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Complex formulation of the availability of sea transport means

SUMMARY

Availability of the transport means, both reparable and unreparable, was presented in the aspect of their preparation for using in accordance with their destination, provided that at a random time instant of calling for an arbitrary task they are in the technical state which makes its realization possible with a given probability. In the case of the reparable means the probability is identical with the technical availability factor. The semi-Markov process theory was applied to exemplify determination of the factor.

INTRODUCTION

Availability of many transport means, e.g. sea-going ships, is a very important feature which characterizes their suitability to be used in accordance with their destination. It is so because the means are able to perform different tasks in different conditions (to which they were designed and manufactured, further called „design-consistent tasks"), being themselves in various states of serviceability [3,8]. Some of the states can be effected by failures of particular machines or other equipment elements of the transport device in question. In the case of the sea-going ship that can be for instance : one of the main engines, electric generator, fire or ballast pump, boiler, windlass etc. The ship, in spite of such failures, is able to perform some of the tasks. Therefore the sea-going ships can be considered as the technical objects in which failures can be tolerated. Availability of such objects was presented in [2] with accounting for different changes of their technical state. The suitable technical state of particular machines and other equipment of the ship is only a necessary, but not sufficient, condition of her use in compliance with her design. An adequate energy state of the devices, in particular the main diesel engines and steam boilers, is necessary. For instance if a ship is in the state of full serviceability (as defined in [2]), her design-consistent use beginning from the time instant *t* in which a task is requested, is possible (in some cases) only after several hours. It results first of all from the fact that the main engines must be prepared for starting (connected with heating them even for 6 hours) and after starting - gradually loaded (sometimes even for 3 hours if the engine power per cylinder is not less than 750 kW) until the full power is obtained, in order not to cause excessive thermal stresses. The problem of ship availability is below presented with respect to the main engines, as the main propulsion engines, of sea-going ships, like the aircraft engines, are weak links as regards their availability.

DESCRIPTION OF EXPLOITATION SITUATION OF MAIN ENGINES

The main engine operation process during which the effective power produced by it is transmitted to the propeller, is always preceded by a starting procedure. The starting consists in :

- ⇨ preparation of the engine and devices cooperating with it
- ⇨ effecting the engine to start, i.e. speeding up the engine crankshaft by delivering some energy amount from an external energy source (usually the air pressure tank) to such rotational speed which makes it possible to stabilize fuel combustion process in its cylinders.

The adequate technical state of all its functional systems as well as energy (thermal) state of its main tribological systems are the basic conditions for starting the engine quickly and effectively. Attempts to start the engine of not quite full serviceability [3] and/or heating its relevant systems to too low temperatures cause only excessive consumption of starting air energy. For this reason all its elements accessible for control without disassembling as well as the states of all energy media are checked. The checking is made especially thoroughly just before the first starting the engine after its long standing-by, after its technical maintenance (preventive or forced) as well as on completion of general overhauls (repair). The particular actions which the scope of the engine preparation for starting and operation consists of are performed by crew members in the adequate sequence which depends to a large extent on construction of the engine and power plant in which it is installed. The scope and sequence of the actions are determined in detail by the technical and operational guidelines. In general the preparation of the engine to starting usually consists of :

- completeness checking of the engine systems and their connections
- free-movement checking of all movable engine elements
- serviceability checking of particular engine systems such as : starting system, air supply system, cooling system, lubricating system, fuel supply system and control-measurement system
- preliminary heating of the engine just before starting.

The preliminary heating of the engine consists in making temperatures of the lubricating oil in the circulation-pressure installation and of the engine-cooling fresh water appropriate. Duration time of the lubricating oil heating is a random variable. Its realizations in the subsequent engine-heating attempts depend on its initial temperature and the water amount within the installation. The time values are usually not lower than 30 min in the case of the low-power engines and not lower than 2 hours for the high-power ones. The oil heating is necessary to :

- lower oil viscosity hence mechanical energy loss and tear and wear, first of all, of the pins and sleeves of the main and journal bearings
- make the engine pistons warmer (in the case if they are oil-cooled during operation of the engine) and hence make the thermal stresses in them lower which leads to increasing durability of the pistons and therefore to greater operation times between subsequent failures.

The heating is also carried out with respect to the fuel and engine-cooling fresh water. Their heating times are also random variables depending on the similar factors as in the case of the lubricating oil. The heating time realizations can take values of 4 to 6 hours (or even more).

The engine in the state of full serviceability or an appropriate state of partial serviceability [3], and suitably prepared to starting, should correctly work after 1 to 3 crankshaft rotations.When after performing of those rotations the engine fails to operate correctly, the compressed air flow, and thus the engine as well, is stopped. When after two (or three at the most) starting attempts the engine is not put into operation a search is made to identify possible causes of the situation.

One of them can be such technical state of the engine which does not make it possible to obtain, at the actual heating temperature of the above mentioned energy media as well as starting air pressure, such value of the temperature at the end of air compression process within the cylinder, which would be greater than the self-ignition temperature of the fuel injected to the engine cylinders.The situation can happen especially at low air temperature within the power plant where the starting air tanks are located. During starting the engine the elements of its combustion chambers are washed by the starting air whose temperature can go down to 230K or even 190K during decompression process in the cylinder. The next attempt to start the engine is made after removal of causes of the failed starting attempt.

Even if the start is successful the engine cannot be fully loaded in a too short time period without causing detrimental thermal stresses. Loading the engine up to its rated (or greater) value is performed in a longer period which, being a random variable, is proportional to the power of the engine and depends on its individual, technical and operational features.

Therefore it is necessary to verify the interpretation of availability of the technical objects having the design and operation features similar (or identical) to those of some ship power plant devices. Hence it is reasonable to consider the availability of transport means (e.g. sea-going ships) to start performing their design-consistent tasks in a random time instant, which, within a given time interval (e.g. one year), can be in the state of full serviceability [4] but at various probability levels, also that equal to 1.

It means that considering the availability of the non-reparable devices to perform their tasks is also rational. To determine ratios of the so defined availability of a device it is necessary to formulate the problem mathematically.

FORMULATION OF THE AVAILABILITY PROBLEM

The availability of any transport device, e.g. sea-going ship, can be defined as its ability to immediately start performing the tasks called for at random time instants, which are to be realized in a given time, assumed conditions and places (space locations) [2,6].

The availability of any sea-going transport ship, as well as of any device installed on her board, can be understood as the probability $G(t, \tau)$ of the event that, being in the state of technical serviceability at the instant t, it will start performing the task called for in that instant, after the time $T \leq \tau$. T can be assumed the non-negative random variable of the distribution function F_T. If A means the event that at the instant t a transport device is able to perform the task, and B the event of starting the task realization at the instant τ then :

$$G(t,\tau) = P(A \cap B) = P(A)P(B|A) \tag{1}$$

and :

$$P(A) = k_g(t) \qquad P(B|A) = P(T \leq \tau) = F_T(\tau) \tag{2}$$

where :

B|A - occurrence of the event B on assumption that the event A has occurred

$k_g(t)$ - technical availability ratio at the instant t.

Therefore :

$$G(t,\tau) = k_g(t)P(T \leq \tau) = k_g(t)F_T(t) \tag{3}$$

In the case of high t values ($t \to \infty$) the relation (3) can be presented as follows :

$$G(\infty,\tau) = k_g\, F_T(t) \tag{4}$$

The presented exploitation situation results from that performing the task by any sea-going ship demands fulfilment of three basic conditions compulsory for starting preparation of her devices :

1st The device, at the time instant t of calling for a task to be performed by the ship, has to be in the technical state which makes it possible to realize the task.

2nd At the above mentioned instant t the device should be brought, in the time $T \leq \tau$, to such energy state in which it can be started without any excessive risk of being failed due to this reason.

3rd During realization of its task the device must not suffer such failure that the ship's task remains not fulfilled.

AVAILABILITY RATIOS

Within the scope of these considerations it can be generally assumed that the availability ratio k_g is expressed as follows [2,6] :

$$k_g = \frac{E(T_z)}{E(T_z) + E(T_n)} \tag{5}$$

where :

$E(T_z)$ - expected value of the duration time of the serviceability state which makes task realization possible

$E(T_n)$ - expected value of the duration time of the unserviceability state which makes task realization not possible.

It results from (5) that k_g probability values of any device of the sea-going ship, whose failures during performance of the task can be tolerated, will be different from the relevant values of the devices whose failures during performance of other tasks cannot be tolerated. Therefore the following information on values of the availability ratios should be accounted for at making operational decisions :

- $k_{g(tl)}$ - availabilty ratio of the device whose failures can be tolerated by its user
- $k_{g(ntl)}$ - availabilty ratio of the device whose failures cannot be tolerated by its user.

The relationships defining the above mentioned k_g ratios will be diferrent and dependent on the device type, its operation conditions, demands from the operational system which assigns the tasks to be realized by the ship etc. Deriving the relationships is possible by applying the semi-Markov processes [2,5].

For many sea-going ship devices the set of their technical states, S, is of practical importance :

$$S = \{s_i \,;\, i = 1,..,4\} \tag{6}$$

They have the following interpretation [2] :

- s_1 - the full availability state, i.e. the device technical state which makes it possible to perform all its design-consistent tasks with simultaneous assurance of the values of operational indices required by its user (e.g. the minimum fuel consumption by the main engine)
- s_2 - the partial availability state, i.e. such device technical state which still makes it possible to perform all the tasks (like in the state s_1) but at lower values of the operational indices (e.g. at lower total efficiency of the main engine, thus its higher fuel consumption, higher toxicity of exhaust gas from the engine and/or boiler, lower output of the boiler, lower pressure within the pumping system, lower ship's speed etc)
- s_3 - the task unserviceability state, i.e. the device technical state which makes it possible to perform only some tasks (e.g. the state resulting from the engine failure which demands to exclude from work one cylinder or even the entire engine of multi--engine propulsion system of the ship)
- s_4 - the full unserviceability state, i.e. the device technical state which makes it impossible to perform any of the designed tasks of the device.

The states $s_i \in S$ (i = 1, 2, 3, 4) are values of the semi-Markov process $\{W(t) : t \geq 0\}$, which can be assumed by it in subsequent operation time instants.

To determine the process, the functional matrix is necessary, which describes possible changes of the process states and the initial distribution formed by probabilities of occurrence of the states in the initial instant of the process ($\tau_0 = 0$).

In practice different realization variants of the process can be considered [2]. Such variant can be deemed the most favourable in which full renewal of the device is expected if any of the states s_i (i = 2, 3, 4) occurs. In this case the initial distribution of the process is as follows :

$$\begin{aligned} p_1 &= P\{W(0) = s_1\} = 1 \\ p_i &= P\{W(0) = s_i\} = 0 \quad \text{for} \quad i = 2, 3, 4 \end{aligned} \tag{7}$$

and the functional matrix obtains the form :

$$Q(t) = \begin{bmatrix} 0 & Q_{12}(t) & 0 & 0 \\ Q_{21}(t) & 0 & Q_{23}(t) & 0 \\ Q_{31}(t) & 0 & 0 & Q_{34}(t) \\ Q_{41}(t) & 0 & 0 & 0 \end{bmatrix} \tag{8}$$

where :

$$\begin{gathered} Q_{ij}(t) = P\{W(\tau_{n+1}) = s_j \quad \tau_{n+1} - \tau_n < t \,|\, W(\tau_n) = s_i\} \\ s_i, s_j \in S \quad i,j = 1,2,3,4 \quad i \neq j \end{gathered} \tag{9}$$

From (7) and (8) the following expressions can be derived by using the semi-Markov process theory, which determine probabilities of the process $\{W(t) : t \geq 0\}$ being in the particular states s_i (i = 1,2,3,4) [2] :

$$P_1 = \frac{E(T_1)}{M} \qquad P_2 = \frac{E(T_2)}{M}$$

$$P_3 = \frac{p_{23}E(T_3)}{M} \qquad P_4 = \frac{p_{23}p_{34}E(T_4)}{M} \tag{10}$$

where :

$$M = E(T_1) + E(T_2) + p_{23}E(T_3) + p_{23}p_{34}E(T_4) \tag{11}$$

and

$E(T_j)$ - expected value of duration time of the state $s_j \in S$ (j = 1,2,3,4)

p_{ij} - probability of the process $\{W(t) : t \geq 0\}$ passing from the state s_i to s_j

$$s_i, s_j \in S \quad i,j = 1,2,3,4 \quad i \neq j$$

The particular probabilities P_j (j = 1,2,3,4) determined by (10) and (11) have the following meaning :

$$P_1 = \lim_{t\to\infty} P\{W(t) = s_1\}$$
$$P_2 = \lim_{t\to\infty} P\{W(t) = s_2\}$$
$$P_3 = \lim_{t\to\infty} P\{W(t) = s_3\}$$
$$P_4 = \lim_{t\to\infty} P\{W(t) = s_4\}$$

In this variant of state change of the process $\{W(t) : t \geq 0\}$ which is realized in compliance with its initial distribution (7) and functional matrix (8) the user can take risk of fulfilling the task at the device state s_2 and even of realizing some tasks at the state s_3 of that device.

In the first case the availability ratio is expressed as follows :

$$k_{g(tl)1} = P_1 + P_2 \tag{12}$$

and in the second case :

$$k_{g(tl)2} = P_1 + P_2 + P_3 \tag{13}$$

Obviously, if the state s_1 of the device is necessary to realize the task its technical availability ratio is defined as follows :

$$k_{g(ntl)} = P_1 \tag{14}$$

If realization of the task is not possible as the device is in another state than s_1 then full renewal of its technical state is obviously necessary to restore its full serviceability in compliance with the matrix (8).

It yields from (4) that it is necessary to know, apart from the technical availability ratio k_g, the probability $P(T \leq \tau) = F_T(\tau)$ to determine availability of the ship as well as of any of her devices. Therefore the problem remains of determining the probability $P(T \leq \tau)$ of the device being in the full serviceability state at the time instant t, i.e. the probability that preparation time of the ship (or any of her devices) will not be greater than t.

At the time instant t when a task to be performed is requested the device is in the technical state which makes fulfilling the task possible, however it simultaneously is in the energy state e_0 not sufficient for its designed application. Therefore it is necessary to bring the device to the energy state e_1 which makes the application possible. Hence the device passes from the state e_0 to state e_1 in the time T (which is a random variable) with the following probability [4] :

$$P(T \leq \tau) = F_T(\tau) = 1 - \exp\left\{-\int_0^{\tau} \lambda(\vartheta)\, d\vartheta\right\} \tag{15}$$

where : ϑ - an arbitrary instant within the time interval $[0, \tau]$.

In result the expression (4) can be transformed to the following form :

$$G(\infty,\tau)=k_g\left(1-\exp\left\{-\int_0^{\tau}\lambda(\vartheta)d\vartheta\right\}\right) \tag{16}$$

If the device can be prepared in a time not longer than t_g then (16) is reduced to :

$$G(\infty,\tau)=k_g \tag{17}$$

In practice it should be taken into account that a value of τ_0 exists below which a given ship device cannot be prepared for starting. Therefore it is necessary to take into account that the device is not able to start and commence the task till τ_0. The time can be called „the availability threshold" of such devices. For the ship main diesel engines that time can be understood as the total time necessary to :

- preliminarily heat the engine and prepare it for starting
- step-by-step increase the engine loading after it started working, in order to avoid excessive thermal stresses in its elements.

Hence the expression (15) can characterize, for many ship devices (e.g. main engine), their „energy-related availability"; and the probability $F_T(t)$ can be called „the energy-related availability ratio"of such devices.

From these considerations it results that the probability of preparation of such devices to be started within the time interval $[0,\tau]$ can be expressed, if T is exponentially distributed, as follows [1] :

$$P(T\le\tau)=\begin{cases}0 & \text{for } \tau<\tau_0\\ 1-\exp[-\lambda(\tau-\tau_0)] & \text{for } \tau\ge\tau_0\end{cases} \tag{18}$$

where :

$\lambda=E(T)^{-1}$ - scale parameter

$E(T)$ - expected value of the device preparation time for starting.

The time T can usually be assumed to have the exponential distribution for the following reasons :

- the preparation time for starting every device is a random variable (until the preparation actions to achieve the state e_1 by a given device are commenced) independent of the realization stage of the preparation actions for starting the device. Therefore the distribution of the time required to perform the remaining actions does not depend on the already performed work (which satisfies the stationary condition)
- the time and range of the actions which make it possible to prepare the device for starting are independent of each other (which satisfies the no-after-effect condition)
- particular preparation actions to start the device are independently performed which results from the above mentioned singularity of appearing of particular requests to perform a given action (which satisfies the singularity condition).

In this situation the availability ratio can be presented in a general form as follows :

$$G(t,\tau)=k_g(t)\{1-\exp[-\lambda(\tau-\tau_0)]\} \quad \text{for} \quad \tau\ge\tau_0 \tag{19}$$

and for very large t values ($t\to\infty$) :

$$G(\infty,\tau)=k_g\{1-\exp[-\lambda(\tau-\tau_0)]\} \quad \text{for} \quad \tau\ge\tau_0 \tag{20}$$

The expression (20) , after accounting for (12) and (13), can be presented in the below given versions if the operational situations are taken into account in which the tasks can be fulfilled when the ship or her device is at least in the technical state s_2 or s_3 :

➔ when occurrence of the state s_2 is sufficient to fulfil the task :

$$G(\infty,\tau)=(P_1+P_2)\{1-\exp[-\lambda(\tau-\tau_0)]\} \quad \text{for} \quad \tau\ge\tau_0 \tag{21}$$

➔ when occurrence of only the state s_3 is sufficient to fulfil the task :

$$G(\infty,\tau)=(P_1+P_2+P_3)\{-\exp[-\lambda(\tau-\tau_0)]\} \quad \text{for} \quad \tau\ge\tau_0 \tag{22}$$

If solely the state s_1 of the ship or her devices is necessary to fulfil the task, then, taking into account (14), the expression (20) takes the following form :

$$G(\infty,\tau)=P_1\{1-\exp[-\lambda(\tau-\tau_0)]\} \quad \text{for} \quad \tau\ge\tau_0 \tag{23}$$

The availability of the transport means, determined by using the expressions (1), (3), (4), (11) and (19) to (23), can be called the „functional availability" different from the „technical, energy-related, operational" and other availabilities [6], as it characterizes availability of the means to start functioning in specified conditions and time without an excessive risk of failure during preparation for their designed application. This is the complex availability which covers both the technical and energy-related availability.

The probability k_g can be rather easily determined by assuming the semi-Markov model of the changes of technical state of the object [2]. However determination of $k_g(t)$ can be difficult as it requires applying the conditional probabilities $P_{ij}(t)$, i.e. those of passing the object from the state s_i to s_j at the time instant t [2,5].

The probabilities have the following interpretation :

$$P_{ij}(t)=P\{X(t)=s_j|X(0)=s_i\} \quad i,j=1,2..,n \quad i\neq j \tag{24}$$

The equations defined by (24) can presented, by applying the Kronecker symbol δ_{ij}, in the following form :

$$P_{ij}(t)=\delta_{ij}[1-G(t)]+\sum_{k=1}^{m}\int_0^t P_{kj}(t-\xi)dQ_{ik}(\xi) \tag{25}$$

where :

$G_i(t)$ - the distribution function of the random variable T_i which determines the absolute duration time of the technical state s_i, i.e. the random variable which determines duration time of i-state of the process $\{W(t) : t\ge0\}$ independent of the state to which it will pass

ξ - an arbitrary instant within the time interval $[0,t)$.

The availability ratio $k_g(t)$ can be then presented as follows (on assumption : $j=i$) :

$$P_{ii}(t)=\sum_{k=1}^{m}\int_0^t P_{ki}(t-\xi)dQ_{ik}(\xi)+1-G_i(t) \tag{26}$$

The right-hand-side component of the equation (26) results from that the semi-Markov process which took the value $s_i\in S$ in the instant $t=0$, can also be in this state when no state change of the process occurs within the time period $[0,t)$, i.e. the event $A:(T\ge t)$ happens.

The equation set (25) of unknown probabilities of passing the semi-Markov process is a special case of the so called „Markov's renewal" equations described in detail in [3,5].

Taking into account the random variable Θ_{ij} which determines the return time of the process $\{W(t) : t\ge0\}$ to the state $s_j\in S$ ($j=1,2,3,4$) one can determine the afore mentioned technical availability ratio as follows [5] :

$$P_{jj}(t)=1-G_j(t)+\int_0^t P_{jj}(t-\xi)d\Phi_{jj}(\xi) \quad (27)$$

where :

Φ_{jj} - the distribution function of the random variable Θ_{jj}; $\Phi_{jj}(t)=P(\Theta_{jj}<t)$

In the case of knowing the expected values $E(\Theta_{jj})$ and $E(T_j)$ the probability of the device being in the state s_j, which makes it possible to fulfil the task (i.e. its availability ratio), can be determined as follows :

$$P_j=\frac{E(T_j)}{E(\Theta_{jj})} \quad (28)$$

The expression (28) is obtained by transforming the following relationship [5] :

$$E(\Theta_{jj})=\frac{E(T_j)}{P_j} \quad (29)$$

which is sensible if the state $s_j \in S$ is the positive returning state of the semi-Markov process of the finite state set S. And the returning state is the positive returning one if :

$$0<E(T_j)<\infty \quad (30)$$

For the sea-going ship devices the inequality (30) is sensible, therefore (28) can be applied to determine their availability ratios.

However most often the limiting distribution of the process is used to determine those ratios [2,3,4,5] :

$$P_j=\lim_{t\to\infty}P\{W(t)=s_j\}=\lim_{t\to\infty}P\{W(t)=s_j|W(0)=s_i\} \quad (31)$$

and simultaneously : $s_i \cap s_j \in S \quad i\neq j$

This distribution is determined by the following relationship [3,5] :

$$P_j=\frac{\pi_j E(T_j)}{\sum_{k=1}^{m}\pi_k E(T_k)} \qquad j=1,2,..,m \quad (32)$$

where π_j ($j=1,2,...m$) is the limiting distribution of the Markov chain $\{W(\tau_n): n=0,1,2..,\}$ placed into the process $\{W(t): t\geq 0\}$ of changes of the distinguished technical states $s_i \in S$ ($i=1,2,..,m$) of the device in question.

In [2] the expression (32) was applied to determine the availability ratios for various change variants of the distinguished states of the device.

The expression (18) becomes unsuitable for determining the probability $P(T\leq\tau)$ when the time T cannot be assumed to have the exponential distribution. In such case another distribution suitably describing that random variable should be applied [1]. For instance the following relationship for Weibull distribution (of which the exponential distribution is a special case) is obtained :

$$P(T\leq\tau)=\begin{cases}0 & \text{for } \tau<\tau_0\\ 1-\exp[-(\tau-\tau_0)^{\gamma}\beta^{-1}] & \text{for } \tau\geq\tau_0\end{cases} \quad (33)$$

where :

γ - shape parameter

β - scale parameter.

Next, the following expression can be applied to Erlang distribution (a special case of γ- distribution) :

$$P(T\leq\tau)=\begin{cases}0 & \text{for } \tau<\tau_0\\ 1-\sum_{k=0}^{r-1}\frac{[\lambda(\tau-\tau_0)]^k}{k!}\exp[-\lambda(\tau-\tau_0)] & \text{for } \tau\geq\tau_0\end{cases} \quad (34)$$

where :

r - shape parameter

λ - scale parameter.

Similar relationships to determine the probability $P(T\leq\tau)$ with application of other distributions of the random variable can also be achieved, e.g. those considered in [1,8].

The availability of the unreparable sea transport means, e.g. pontoons, lifeboats etc, can be defined as follows :

$$G_n(t,\tau)=P(T_p>t)P(T\leq\tau) \quad (35)$$

where : $P(T_p>t)$ - the probability of the event $A_p \equiv T_p>t$ that the correct operation time T_p of an unreparable transport object will be greater than the operation time t demanded for realization of the previous task by that object.

For the initial operation period $[0,t_0]$ the relationship (35) obtains the following form if it can be assumed that during this period the transport means are reliable, i.e. their $P(T_p>t)=1$:

$$G_{n(o)}(\tau)=P(T\leq\tau) \quad (36)$$

where t_0 is the so called „sensitivity threshold" [1].

The probability $P(T_p>t)$ is the reliability function $R(t)$ of the unreparable transport object, defined as follows [1,6,7] :

$$R(t)=R(0)\exp\left[-\int_0^t\lambda(\xi)d\xi\right] \quad (37)$$

It is usually assumed that a transport object put into the operation system is in the serviceability state in which $R(0)=1$.

Therefore the reliability $R(t)$ of the unreparable sea transport object can be determined for any time t by using (37), thus its availability for realizing the next task after the time period t can be defined as follows :

$$G_n(t,\tau)=R(t)P(T\leq\tau) \quad (38)$$

The possible distributions of the correct operation time T_p of various technical objects are presented e.g. in [1,6,7].

FINAL REMARKS

● Availability of many transport means, e.g. sea-going ships, strongly influences their operational effectiveness as the following things depend on it :

- number of the tasks possible to be fulfilled, out of their set consistent with the design of the transport means in question
- ability to timely commence the tasks assigned to the crew
- duration time of the state which makes performing by the transport means of their designed tasks possible.

The availability of those means influences their durability and reliability in accordance with the relation: the higher availability the lower durability and reliability. Some sea-going ship devices are maintained in the so-called „duty state" if it is difficult to foresee their calling-for time instants. In this case the intensive energy processes occur which cause premature failures of the devices. Hence their durability to the first failure and time between failures drops, and their maintenance scope and time-consumption and thus their cost grows. Therefore operation life-time of the devices, i.e. the time to their scrapping, decreases. The similar situation occurs if the devices are not prepared to start but an attempt is made to start them operating.

● Rational planning and then controlling the operation process of the ship devices can be more accurate if their availability is suitably identified. Therefore the availability ratio of the ship power plant devices is very important factor because, when applied as an optimization criterion, it makes possible maximizing the income during fulfilment of the task [3,5]. Moreover if the power plant user has at his disposal a set of the devices which are able to perform the same important tasks, knowledge of the availability ratios of the devices can shorten duration time of the afore mentioned duty state. The expressions (16) to (23), (27) and (32) to (38) could be useful to get the knowledge.

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ZTM

Gdańsk Gdynia Szczecin

Transport Committee (KT) of the Polish Academy of Sciences (PAN)

Section of Transport Technical Means

MARINE TECHNOLOGY UNIT

Polish Academy of Sciences (PAN) realizes most of its statutory tasks by activity of the committees whose members are outstanding scientists and experts from relevant scientific disciplines as well as from practical areas of social and economic life. One of the committees is the Transport Committee within which many specialty sections operate and among them the Section of Transport Technical Means covering land, air and sea borne transport. The latter kind of transport is the area of interest of the Marine Technology Unit (ZTM). The following tasks of the unit were formulated during its inauguration meeting on 30 January 1996 :

- Integration of the scientific-didactic and scientific workers who deal with the problems of both cognitive and utilitarian values, concerning the area of design, manufacture and exploitation of the sea and inland-waterways transport means, as well as with other marine technology problems focussed on adapting sea environment resources to human needs.
- Facilitating the preparation of theses to obtain a doctor or associate-professor degree.
- Promotion of the scientific accomplishments of ZTM members and their scientific circles on the forum of Section of Transport Technical Means and as far as possible wider, in the form of papers presented at conferences as well as of monographies and articles published in various journals, inclusive of „Polish Maritime Research".
- Developing co-operation with the enterprises and institutions which act for the development of maritime economy.
- Organizing and co-ordinating the efforts necessary to develop marine technology, which make it possible to develop the cognitive and utilitarian knowledge gained with the use of scientific methods.

To realize these aims the following forms of activity are promoted :

- Preparing concepts of scientific research development in the area of water transport technology, and considering its important scientific problems.
- Organizing :
  - various forms of research personnel education
  - scientific research conventions, conferences and meetings, domestic and international, with active taking part in them by ZTM members.
- Analyzing and assessing the state and organization of the sciences being the area of ZTM activity.
- Providing scientific support to scientific specialty societies and social organizations.
- Initiating :
  - scientific research and competition in practical applying of its results
  - various forms and methods of research staff development
  - development of the scientific research facilities for water transport
  - co-operation with Polish maritime economy enterprises and institutions as well as relevant foreign scientific centres
  - development of publication activity.

The wide scope of the tasks faced by ZTM makes it necessary to engage a huge potential of scientific knowledge and professional experience. Hence ZTM has 54 members, among them :

- 14 Professors and Associate Professors from Polish Naval Academy, technical universities of Gdańsk and Szczecin, Maritime University of Szczecin, Gdynia Maritime Academy and Maritime Institute, Gdańsk, as well as
- 15 outstanding experts, representatives of the enterprises, institutions and social organizations having important influence on maritime economy development.

In 1999 six ZTM meetings were held dealing with the following issues :

- „A concept of determining the discipline „Transport"
- „Polish fish cutter fleet and its fishing capacity"
- „Modern navigation techniques"
- „Competition impact of the world market on the organization and technical development of shiprepair yards"
- „Selected problems of ship safety"
- „Safety analysis of shipboard machines – a component of ship safety assessment"
- „Experimental model testing – a basis for reliability assessment"
- „Design problems of contemporary car carriers"
- „Situation of Polish inland shipyards"
- „Exploitation decision-making taking into account ship safety in operation"
- „Decision-making by ship master to avoid a tropical cyclone".

Three of the meetings were hosted by the Maritime University of Szczecin, two – by Technical University of Gdańsk and one – by Technical University of Szczecin. Holding the meetings in different scientific centres and environment helps to integrate people and institutions dealing with marine technology.

In the last four years ZTM contributed also to organizing and running 7 scientific conferences, namely :

- III Conference on Ship and Ocean Technology – Development of shipboard machines and cargo handling technique
- XIX International Symposium on Ship Power Plants
- National Scientific Technical Conference EXPLO-DIESEL '98
- IV Conference on Ship and Ocean Technology – Port engineering and shipboard equipment
- XX Symposium on Ship Power Plants
- IV National Conference DIAG '98
- National Scientific Technical Conference EXPLO-SHIP '99.