. Expediently constantly to support all possible exchange processes with the "external" world, including periodic replacement of members of group.
3. It is necessary to look for the operating influences considering predispositions of group certain members and group in general.
4. Change of a kind of activity for group members can be useful during crisis.
5. The competition between groups, different interactions with other groups, as more, and less developed is useful.
6. It is needed to change methods and the government forms periodically and to vary democratic and authoritative management style.

Fig. 6. Formation technology of production group for aviation equipment maintenance

Conclusion

Thus, the solution of a problem of management optimization of aviation equipment service production group for ensuring its safety by development of algorithm and a technique of a control system actions is received. The task is solved by

means of the offered new mathematical models and their adaptation to the air enterprises practical activities through a complex of original algorithms and programs.

The made numerical experiment with model of displays showed that at change of parameters the production group can pass from one dynamic mode into another, and also into the chaotic behavior mode, and vice versa: from the chaotic mode in one of the possible dynamic modes. Displays parameters are predicted by results of the model analysis and can purposefully change (for example, the group head) or is casual, and after each change of parameters the forecast is specified.

Synchronization of oscillators acts as a prototype of interactions in group. Dissipative and inertial communication between oscillators by the principle everyone with everyone is considered. Positive communication conducts to mutually assistance (to interaction in the mutual aid form) participants of group, negative communication conducts to of counteraction. In view of bilateral nature of any communication for the accounting of interaction between oscillator's pairs into model of the three serially pairs of excited oscillators in addition enter the fictitious oscillator, pair to the third.

Transition from dynamic system in the chaotic mode is also back carried out by means of management of system parameters, which can change, in particular, and in a random way.

The presented mathematical models allowed to develop recommendations for support system of administrative decisions adoption for the organization of M AT processes and to develop a technique of production group formation for AT maintenance as a technique of a weak link in production group compensation.

The received results can be applied at improvement of support system of administrative decisions adoption for the organization of productions other types on air transport.

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