THE METHODOLOGICAL PRINCIPLES OF THE DECK OFFICERS TRAINING AND MANAGEMENT OF THE TRAINING PROCESS

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Abstract. The navigator – the operator represents the most difficult dynamic system. The feedback control in this system is carried out on the basis of the information processing. This system consists of set of the subsystems which coordination for concrete activity prior to the beginning of training is expressed poorly. From the beginning of this process there is a streamlining of communications which originally were in the relative disorder, therefore trained (or skilled) navigators more correctly and with a smaller expense of energy carry out the functional duties. It is known that the quantity of the information which have been saved up in a control system as a result of its information interaction with environment, defines the level of the organization of the given system. In relation to the navigator it means that the information received him during training joins to already save up and influences on his future actions. Navigational simulators played and continue to play a special role on the deck officers training. Efficiency of application of the simulator in a greater degree depends on accurately formulated goals and the training implementation, definition of objectives and programs of trainings, application of the modern techniques developed with the account psycho-pedagogical principles of training, and also use of an effective quality monitoring and estimation of activity of navigators during the education and training. Research of these aspects of the navigational simulator training is the purpose of given articles.

1. THE TRAINING GOALS AND OBJECTIVES

In the most general case the main objective of training is to provide the required professional standards: so that the level of the training should be in compliance with the following:

- It should be adequate to the requirements of the system as a whole;
- It should be defined either quantitatively or by means of exports.

In the determination of the training purposes the initial knowledge and skills of the trainees should be considered, and they are to be informed concerning this which is a necessary condition of the active relation of the trainee to the material.

Thus, an ultimate goal of simulator training of navigation is the mastering the professional knowledge, skills and the abilities providing a reliable qualitative and effective navigation in the constrained condition.

The training course content should be based under problems corresponding to the basic components of the navigating activity while sailing in constrained waters. The problems should be in compliance with the requirements of the international documents, in particular, to the International Convention on Standards of Training, Certification and Watchkeeping 78/95.

However the training process content is determined not only due to the content of ship navigating activity. It should be in compliance with the pedagogical principles: accessibility, gradualness, sequence, a systematic character of training, maintenance of unity of training and education; construction of educational process on the bases of conscious and active participation of trainees; the account of specific features of those trained; monitoring and estimation of durability of mastering the material. This

principles are realized on the bases of the account of psychological laws of attention, perception, memory, imagination and thinking.

Training of navigators requires inclusion in the training process of the questions which would form not only knowledge of the process of ship navigating but also influence of these processes of the "human factor". Besides, training of navigators should include both the moods of operation in normal conditions and also in critical extreme situations.

2. BASIS OF TRAINING TECHNIQUE

Under training methods we understand the ways of realization of educational activity with navigators and ways of management of this activity carried out by instructors.

The methods concertised according to problems, the content, means and conditions of training are called techniques of training which should provide:

- Necessary level of motivation;
- Basic distribution of a complex of problems in time;
- The maintenance of conditions;
- For positive carrying over of skills;
- Conditions of intelligent mastering of presented material;
- Timely giving of the information to the trainee about quality of his work.

The basic methods of training of a navigator on a simulator are: lectures which help the trainees to assimilate the information which is subject to mastering, including the information of the problem, the purpose, the content and the way of performance; teaching material demonstration exercise, i.e. independent repetition of an educational problem on the operated model of the vessel. Generally specified the three methods are used in the course of training in this or that combination. The explanation can be accompanied with the visual demonstration; the demonstration can precede or accompany the explanation; exercise can be combined with additional explanation.

Connection of the methodical side of training with problems, the content and the training program is understood by the following. Tactically the choice of problems and the content of education action, determination of their sequence and the training program as the whole already to a certain extent determines the precondition for the choice of methods of training. Their final choice and the further concretization is carried out according to the character of the existing or practically available means of training psycho-pedagogical principles and the practical experience of their use, the required and initial level of competence of navigators and qualification of the instructors.

The basis of the process of formation of skills of regular repetition of educational problems which differs from simple repetition in the following:

- Aspiration of the navigator to raise quality of carried out activity;
- Self-checking of the navigator and the use of the results achieved at the previous stages;
- Increase of complexity depending on results of mustering the material;
- Exercise distribution in time.

It is necessary to note that even in the presence of perfect programs techniques and the tutorials the necessary level of training is not achieved if the instructors do not possess corresponding special both pedagogical qualification and necessary pedagogical qualities. Therefore the personality of the instructor is the key figure of the training center.

3. THE BASIC REQUIREMENTS AND INDICATORS OF ACCURACY OF NAVIGATION IN CONGESTIVE WATERS

For sailing in congestive waters the basic solution is the visual – comparative or the pilot method of navigation which consists in conducting of a vessel by means of the continuous monitoring of the sizes of linear and angular evasion from the route. This information possessed by the navigator becomes the managing one, however because of a considerable inertness of a heavy- tonnage vessel, to operating actions occurs with a big time delay. Presence of external casual disturbances, absence of methods of the exact forecast of movement of a vessel under the influence of operating actions creates a mismatch of actual and required trajectories. This mismatch is found out by means of the navigating equipment providing conductive of a vessel and by the received estimation navigator chooses the correct maneuver. Thus, a vessel, moving on the set mood makes fluctuation concerning it, and oscillative motion parameters depend of the navigation error.

The navigation error should be divided into two components – the error of navigation and the management error. When sailing in congestive waters navigation errors basically are determined by tool and the methodical errors of the systems providing navigation. Management errors are principal in size and are determined by external disturbances, dynamic characteristics of the vessel and characteristics of the navigator as a link in a control system. In unsteady modes of the sailing of a vessel there are additional dynamic errors of transients which can considerably exceed the management error.

For full estimation of accuracy of control of a vessel on the set route it is necessary to establish the degree of coincidence of an actual and a required trajectory.

On Fig. 1 and 2 realizations of trajectories of movement of the vessel in the identical conditions executed by one navigator are shown. From drawings it is clear that in both trajectories the maximum lateral evasion is identical. However in the second case β and K are much less when similar values in the first case. Smaller values of β and K in the second case proves that conducting was carried out more precisely than in the first one. The number of correction in the first case makes three and in the second it is one less.

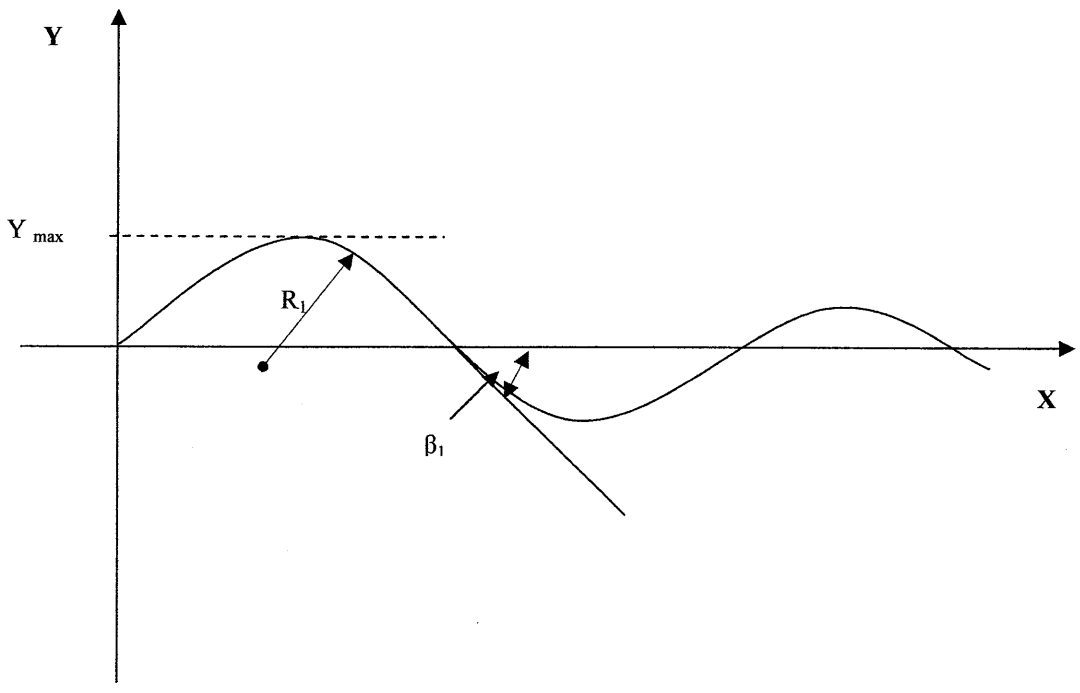

Fig. 1

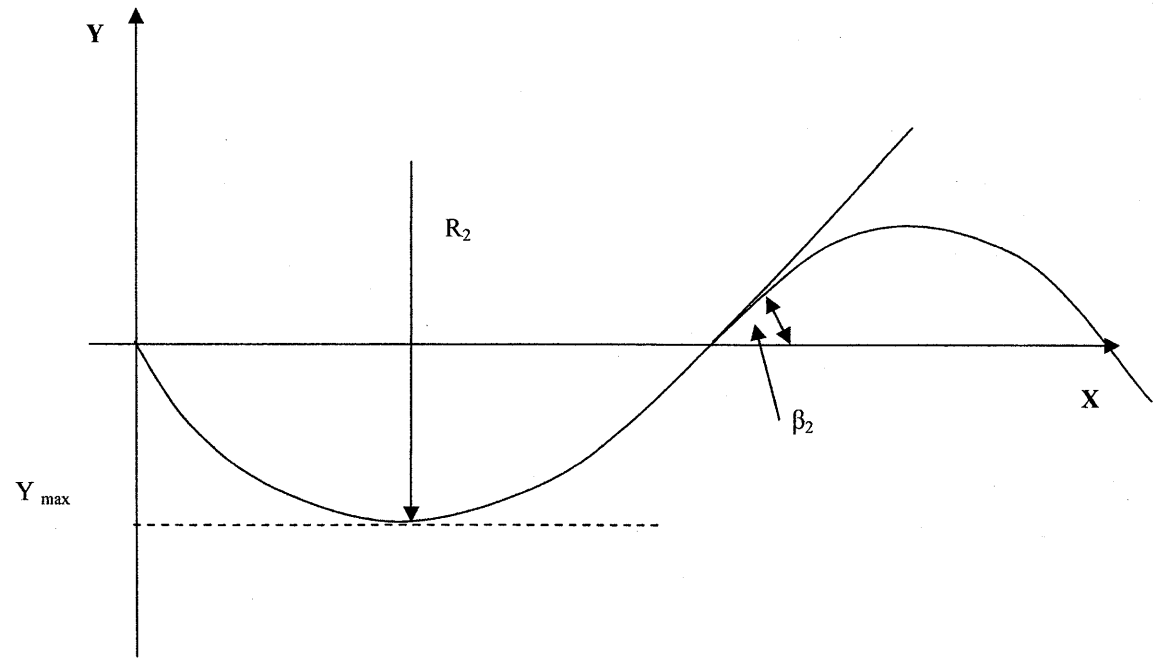

Fig. 2

The technique of the data processing, received on the separate trajectory, allows to estimate quality of work of the navigator – the basic link in the ergonomic system "vessel-navigator". Trajectory indication allows us to find the reasons of supposed errors of management and to find ways of their elimination and prevention. On the basis of trajectory indications the system of estimation of work of navigators which serves as the important means in the practical system of training of navigators is developed.

The final stage of the process of movement of the vessel is the mooring operation.

At the first stage of mooring the vessel of the quay on a trajectory as much as possible removed from navigating dangers and port constructions. Of all the line of movement the necessary zone of navigating safety is accepted. The first stage comes to an end with the vessel turn to the necessary side and progress clearing.

The second stage of mooring has an ultimate goal of direct rapprochement of the vessel with the quay. The distance to the object which with good reason it is possible to consider as a navigating danger for the vessel is purposely reduce. At mooring the contact of the vessel with the quay which is considered bump (heap) absolutely necessary. This difficult operation contains notorious risk because if the energy of bump would exceed the admissible value, the vessel and/or quay damages were resulted.

The complicated movement during this bump (heap) can be presented as the vector of speed of the center of mass V (or its components V_x and V_y) and angular speed of rotation of vessel ω .

For a full estimation of quality of mooring it is necessary to receive the following parameters:

- $\eta = E/E_n$ – relative energy of bump (heap) (the relation of actual energy of bump (heap) to the admissible one);
- φ – the angle between the middle-line plane of the vessel and the quay at the moment of bump(heap) or the vessel stop at giving of the mooring ropes (should be not more than five degrees);

V – the vector of the forward speed of movement of the center of mass of a vessel (or its component V_x и V_y);

ω – angular speed of rotation of the vessel at the moment of contact.

As the estimation of the activity of a navigator in a control system it is necessary to consider "working mood" which can be of three kinds:

- Faultlessness, when the basic motive of behavior is the inadmissibility of any errors, the accuracy and the performance time are of minor importance;
- Accuracy, when the basic motive is the required level of accuracy, faultlessness and performance time are of minor importance;
- Rapidity, when the basic motive of behavior is the performance of the work in the possibly shortest time, the faultlessness and the accuracy are of minor importance.

The mixed working mood, faultlessness and accuracy dominate in the shiphandling.

4. THE OBJECTIVE CONTROL OF ACCURACY OF NAVIGATION

Training of navigators is affected on specially equipped ranges. The ranges are equipped with navigational measuring instruments with which the model movement is made and the trajectory managements are effected. The schemes of the above ranges for the performance of the problems conditionally termed as "Movement on a Waterway", "Turn" and "Mooring" are presented on Fig. 3, 4, 5.

The location of the navigational marks and measuring equipment as well as the system of coordinates accepted for the processing of supervision results are presented on the schemes. Processing of results of the trajectory management for the purpose of subsequent analyses of activity of the navigator is made on PC by means of algorithm developed with the references of the fulfilled problems.

The problems "Movement on a Waterway" and "Turn" consist in vessel conducting on the set route and its deduction in the established lane wherefore the basic indicators of quality of performance of these problems are sizes of lateral deviation of the extremities of a vessel from the set route. By the sizes of lateral deviation it is easy to determine all the other indications characterizing of the reliability of conductive of the vessel and the degree of coincidence of set and actual trajectories.

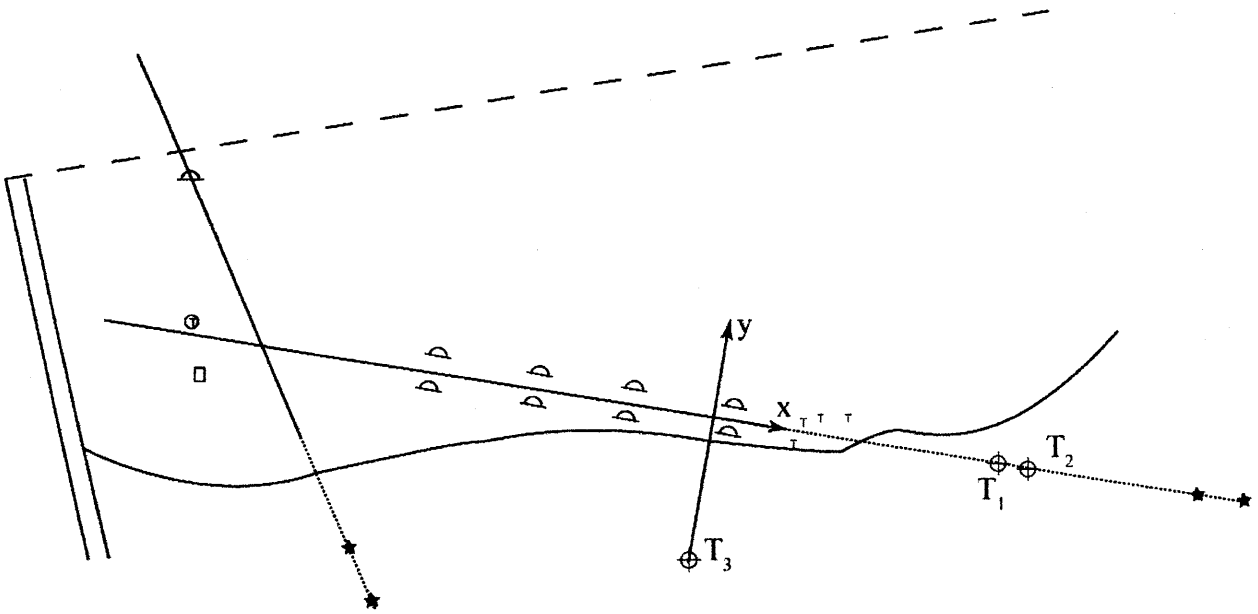

Fig. 3

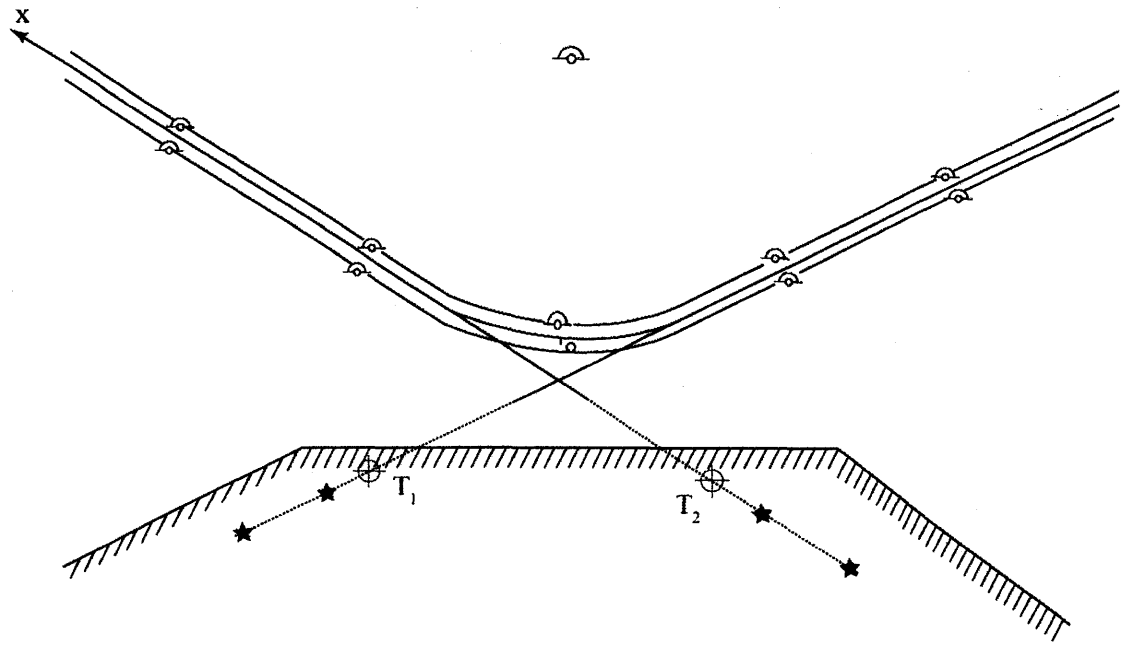

Fig. 4

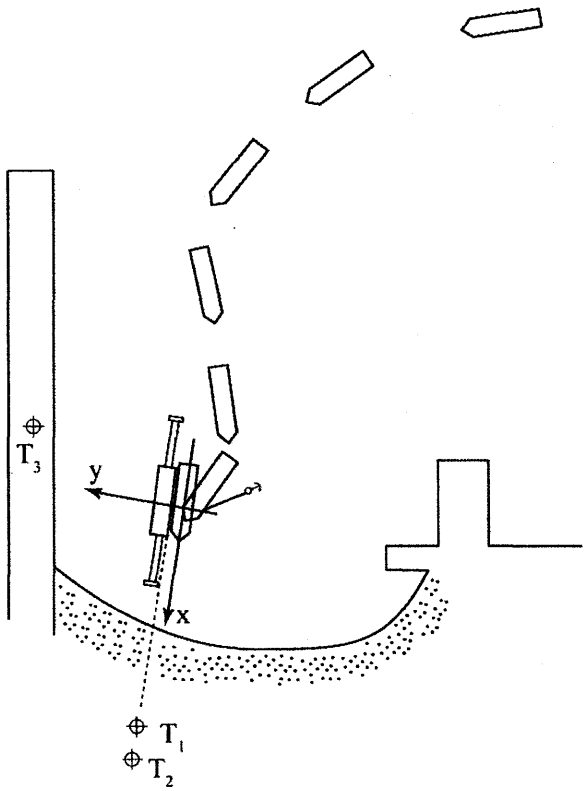

Fig. 5

The problems "Movement on a Waterway" and "Turn" consist in vessel conducting on the set route and its deduction in the established lane wherefore the basic indicators of quality of performance of these problems are sizes of lateral deviation of the extremities of a vessel from the set route. By the sizes of lateral deviation it is easy to determine all the other indications characterizing of the reliability of conductive of the vessel and the degree of coincidence of set and actual trajectories.

By the following values are calculated by means of the measurement results; the waterway excess; coordinates of the center of mess of the vessel; lateral deviation of its extremities from the conducting excess.

When effecting the problem "Turn" the vessel movement is supervised by measurements of the course angle of the motionless buoy φ located in the center of curvature of a rotary part of the set route and two set angels.

For the estimation of activity of the navigator when solving the problem "Mooring" it is necessary to determine model trajectory characteristics (φ, X_g, Y_g, Y_n, Y_k),, angular and linear speeds of its movement (ω , V_{xg}, V_{yg}, V_{yn}, V_{yk}), and also, in case of contact to a berth, the relation of actual energy of bump(heap) E to standard for the given vessel and berth E_n.

The characteristics of the position of model (φ, X_g, Y_g, Y_n, Y_k) are calculated by means of formulae: X in this case is directed in parallel to the berth and is departed from it on the size of the sum of the semiwidth of the vessel and the thickness of the fenders and the axis Y is perpendicular to the berth through the middle of its technological platform as it is shown in Fig. 5. Speed parameter of the model movement is calculated by means of to consecutive values of corresponding coordinates. Also, the energy of ship bump (heap) on the berth are calculated in a similar way.

5. CONTROL OF THE LEVEL OF TRAINING OF THE LEARNING EFFICIENCY

In conformity with the works /6 – 9/ the process of practical training is reduced to consecutive presentation to the navigator of the problems, the repeated solution of which leads to the occurrence of the corresponding skills in the dosed acting on the controls. It is possible to present process of practical training in the form of the curves shown on figure 6. where *n* is the number of cycles of presentation to the navigator of the problems which are subject to solution; W(n) – criterion function of management or a curve of change of a local trainability measure of a navigator; σ(n) - is a curve of change of an average quadratic deviation of criterion function of steering the vessel in the course of skill formation.

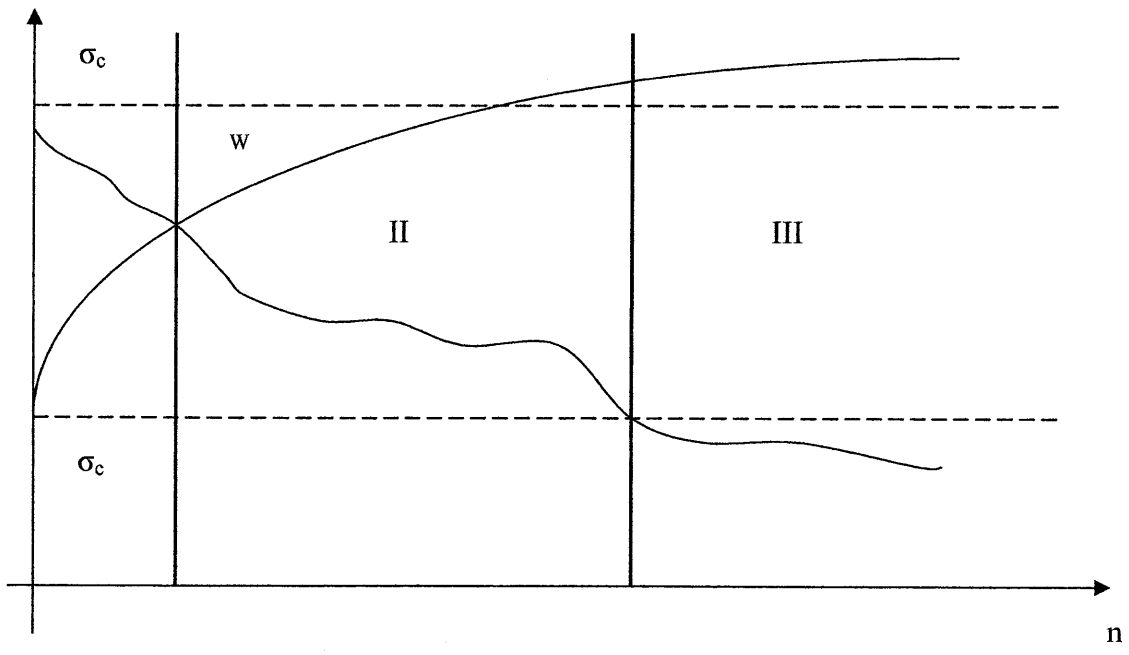

Fig. 6

Fig. 6 shows the initial stage of the habituation of the navigator to the peculiarities of steering the vessel on which his structure of activity is formed.

Stage II is the process of formation of skills in which limits the trained navigator knows the program of the task performance, but his actions are still in sufficient exact and timely.

Stage III is the process of statistically stable level of the skills which has arisen in the course of training. It is evident that for formation of steady skill at stage three it is necessary to provide some stock of additional cycles of training.

As the rule acquisition of skills occurs much faster than their forgetting. Besides, eventually (with each subsequent cycle of training the acquisition of skills is carried out with greater ease, and their forgetting goes more and more slowly.

Well organized program of training should provide stages on which the trainee would receive the data of his performance and the information of his progress. At the final stage his should receive data on the general level of training and also on his weak sides in order to pay a special attention to the farther practical activity. Thus the evaluation becomes a part of the system of training and cooperate both with it and with training problems. Therefore with the reference to the problems of navigation the evaluation should be carried out on the basis of the objective criteria, characterizing accuracy, reliability and the speed of activity that finally determines probability of performance of the problem put before the navigator.

With reference to the problem considered above "Movement on a Waterway", "Turn", "Mooring" the ten points system of estimation of the activity of the navigator, characterizing first of all the quality or accuracy of performance of the problems is developed. The estimation is made on two stages on the basis of two criteria with different priority. The criterion with higher priority allows to state the approximately estimation reflecting the most important result for the problem. The additional criteria is intended for specification of the estimation taking into the account the most essential factors from the point of view of the problem being solved.

While steering a vessel the basic indicator of complexity according to all above, may be the quantity of the operated co-ordinates. For example, when steering the course on the compass the common law of work of the operator (or an automatic regulator) is.

$$\varepsilon_c = - K_\omega \omega - K_\Psi (\Psi - \Psi_z) - K_\alpha \alpha,$$

where ε_c – a signal of mismatch of the set and the actual courses;

α – angle of a return of a wheel;

ω – the angular vessel speed;

$K_\omega, K_\Psi, K_\alpha$ – regulation factors.

When steering a vessel by means of autopilot regulation factors are fixed. The operator operating the vessel purposely changes them in a wide range.

Thus steering a course is carried out on two coordinates.

Let's agree to define the complexity of the problem in 3-point system depending on the number of operated coordinates : "one" is a simple problem which contains less than three coordinates, "two" is an average complexity program containing from four to five coordinates and "three" is a complicated program containing more than five operating coordinates.

For example, when sailing by a waterway or a channel equipped with the system of leading marks and buoys, the law of steering the system regulated on cross-section displacement is determined by expression.

$$\alpha = - K_\Psi \Psi - K_\omega \omega - K_Y Y - K_{\dot{Y}} \dot{Y},$$

where Y – is a lateral deviation of a vessel from the conducting axis;

$\dot{Y}$ – speed of lateral deviation.

Thus, steering the course should be regarded as simple problem, vessel conducting in the channel, carried out on four operated co-ordinates, belongs to problems of average complexity.

When a vessel moves in the constraint water aria to the mooring place both the operating coordinate and the control facility constantly vary. The navigator should consider and operate the following co-ordinate simultaneously: value of speed, longitude of the central of gravity, cross-section displacement of the bow and the stern of the vessel, the angular speed and the course. In this case the number of operated coordinates is more than five and the problem belongs to the category of the difficult ones.

A relatively easy problem is characterized estimated by 1 – 2 points, a problem of the raised difficulties – 3 – 5 points, a problem of limit difficulties – 6 points. Using tables 1 and 2 the estimation of difficulty above six points is possible in some cases which prove the impossibility solving such a problem at a high level at a stable manner.

Table 1

$\bar{B}_1$	Mark T	Marks' increasing											
		$\bar{r}$	ΔT_1	$\Delta\varphi,^\circ$	ΔT_2	$\bar{h}$	ΔT_3	Wind's Force	ΔT_4	Gale	ΔT_5	Currents	ΔT_6
≥ 6	1	≥10	0	≤ 30	0	› 1,2	0	≤ 4	0	≤ 4	0	≤ 0,5	0
4–6	2	5–10	+1	30–60	+1	≤ 1,2	+1	5-8	+1	4–5	+1	0,5–1,5	+1
2,5–4	3	‹ 5	+2	› 60	+2			› 8	+2	› 5	+2	› 1,5	+2

Table 2

$\bar{B}_1$	Mark T								
		$\bar{B}_2$	ΔT_1	$\bar{h}$	ΔT_2	Wind's Force	ΔT_3	Gale	ΔT_4
≥ 2	2	≥ 4	0	≥ 1,2	0	≤ 4	0	≤ 3	0
‹ 2	3	‹ 4	+1	‹ 1,2	+ 1	5–8	+1	4 – 5	+1
						› 8	+2	› 5	+2

Requirements of the system vessel-navigator-water area influence a separate problem establishing criteria (speed, accuracy, faultlessness) for its solution.

All the people suppose that there is "something" in the problem containing the answers to the questions how a navigator should be taught to enable him to solve properly any real problem. But what is that's

"something"? Where can it be observed in the solution of a problem? Where in a problem we can find the skills and the knowledge to be acquired in the process of its solution?

If the purpose of a training problem consists in training, it is possible to state the following: the person being trained who has made many errors and has corrected them has learned more than the one whose actions all the time were correct. On this ground it is possible to state that the estimations of skills and knowledge are expressed in the form of errors the information of which can be received on the basis on the objective control of accuracy of navigation and a faultlessness of operations.

Critics of simulator training assert that the big realism and fear of an error compels the trainees to use the usual cautious methods of steering a vessel which they have acquired earlier in the course of their previous practical work. In such conditions the acquisition of new skills of steering a ship proceeds slowly enough and often does not bring success. As a basic methodical precondition applied in the training centers the following thesis is put forward: training on a simulator gives much more then the acquisition of skills. It is possible to consider that it is an acquisition of an additional experience on the bases of already existing one. Therefore the training process should be based on the application of complicated and difficult problems and create still greater attention, than the experience of navigation allow.

The similar technique is applied for training of operators of control systems of the movement of air transport. The results of the work of the operators trained in the conditions of constantly high load were better than those of the operators trained in the conditions of constantly raising load.

The training main objective is to provide a required professional standard. Thus, the unequivocal formulation of the purposes of training is impossible without allocation of those abilities which the navigator should acquire in the course of training. Selection of these abilities is made taking into account standard requirements to the navigator and those concrete conditions of sailing he will face in the course of practical activities. With reference to navigation in the constrained conditions it is necessary for the purposes of training to single out three levels of abilities which are connected with three types of problems:

- Training to concepts, that is mastering of essence of the physical phenomena of the inter action of a vessel with the environment and control of a vessel in the constrained conditions.
- Training psychomotor skills of the control process of a vessel, working out of a fast and economic way of operative thinking and decision making.
- Training the solution of problems working out of a predictive way of thinking, ability to use the acquired skills in new conditions.

The first level of problems of training is the training of the concepts and principles should be academic, based on the modern level of our knowledge of process of movement of a vessel and its interaction with the environment.

Unlike training of concepts and principles which basically never comes to the end i.e. their full and definite understanding is never achieved, it is possible to present psychomotor skills as the possession of the final optimal level of mastering. It does not mean that the perfect possession is achieved by all the trained ones, simply it is possible to analyze actions and the description of types of reactions optimal for realization of activity by means of algorithmic methods.

Algorithmic procedures of the management are represented by a sample of legibility and clearness. Determinacy and the productivity peculiar to them regulate reception of unequivocal results at the identical initial data. If a person in everyday life could use only similar procedures of the solution of problems, his behavior could be completely predictable. However it is known that any systems in which "elements" are people will be necessarily not reflexible. Different navigators differently react on external influences. A navigator processing the navigator information makes a decision resultative from

compromise, adaptation of his own interests, objectively inherent or the way he understands them, to the peculiarities of the environment and external influences included. Therefore the algorithmic procedures in steering a vessel do not meet determinacy requirements. That is what we name (fuzzy) algorithm in which the system of instruction sets some procedure with a certain sequence of steps, some of which are unequivocal and others are understood not uniquely.

Psychomotor skills are realized in the exercises made up on the basis of quasialgorithms, i.e. on the purposeful and multiple repeated actions for their improvement.

On the basis of concepts (knowledge of the physical basis of control) and skills the ability of the navigator is formed to solve problems, this ability is shown by the solution of non-standard (heuristic) problems and offers a good orientation of the navigator in new conditions and acts not a simple repetition of the last experience And includes not only simple repetition of the last experience bur includes a creating element. The ability and skills develop in indissoluble unity. On the one hand mastering the circle of skills is necessary for formation of abilities on the other one a navigator possessing certain abilities can master new skills /6 – 8/.

CONCLUSION

The necessary condition of any training and learning process is the interrelation between the instructor and trained navigator. Creation of steady skills depends to a great deal on the ability of the instructor to consolidate the learning process of navigators to motivate them and to create the positive relation to new cognition. It is obvious that any training occurs in the conditions of some motivation but an optimum level of motivation type exists for each individual. It is possible to tell that at two strong motivation results in passion and an error consequence is despair so, eventually, the individual comes back to habitual comfortable behavior and ceases to study. The standard complaint of the navigators attending the courses is well-known: too much material, not enough time to assimilate it and in general all of it is of purely academic interest.

The most effective way of teaching is creation of emotional positive atmosphere in interrelations between the instructor and the navigator based on respect of human dignity of each other. In other words the instructor should not only teach but also cause the pleasure from training. Hands the ability of the instructor is to provide a reinforcement which is one of the decisive stages of training.

The reinforcement theory is based on the understanding that the uneasiness generated by the thread of punishment hampers the cognitive ability and the reinforcement of correct action not only strengthens the performance of actions but also creates favorable conditions for the father training: the success generates success, failure conducts to failure.

In a big number of groups the instructor can not support each correct step of the trainees. Usually he uses the group for an indirect reinforcement of individual actions. For example, discussion of correct result of any fragment of studies naming those who has successfully coped with the problem "steering". However in this case the praise of the correct action is perceived by the others as the censure of incorrect actions. This eternal dilemma of training of a big group can only be resolved by reduction of number of those trained to that limit at which the individual training can be provided.

An integral part of any system of training is the control and estimation of the results of teaching and learning. The estimation of the level of training of a navigator should be based on the analysis of the parameters defining the exact temporal and reliability indicators of his activity and characterizing finally probability of the performance by him of the task in view. The estimation of each trained should depend on the success level of performance of the tasks by all group from a degree of achievement of the programmed purposes of training by them. Estimations at all stages of training specify the optimum ways of transition from one stage of training to the other, up to its end. It is necessary to underline that

estimations should concern not only the actions of those trained but also the activity of the instructor: the feedback allowing to improve the activity which is necessary for it.

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