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Prognostication of residual resource to applications by non-destructive control

Annotation. There is submitted an original method over of prognostication of residual resource of agricultural machines is brought at the use of methods of non-destructive control (golographical) in the article.

Keywords: remaining resource, prognostication, non-destructive control, holography, mathematical hope, agricultural technique

Raising of problem

The problem of estimation of remaining resource of objects of pertaining to national economy value, that have a considerable term of the protracted exploitation, requires at the modern state of economy of Ukraine of the increased attention. In the plan of determination of remaining resource the institutes of the electric welding work purposefully, physical and mechanical, problems of durability, problems of engineer, Southern machinery et al [1,3,5].

Without regard to the attained successes and purchased practical achievements, for today out of dates of researches from the study of the technical state of detail, knot, aggregate or machine at the different types of loading (single or in common - operating) with the study of the by volume fields of superficial layers. The got positive results of providing of reliability of agricultural machines carry partial character mainly due to the exposure of faults of separate surfaces or even their fragments. At the same time prospects in the plan of providing of reliability of machines open considerable potential possibilities of technological methods, that is related to the exposure of marketability's of complex combination of methods of holographic interferometry at non-destructive control of wares, beginning from material of purveyance and ending a machine on the whole [2].

Analysis of the last researches and publications

As practical experience shows, ill-timed replacement of defective detail, knot with an imperfect detail results in appearance in exploitation conditionally of good-working vehicle, probability of death that depends on time, when on condition of unfound out an in time defect or damage, there are a refuse and destruction of machine. Dangerous is a situation, when at the stationary process of loading, there are tensions that acquire non-stationary stochastic character, here operatively and forecast to manage them it is practically impossible.

In obedience to the analysis of results of researches conducted by scientists: Paton E.B., Lobanov L.M., Kluev V.V., Boone P.,Xizniyk A.I., Markov

V.B. et al, technical state of details, their fitness to further exploitation with the set parameters of reliability determined from one side by structural parameters, and from other - them by physical and mechanical properties [4,6]. Such descriptions of working surfaces of materials of details differ in comparatively small values dispersions of sizes, that answer sizes and types of loading, microstrain, time loading and can be presented in a narrow enough interval at their possible state.

Aim. To conduct research and define the possible ways of prognostication of remaining resource with the use of optical methods of non-destructive control.

Results of researches. The indexes of longevity determine the loss of capacity of machine after time of her exploitation. The value of index of longevity can be certain maximum - by the possible size of weekend to the parameter and by some unstated casual process of loss of capacity, for example - by the loss of durability of superficial layers of working contacting inter se zones of details, size of wear, warping or corrosion. A resource of responsible details is the regulated size, and they are potentially capable of working. As results of researches showed, no less as 30% from the number of all technical services on regulation executed without an actual necessity.

Taking a machine as complex of various elements that co-operate inter se during work and create capable of working good, it follows notices, that longevity of her must be taken into account with determination of size of working time or mean-time-between-failures of her separate elements. Prognostication of the technical state of agricultural machines is the difficult process of establishment of initial parameters them the technical state. One of main values of result of prognostication there is determination of remaining resource of basic elements of machines the effective use of all good depends on the capacity of that.

Prognostications of resource of machines do on the basis of data got at their diagnosticating. Him mostly the internals of making (to repair), stowage of machines apply for initial control or them pre-repair the defects determination with establishment of kinds and volumes of works, exposure of defects or damages of measuring diagnostic conducted without the change of the mode of operations of object by setting to realization of impulsive speckle-interferometers in the process of exploitation of agricultural technique. Thus find out changes technical each of her elements, for that there is the real probability of refuse in a period between repairs. The maximum state of details is determined as impossibility of further exploitation of machine on technical reasons or at the decline of efficiency of her use, or at disparity to the requirements to safety of labor, productive sanitation or ecology.

Prognostication in the modern terms of market economy of our country plays an important role. Absence of money in farmer and other economies on acquisition of new machines requires the use of technique that already was in exploitation. Establishment of terms of possible effective exploitation gives an

opportunity of land-users to optimize the management of conduct to the economies, in the plan of effective application of technique.

For machines or her element that is control in creation of capacity, for example engine or transmission, time of faultless work (resource) will be determined from dependence:

$$M(T_{res}) = \min\left[M(t_1); M(t_2); M(t_3); ...; M(t_{n-1}); M(t_n)\right], \qquad (1)$$

where $M(T_{pec})$ is a mathematical hope of resource or time of faultless work of machine, by hours;

$M(T_{ti})$ is a mathematical hope of time of faultless work of elements of machine, by hours

In this case, death every detail will result in the loss of capacity of all system.

Subject to condition, when it is necessary to define the resource of the multicomponent system at that death certain element does not conduce to the loss to the capacity of all good, for example sowing grains or plough. Quality of treatment of the field can negatively change in this case, but a machine remains capable of working, though defective. A resource or time of faultless work will define after a formula:

$$M(T^{1}_{res}) = \min\left\{\left[M(t_1); M(t_2); \max(M(t_3); M(t_4); M(t_5); ...; M(t_{k-1}); M(t_k)\right]; ...; t_{n-1}; t_n\right\}, \qquad (2)$$

There is death in such terms, some certain element of machine will not cause losses of her complete capacity. In the process of work of detail of machines and their elements lose the capacity gradually, and time of faultless work each of them is a casual size that gives an opportunity to estimate the mathematical hope *of* all elements of machines In this case there is possibility to apply the method of Monte Carlo. In order that in our case to realize this method it is necessary to know 1) are probabilistic descriptions of all elements of the system or machine; 2) - to know the function of distribution of sizes that investigate.

In the process of realization of researches dependence of size of resource of machines or their elements was set on a size microstrains (*U; Y; Z*), that, in turn, depend on the technical state of object. The size of microstrain, that is determined by means of holography, makes the not more than half of wave-length to the laser. Establishment of the technical state of detail and all machine passes at microscopic level and gives an opportunity to prevent development of destructive processes. During realization of holographic methods determine the sizes of microstrain for three (speckle-interferometry) or two (computer) components of vector of microstrain, that other methods are impossible. Knowing not only the scalar size of vector of microstrain but also him spatial direction, there is possibility to set directions of destructive efforts and moments that operate on machines. Then dependences 1 and 2 will assume an air:

$$M(T_{pec}) \cong \min\left[M(u_1);M(u_2);M(u_3);...;M(u_{n-1});M(u_n)\right] \quad (3);$$

$$M(T_{pec}) \cong \min\left[M(y_1);M(y_2);M(y_3);...;M(y_{n-1});M(y_n)\right] \quad (4);$$

$$M(T_{pec}) \cong \min\left[M(z_1);M(z_2);M(z_3);...;M(z_{n-1});M(z_n)\right] \quad (5);$$

$$M(T^1_{pec}) \cong \min\begin{Bmatrix}\left[M(u_1);M(u_2);\max(M(u_3);M(u_4);M(u_5);...;M(u_{k-1});M(u_k)\right];... \\ ;M(u_{n-1});M(u_{,n})\end{Bmatrix}, \quad (6);$$

$$M(T^1_{pec}) \cong \min\begin{Bmatrix}\left[M(y_1);M(y_2);\max(M(y_3);M(y_4);M(y_5);...;M(y_{k-1});M(y_k)\right]; \\ ...;M(y_{n-1});M(y_n)\end{Bmatrix}, \quad (7);$$

$$M(T^1_{pec}) \cong \min\begin{Bmatrix}\left[M(z_1);M(z_2);\max(M(z_3);M(z_4);M(z_5);...;M(z_{k-1});M(z_k)\right]; \\ ..;M(z_{n-1});M(z_n)\end{Bmatrix}, \quad (8)$$

The conducted experimental researches gave an opportunity to establish, that holographic methods allow correctly and in a complete measure to define the technical state of agricultural machines. By means of computer holography it maybe to estimate the microstrain of superficial layers of working zones of detail complex and integrally, but not differentially - point-to-point, as by other methods of non-destructive control. The sensitiveness of the optical system allows to fix small changes in superficial layers, and it gives an opportunity to estimate the technical state and accordingly capacity in expensive arbitrarily chosen moment of time of productive exploitation of agricultural machine in turn.

Basis of prognostication in our case is a study of the real process of change of the technical state of element of machine with the exposure of influence of complex of factors is a microstrain, tense state of working surface of detail, size of wear for certain operating time, and also control periodicity is diagnostician with establishment of the technical state of element of machine. Realizations of such plan of works are difficult enough in practical researches. For the real terms, prognostication must determine the size of remaining resource, being based on the got results of scientific researches. Realization of such works is labor intensive and expense, more effective in this case there is application of mathematical and statistical methods and, as be said higher, to the method of Monte Carlo. For this purpose it is needed to define probabilistic descriptions of elements of machine, and also know the function of distribution of these sizes. Researches that were conducted with application of methods of mathematically-stochastic design more exactly describe the casual process of loss of capacity a machine and require realization of less of tests. The exact enough and reliable prognosis of resource of machines, that is arrived at on the draught of the limited period of time, is thus provided.

Average value initial to the parameter set on technical requirements, and or after the values of the first time diagnostician. Realization of holography stipulates an acceptance for a diagnostically parameter size of microstrain, or in

concrete cases for an agricultural technique form of interference stripes, their distribution and change at a change to the parameter of loading or continued of term of exploitation.

On the basis of basic value to the parameter and his sizes in the moment of prognostication the calculation of mathematical hope of size of remaining resource was conducted after a formula:

$$M(T_{rez}) = M(T_{\text{int}})\left[M(\partial_{\lim}) / M(\partial_{cur})\right]^{1/\alpha} - 1] \qquad (9)$$

where $M(T_{rez})$ is a mathematical hope of size of remaining resource, by hours;

$M(T_{\text{int}})$ is a mathematical hope of size of initial resource, in the moment of research, by hours;

$M(\partial_{cur})$ -is a mathematical hope of size of change of microstrain in maximum terms, when further exploitation of machine is technically impossible or economically unprofitable and it is determined from the condition, mkm;

$M(\partial_{\lim})$ - is a mathematical hope of size of maximum value to the parameter, mkm;

α –coefficient that characterizes speed of change to the parameter.

Holographic equalizations of regression, that describe distribution of size of microstrain on the surface of detail, are got as a result, give an opportunity to set such sizes by realization of corresponding mathematical transformations. From every equalization regressions, that is got for a concrete detail it is necessary to define the coordinates of points, for that a value of size of microstrain will be extreme. It is known that taking the first derivatives from cross-correlation equalization in directions of axes of coordinates and equating them with a zero it maybe to define the sizes of coordinates for the extreme values of microstrain, for example for maximum terms.

Putting the sizes of the got coordinates in equalization 9 determine the size of $M(T_{ti})$. For the reliable estimation of probability of offensive of the maximum state of detail it is necessary to put the value of the got sizes of coordinates in equalization of components of tensors with a next substitution them to equalizations 7, 8 and 9 with the aim of decision of question about the offensive of the maximum state through a power criterion.

Then from specified data about the parameters of the maximum state determine the sizes of remaining resource. On condition that calculations specify on that a detail did not attain the maximum parameters of the state on a power criterion, calculations conduct with the use of possible parameters of the technical state and conduct clarification data that is got an experimental way at голографуванні, in relation to a difference in the possible and maximum parameters of the state of detail.

Like conduct calculations for determination *of* $M(T_{ii})$, when use the dependences got experimentally, taking the first derivatives from corresponding equalization and determining the sizes of coordinates of being of extreme values of microstrain in initial conditions, equating these equalizations to 0.

For a basic value to the parameter and, at the known values of sizes of initial or nominal and maximum parameters of the technical state (in our case of microstrain or tension of superficial layers) and measuring to the parameter that is diagnosed in the moment of prognostication, then a remaining resource is determined after mathematical dependence 9. The size of index to the degree is determined by the experienced way in every concrete case, as speed of change to the parameter of prognostication, that is got by statistical treatment of arrays of experimental data

Conclusions.

The offered method of determination of remaining resource gives an opportunity to forecast him by means of one determination to the parameter - size of microstrain in the moment of realization of diagnostic. The average value of initial and maximum parameters is determined on the base of complex of experimental researches or on technical requirements. Basic advantage of the worked out going near prognostication of remaining resource is: account of the real operating information and potential of possibilities of holography, and also possibility of receipt of reliable information about the terms of origin of the maximum state and dynamics of development of deformation in details. The analysis of results of prognostication from fluid and retrospective data showed high enough authenticity of the obtained data.

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Прогнозирование остаточного ресурса с использованием неразрушающего контроля

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Аннотация. *В статье. представлен оригинальный метод прогнозирования остаточного ресурса сельскохозяйственных машин при использовании методов неразрушающего контроля (голографический)*

Прогнозування залишкового ресурсу з використанням

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Анотація. В статті представлений оригінальний метод прогнозування над залишкового ресурсу сільськогосподарських машин використанні методів неруйнівного контролю (голографічний).