

## DEPENDABILITY OF MACHINE SYSTEM - USABLE CHARACTERISTICS

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### **Abstract**

*The subject of this paper deals with dependability of machine systems base on selected usable characteristics. In the subsystem man-machine and environment, determined tasks are carried out. The sequence of activity is following: man handles machine, which in turn makes the environment deliver desired reaction, e.g. processing or transportation. A machine and desired reaction of environment will recognize the positive effect of above activities as carrying out of set task. It is also of utmost importance that the man and machine's impact on environment is efficient and harmless. Therefore the selection of an adequate machine and its operator to carry out the given task is crucial. The circumstances considered as undesired for task implementation are identified as hazard to man and machine. Within the endangered man - machine and environment subsystem, we can distinguish following phases in the machine degradation process: worthy, partially worthy, partially unworthy, critically unworthy and totally unworthy. The selection of adequate means towards achieving set goals is considered important, and, subsequently, the description of selected machine and human (as operator and decision maker) attributes has been undertaken. The basic attributes of man and machine complex are: adequacy, dependability, safety, durability and effectiveness. Adequacy, described as common machine property, turns out to be a collection of four attributes: functionality, configurability, coverage, and programmability. Reliability, on closer inspection, as a combined property of man - machine complex, is described by four attributes: reliability, redundancy, faultlessness and availability. Safety, as a man - machine - environment property is described by a collection of five attributes: protectionability, hazardousness, harmlessness, safeguardability and deleteriousness. Durability as a machine property can be described by five attributes: strength, refractoriness, maintainability, supportability and serviceability. Effectiveness as a man - machine system property is described by four attributes: efficiency, capability, economically and managementability. It is acceptable to assume that the attributes mentioned above can be of use when selecting machines for outdoor exploitation and facilitating of selected tasks. Particular significance is in the relations between basic attributes of the man - machine - environment subsystem, namely: dependability is the starting point for safety and effectiveness, durability assures dependability, safety and effectiveness, adequacy guarantees a successful outcome of all named attributes of man - machine system.*

**Keywords:** *dependability, machine system, transport*

### **1. Introduction**

The object of this paper deals with dependability of machine systems base on selected usable characteristics. Man can act in the above system both as a decision - maker or as an operator. Man psychophysical efficiency depends on undertaking faultless decisions, as well as on correct controls and skilful machine operating.

The problem of developing dependability machine systems is a subject of many publications (Smalko, 1987; Avizienis, et al (2000). Morel, et al, 2003; Szpytko, 2004; Waeyenbergh and Pintelon, 2004). The dependability problem of technical devices (mostly it is a set composed by man and machine) is overlooking from the point of their selected usable characteristics, e.g. safety and reliability, or more generally from the quality needs of the user.

Machine was designed to man's aid, both from energetically and information side. The examples of such integrated aid are so-called mechatronics objects. The surroundings include the techno-zone (resulting human activities) and natural environment.

In set composed of: man - machine - surroundings, the realization of definite working tasks have place. We can recognize the following operation sequences: the man has an effect on the machine; the machine has an effect on surroundings (processing, displacements, etc.). The positive result of the above activity we will recognize as done by man, supported through machine and desirable environment reaction. It is desirable, that influences of man - machine set at the surroundings must be effective and harmless. The above results with selection of suitable machine and suitable operator to realization of definite task (activity).

The effective and safe realization of described task (activity) by the man - machine - surroundings set in practice not always is possible, because the following events can occur:

- the positive man influences on machine can accompany undesirable reactions coming from machine, which are harmful for man, e.g.: vibrations, noise,
- the positive machine influences on surroundings can accompany undesirable reactions coming from surroundings, which are harmful for machine, surroundings and men, e.g.: conflicts and collisions with elements belong to surroundings on micro- and macro- scales,
- the positive surroundings secondary influences on machine can accompany undesirable reactions, which are harmful for man, e.g.: his senses of sight, hearing and smell.

The described factors, together or separately, cause with unfavourable changes of technical states of elements the man - machine set. The unfavourable task realization circumstances are mostly identified with hazards affecting the man and machine. They are coming both from external and internal forcing factors, which have fatigue, wear, or/ and ageing character.

## 2. Hazards in machine system

In menaced machine system it is possible to distinguish the following technical states: fit for use, partial fit for use, partial unfit for use, critical unfit for use and total unfit for use (Fig. 1).

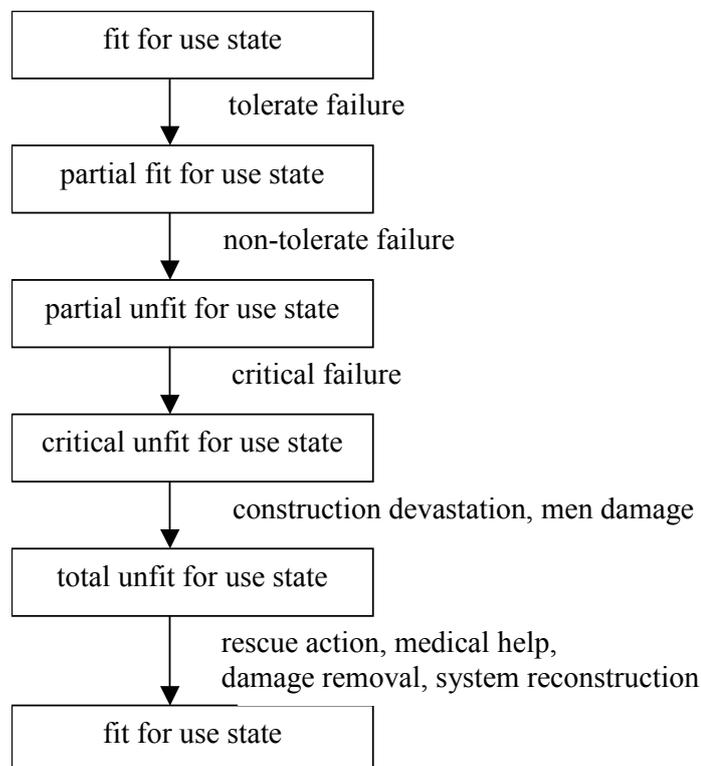


Fig. 1. The unsafe graph of machine system

The system fit for use technical state characterizes with lack of damages, noncross the acceptable operation state of the system, operator feels safe and system is acting correctly. The system moves to the partial fit for use technical state we identify with tolerable damage. The degradation prevention and counteraction of the machine depends on: technical services, losses completing, system technical state monitoring, and user insurance after-effects of incidents, damages and losses.

The system partial fit for use technical state characterizes with tolerable of damages, noncross the acceptable operation state of the system, operator feels light threat, and machine can correctly executing ordered task yet. The destructive process of the system has been started. The system moves to the partial fit for use technical state we identify with intolerable partial damage. The degradation prevention and counteraction of the machine depends on self-acting decomposition of existing excesses.

The system partial unfit for use technical state characterizes with intolerable partial of damages, the acceptable operation state of system is exceed and limiting level is reached, operator feels light threat, and machine is not correctly executing ordered task. Also it is possible to identify first symptoms of arise process of damages and losses, moreover threats are occurring and any accident is possible. The system moves to the critical unfit for use technical state we identify with critical damage. The degradation prevention and counteraction of the machine depends on starting the security units and caution via alarms.

The system critical unfit for use technical state characterizes with critical damages, the acceptable operation state of the system is exceed and critical level is reached, the harmful factors are acting at the operator and machine is not correctly executing ordered task or is a subject stoppage (stops to act and to execute task). Also it is possible to identify first symptoms of arise process of damages and losses. The system moves to the total unfit for use technical state we identify with machine damage and men injuring. The degradation prevention and counteraction of the machine depends on slowing down and interruptions the process of formation of damages and losses, as well as on alarming the surrounding.

The system total unfit for use technical state characterizes with extensive destructions, damages and losses, the critical level of the technical state of the system is crossed, the operator is injured and machine loses operation features and the realization of task is not more possible. The above results within considerable damages and losses. The system returns to fit for use technical state depend on renovation (or interchange) the total machine, men's' medical help, damages and losses results compensation. The degradation prevention and counteraction of the men - machine set depends on actuating the rescue system, as well as medical and technical services. From here we can recognize important problem the choosing to defined tasks realization proper devices. Therefore we will occupy oneself with description the selected usable features of the machine and also some man's features (operator and decision-maker).

### 3. Selected operation features of machine system

Main operation features and attribute of machine system enclose: *adequacy, dependability, safety, durability, and effectiveness* (Fig. 2).

Adequacy is the feature of the machine system, describing in multiaspect way preparation this set to executing described tasks in the reference or extremely conditions in operation condition. The adequacy as a joint feature of the device is described by four collections: *functionality, ergonomics, compatibility and operability*.

Functionality – feature of the machine describing her convenience of structure solution so called configurability. Configurability assures device coverage and the programmability.

Ergonomics – feature of the machine describing her adaptation to anthropotechnical and psychophysical feature of the man. The above is possible to achieve via user-friendly solutions, adequate structure solutions, and man - machine interfaces.



Fig. 2. The main and lateral operation features of machine system

Compatibility – feature of the machine describing adaptation of her working organ structure solution to different technical objects, as well as to existing infrastructure feature.

Operability – feature of the machine describing her structure solution which cause with easiness of machine use under operation (navigating, manipulate and maneuver). In this is possible to achieve: getting the response time of working organ which are resulting the control signals (exact and quick answer), control simplicity (simple way steering), the accessibility (access to lever and buttons), good visibility of panels and device technical state indicators, position of the device inside the working space, etc.

Dependability – describing features of the machine system to executing attributed functions, in definite time and in definite conditions of use. Executed activities are safety, effective and without any breaks during operation. Dependability is a joint feature of man - machine set, described through four collections: *dependability, redundancy, faultlessness and availability*.

Dependability – feature of the machine describing her ability to working other breakdowns, in the set time and the settled circumstances.

Redundancy – feature describing total booking arrangement of the machine system, which creates the possibility of tolerance of the machine damages and the man errors. The redundancy results with existing in the man - machine set excesses the following types: structural, functional, time and information.

Faultlessness – the man's feature (decision-maker, operator) describing his ability to correct undertaking the decision about activity starting with support of the machine and to correct machine controlling, with taken under the consideration the possible changes of the device technical state and state of the surroundings.

Availability – total feature of the machine system describing his ability to provide the machine in required technical state assuring her disposability.

Safety – the total feature of the machine system describing the set preparation to avoidance of threats and the risks in movements and in the state of waiting (stand). The more preciously analyzed of this set can be described with five collections: *protectionability, hazardousness, harmlessness, safeguardability and deleteriousness.*

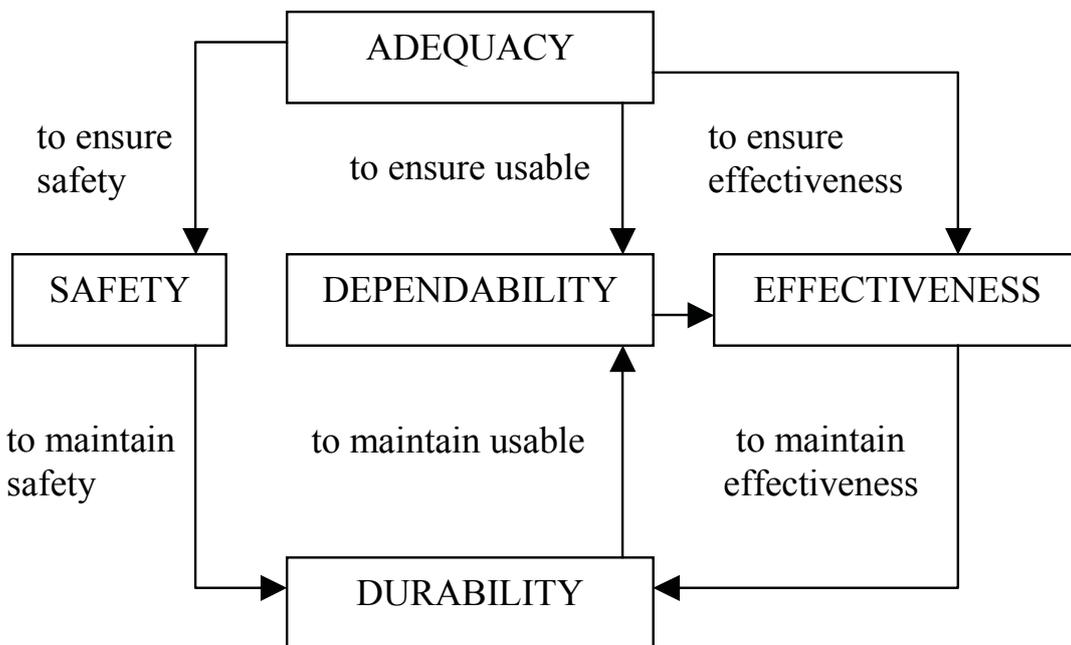


Fig. 3. Relation between main operation of the machine system

Protectionability – feature of the machine describing her preparation to operator protection, the crew, passengers or loads, before results of external and internal possible hazards. These are achieved by strengthener and inurement the construction, as well as in-built to the machine the special protecting devices (the seat belt, Antilock Breaking System, etc.) and servomechanisms. The above is also possible to achieve by use of information and functional excesses enabling to tolerance fail safes (critical damages).

Hazardousness – is a feature of the man - machine set describing preparation the man's and susceptibility control devices to quick manoeuvring, accelerations changing, speed moving and machine slow down. The overlooked benefits are: machine operation with damageless and avoidance of possible conflicts with surroundings.

Harmlessness – the feature of the man - machine set describing his preparation to limitation of harmful influences on natural environment.

Safeguard ability - the feature of the machine - surroundings set describing warning system and blocking unit, which make not possible access to the set by unauthorized persons.

Deleteriousness – the feature of the man - machine - surroundings set describing correctness of cooperation of set elements during elimination and neutralization possible damages and losses.

Durability – is the feature of machine expressed with the limiting period of use of machine (service life), which e.g. results with not acceptable hardness of elements against acting factors. The critical life period of the machine is also a part of expenses spend and linked with maintaining oriented to system availability. The more preciously analyzed of the machine can be described with four collections: *strength, resistance, maintainability, supportability and serviceability*.

Strength – is the feature describing ability to constructional material of machine to counteraction of degradation till moment of crossing of admissible usable burdens.

Resistance – is the feature describing ability to constructional material of machine to counteraction of degradation from influence of external factors.

Maintainability – the feature of machine describing her susceptibility to repair in appointed period of time.

Supportability – the feature describing the machine preparation to provide her in required technical condition during designed period of exploitation, with support services, maintaining, and condition monitoring.

Serviceability – the feature of the man - machine - surroundings set describing the assurance of different services and inspection possibility realization focusing on the machine, through exploitation lifecycle period.

Effectiveness – the feature describing ability of the man - machine set to safe energy consuming, as well as rational utilization of other material and financial expenditures related to the described operation activities. The effectiveness can be described by four collections: *efficiency, capability, economically and thrift*.

Energetically efficiency – is the machine feature describing her useful energy processing.

Capability – the feature describing ability of machine to achieve overlooked results that are a subject of expressing by measurable economical factors.

Economically – the feature of the man - machine set expressed by rational use of money for described task realization.

Thrift – the feature describing the man's skill to realization operation tasks within thrifty principles, including machine service life, object and financial outlays.

#### **4. Final conclusion**

We can suppose that described system features can be useful in selection of machines working in external conditions, favourable to realization the defined working tasks. The definite meanings are playing the interactions between main features of man - machine - surroundings set: dependability is conditioning safety and effectiveness, durability maintains dependability, safety and effectiveness, adequacy is conditioning all positive outputs of described features of man - machine set (Fig.3).

The present study is the starting contribution focusing on methods that helps select machines<sup>S</sup> feature in variable conditions of use.

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