A general concept of design procedure for floating docks regarding their reliability, safety and ecological aspects

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ABSTRACT

In this paper is presented a concept of design procedure, and problems resulting from it, for floating docks with a view of taking into account their reliability and operational safety. It has been stressed that such design procedure is necessary for ensuring the docks appropriate pro-ecological features. It has been also shown that the design procedure should have several stages. The following kinds of design stages have been proposed to be accounted for : offer (canvassing) design, contract (ordered) design, concept (study) design, preliminary design, technical (classification) design and working design as well as the stage of elaboration of technical operational (delivery-acceptance) documentation. Knowledge areas necessary for such design procedure have been indicated. Attention has been also drawn to the necessity of accounting for, in designing the floating docks, diagnostic systems suitable to aid operational decision making .

Keywords : safety, floating dock, reliability, design procedure

INTRODUCTION

Every floating dock should be so designed as to ensure its use with the profitability as great as possible in given conditions and not causing any contamination of port waters during docking operations associated with building new ships or repair works on existing ships [6, 7, 11].

One of the crucial problems in designing the floating dock is to reach its required reliability, especially of its energy systems, because mainly on these systems the dock's profitability, its pro-ecological features and operational safety, depends. A difficulty in realizing the postulate results from that the floating docks built on the basis of the same design form statistical sets of a small number of elements or even are singular and unique. Moreover an additional difficulty associated with forming their reliability is that they are technical systems of a long lifetime. Additionally, design offices do not render their surveillance over the docks in service. For this reason they have not in their disposal any relevant *data bases* necessary in design phase to estimate reliability indices demanded for particular structural units of floating docks. Also, there is a lack of probabilistic design methods to make it possible to build a floating dock for a given reliability [7, 8, 11, 12, 14].

Two approaches to design procedure of floating docks, accounting for reliability are possible [12] :

- design procedure consisting first in determining reliability indices of the devices intended to be installed in a given dock, and next in determining total reliability of the dock in question
- design procedure consisting first in assuming such total reliability of a given dock, which is available for technical and economical reasons, but not less than that demanded by its future user, and then in selecting such particular devices intended to be installed in the dock as to reach the demanded reliability.

Each of the design approaches first of all requires to describe a method for forming the reliability and safety of floating docks, next to determine reliability structures of their subsystems and systems and to perform an analysis and synthesis of reliability of the docks. The reliability problems should be undertaken in all design stages of floating docks in parallel with the problems associated with forming their energy merits [13].

DESIGN STAGES OF FLOATING DOCKS WITH ACCOUNTING FOR THEIR RELIABILITY AND SAFETY

Reliable and safe operation of floating docks makes it possible to use them in a pro-ecological way. To estimate reliability of a dock not always is possible. It results from that design methods used in the contemporary designing of floating docks are deterministic. Though their application makes it possible to elaborate the designs whose realization results in building the floating docks of reliability intuitively estimated to be high, but it does not allow for determining the reliability in the form of reliability indices. In this case the subjective probability serves as an estimate of dock's reliability. Such probability – though possible to be graded – has no numerical measure. However the reliability indices even such as logical or statistical probabilities, are necessary for rational planning and control of operational processes of the docks. Hence there is a need to elaborate the probabilistic methods for forming reliability of floating docks and to apply them in the phase of designing. [3, 9, 11, 12].

To this end the following theoretical tools should be applied : contemporary theory of reliability and safety of complex technical systems, probability calculus and mathematical statistics as well as theory of the devices (mainly heat engines and electrical machines) installed in the docks, and theory of stochastic processes, especially semi-Markovian ones [1, 2, 3, 4, 5, 6, 8, 11, 13]. And, technical diagnostics and results of failure analysis of devices of the docks similar to designed ones should be applied to elaborate sets of reliability states of designed floating docks [13]. Knowing the indices of operational reliability and safety of particular floating docks with accounting for diagnostics, one is able to make more rational operational decisions.

Requirements concerning reliability of floating docks or only their energy systems, as well as operational safety of the systems and whole dock should be submitted in writing by its

future user in the form of the design assumptions.

The design offices do not have in their disposal any selective data bases on failures of devices of floating docks and other important events occurred in their service. Hence they do not apply models and techniques aimed at forming reliability and operational safety. For such reasons the design procedure of floating docks should be multi-stage one. Like in ship power plant designing the following design stages could be distinguished in the case in question [11, 13] : offer (canvassing) design, contract (ordered) design, concept (study) design, preliminary design, technical(classification) design , working design, as well as the stage of elaboration of technical operational (delivery-acceptance) documentation. As a result of realization of the above specified design stages the respective design projects should be elaborated. Finally, its technical operational documentation would be delivered together with the dock.

In contemporary designing the first design stage resulting in an offer design, is especially important. **The offer design** is aimed at gaining interest of future buyers of the dock.

In such design, apart from design solutions of the systems intended for installing in the dock , should be contained reliable information on its durability, reliability and operational safety. From the design of the dock it must be clearly seen which its elements are novel as far as its construction , technology and design procedure is concerned. To demonstrate merits of a novel solution of a dock the following items should be included in the project [13] :

- general data on the dock such as type of the dock (autonomous or non-autonomous), its use (for building new ships, ship repair, shiprepair and new building), load carrying capacity, main dimensions (total length, internal and external breadths, depth, pontoon height, height of keelblocks, freeboard to the upper deck, freeboard to the pontoon deck), lifting time of a ship of a given mass, capacity of tanks for energy media (diesel and heavy fuel oils, lubricating oil, wash water, boiler water, cooling water) and waste liquids (bilge water, residuals from centrifugal separators and oil separators, sewage) etc.
- schematic general arrangement plan of the dock distinctly showing its crucial energy systems and pipe lines as well as reliability structures of its energy systems
- data on output of electric generating sets, kind and type of driving engines and generators of the sets
- technical specification of energy systems (kind, type, output and rotational speed of combustion engines and electric motors, output and capacity of compressors and main and drying water pumps, steaming rate and pressure of boilers, pulling power of capstans, hoisting capacity of dock cranes etc.)
- reliability description of devices, systems and the dock itself (reliability indices of devices, energy systems and dock such as : probability of correct work till the first failure, probability of correct work between successive failures, kind of risk function, expected value of correct work time and standard deviation, availability factors etc.)
- schematic diagrams and description of automation of the energy systems
- specification of kinds and values of operational parameters of energy media, e.g. maximum values of pressure and temperature of air in compressed air system, water for cooling the combustion engines, fuel and lubricating oils
- schematic diagrams and description of main and emergency systems of electric energy supply (output, voltage, current frequency).

In this project is especially important to propose a concept of operation of the dock in accordance with its intended use, that requires to show a model of control over its operational process with accounting for expected operational costs or expected incomes, i.e. profits at a given operational outlays. The concept should be supported by economical calculations demonstrating profitability of building and purchase of such a dock for its future user.

The offer design is useful not only during negotiations and next in elaborating the contract design with accounting for requests from the side of a body ordering the design, but also for preliminary justification of the need for elaborating a study design.

The contract design is the first stage of floating dock design procedure, during which concepts presented in the offer design as well as requirements of future buyers and users of the dock are taken into account.

The contract design is elaborated in compliance with designer's proposals included in the offer design as well as with the ordering body's decisions made on the basis of its operational strategy for technical systems.

In the contract design should be also contained suggestions if the successive design stage has to result in elaboration of the preliminary design, or to elaborate the concept (study) design first is more justified.

The concept design should be a continuation of the contract design. This design is an improved and detailed development of the contract design as well as elaboration of novel design solutions.

In the concept design stage should be realized the scientific research projects (planned in advance in the contract design phase) such as modelling, calculations, composition, analysis and synthesis of a few variants of design solutions of the designed floating dock, aimed at selection of an optimum solution satisfying the criteria vital for the dock's user. Therefore already in the initial part of the design should be presented the problems to be solved and research topics resulting from them in order to make it possible to assess the scope of the mentioned research projects and costs of their realization.

In this design stage special attention should be paid to operational reliability and safety and pro-ecological features of the designed dock by analyzing first of all : correctness of operation of energy systems of the dock, their durability, repairability, functionality, ergonomic features and lifetime. Next one should estimate quantitive reliability measures in order to make reliability analysis and synthesis of the systems, verification of the economically justified solutions and elaboration of data bases. In this stage, methods to improve reliability during designing, manufacturing and operating the floating docks, should be proposed. Also, cost of application of the methods should be estimated.

Choice and effectiveness of application of the methods for improving the reliability of particular systems of the docks depend on :

- degree of recognition of physical processes leading to failures
- possibility to remove failures occurred in the dock's life time
- possibility to predict occurrence of failures and to counteract them by removing causes of their occurrence.

The study design should be of a breakthough importance for designing any type of docks. From operational practice of various technical objects it results that the initial designing phase has

a main impact for ensuring an appropriate level of durability, reliability, serviceability, operational safety etc. As the course of the designing phase is decisive of whether a study design would be ahead of a current technical level, or only keeping up with the level, hence the study design should be at least that ensuring to keep up with the current technical level.

The study (concept) design project, being a result of the considered designing stage, should contain proposals of possibly most up-to-date design solution of floating dock together with description of its technical operational merits (including those economical as well as concerning reliability, durability and safety with accounted for environmental protection demands). In the case if the assumed technical operational parameters are not achieved , a justification of this fact has to be presented together with conclusions about causes of that failure and suggestions on what should be done in further phases of design process, including also future modernization and even recycling of the dock.

In the concept (study) design a concept of operational process of the designed dock should be included. States of operation and maintenance are quantities of such process. The state of modernization can be distinguished out of the latter ones. Contemporary design process of the dock cannot be ended in the moment of elaboration of its technical operational documentation but must also include actions to initiate and support the process of disclosing the manufacturing errors (made during phases of designing and manufacturing the dock) and operational ones , as well as their analysis. From the analysis it should result whether the proposed design solutions do not force by chance the user to make errors leading to failures of the dock devices and systems. The modernization of the dock is necessary as it makes it possible to remove possible defects and design faults, and their causes in particular.

The preliminary design is a result of making the concept (study) design more exact. In the case when in designing the dock no novel solution is required the design stage is only a continuation of the design process with taking into account the contract design and the agreements made with the body ordering the dock.

In the preliminary design process manufacturing conditions and capabilities of a shipyard intending to build the dock should be taken into account after making a prior analysis of manufacturing capabilities of other shipyards also prepared for building such objects.

The preliminary design should contain precise arrangement of the dock systems and devices being elements of the systems. Also, complete technical operational characteristics of the devices intended to be installed in the dock, including those dealing with their reliability, safety and pro-ecological features, should be presented.

The final result of the preliminary design stage should be the design documentation including its most important element – the general arrangement plan of the dock together with its concise description and justification of the presented solutions.

The design should be verified by an independent group of experts and after obtaining their positive opinion – submitted to the ordering body to get its acceptance.

If the verifying procedure is finished the next stage of designing, i.e. the technical (classification) design stage may be commenced.

The technical (classification) design is a more exactly determined version of the preliminary design. It is crucial that results of the earlier planned empirical research realized within the study design stage are already known. In the stage in question design solutions of the dock energy systems and its other structural units should be finally and unambiguously determined. Also, classification schematic diagrams of all systems of the dock should be elaborated in compliance with the requirements of the classification societies. Draining plan of the dock is of special importance for ensuring the required stability of the dock.

The technical (classification) design should be approved by a relevant classification institution, e.g. Polish Register of Shipping. All amendments which could be introduced in the further designing phases must be agreed with surveyors of a classification society supervising the dock's design. After obtaining the classification society's approval for the technical design the last designing stage – the working designing can be commenced.

The working design is a result of the designing stage characteristic of that to elaborate the documentation deep knowledge of manufacturing processes and organization of an enterprise intending to build the dock in accordance with the elaborated technical (classification) design, is required. In the working design all reservations from the side of the classification society should be accounted for. In this phase all detail technical drawings of every element of the dock to be built in the builder workshops should be elaborated and its manufacturing processes described. Also, in the documentation all standard elements not subject to further processing, should be specified.

An important part of the working documentation are the assembly drawings showing the designed structures in the form of appropriate projections and cross-sections. On the drawings more important dimensions should be given , and each element should be specified by providing its gabarites, mass, used materials, symbol of a relevant standard etc.

In the documentation results of all energy tests performed to unambiguously confirm operational usefulness of the devices being elements of the dock's energy systems, should be also accounted for.

The working documentation should make it possible to build the dock with maintaining all its features provided for in the study design, and even better if they are in accordance with those established either in the offer design or contract one.

The technical operational documentation can be elaborated only after completion of the dock. It should contain information making it possible to use the dock rationally. The following items belong to it : principles and procedures of putting the dock's devices into operation, of their loading and stopping, carrying out maintenance , main repairs and those after failure. Information concerning reliability and operational safety is especially important.

The documentation should contain the assembling drawings as well as technical specification of the dock's power plant and other systems characteristic for particular types of docks. Also, reports containing results of delivery-acceptance tests and operational trials of energy systems of the dock should be included.

FINAL REMARKS AND CONCLUSIONS

- From the presented considerations it results that verification of reliability and safety indices should be carried out in all the described designing stages of docks.

- The necessity of verifying reliability and operational safety of floating docks as well as their pro-ecological features during elaboration of their technical operational documentation (delivery-acceptance one), cannot be excluded.
- During elaboration of the offer design reliability structures of all energy systems should be considered and the simplest ones applied. At this stage to estimate reliability and safety of docks accurately may be difficult due to the lack of sufficient amount of results of empirical investigations. However it would be possible to assess the reliability *from above and from below* practically for all devices of floating dock, as their risk functions are ascending , e.g. by applying the suitable formulae [13].
- The above mentioned formulae are of practical importance because they make it possible to assess reliability of the dock's systems if only expected values of their correct operation till failure are known. Therefore they enable to make operational decisions by applying the statistical decision theory if only consequences of the decisions are known. Also they make it possible to assess reliability of the whole dock .

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