Written Discussion on SNAME 99 paper

Dynamic Capsize Vulnerability: Reducing the Hidden Operational Risk
by
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This paper presents an interesting exposition of the dynamic types of ship capsize which could possibly occur if a ship was subjected to the effect of substantial environmental loads. The new aspect of this work is the promotion of systematic use of risk assessment techniques for a variety of naval ship applications. Besides training and operation, these include also design procedures and the development of new stability standards for intact naval ships which should replace the existing ones based on earlier work of Sarchin & Goldberg (1962). Fault trees addressing specific types of dynamic capsize have been identified. These could serve as the platform for subsequent quantification of the risks that are intrinsic to ship operation in certain environments and for the analysis of marine disasters. By combining simulations, information based on experience and risk assessment, this work aims to provide a rational basis, as well as a practical one, for solving the difficult problem of dynamic stability assessment and its impact on ship design. The authors should be commended for addressing this important and very complex subject and for opening the discussion about the directions of future research and the exploitation of the present state of the art.

The proposed methodology seems at this stage to be better suited for training, for developing an operational guidance and for the analysis of marine disasters, but to a lesser extent for design and stability standard development. In these last two areas much further work would be necessary before information in a usable, quantitative form is made available. Concerning standards development in particular, there could be no doubt that an effort to improve standards which, as the authors state in their conclusions, have succeeded the ultimate, i.e. no capsize since 1944, is an ambitious one. Logically, the objective cannot be to make the standards more stringent, but rather, to make them more rational. The only way to achieve this is by utilising the best available scientific knowledge about the various phenomena that play a role in a capsize occurrence. However, the works on which the authors have based their present analysis appear to constitute a very small fraction of the most recent activity in the field of ship stability. In addition, it appears essential to complement existing standards and to address the survivability of naval ships not only in intact but also in damage condition.

One of the types of ship capsize discussed to some length in the paper is broaching. The specific nonlinear phenomena which generate broaching behavior have been determined recently with a series of publications that appeared in one of the two journals published by this same Society [1-3]. In particular, a method was proposed for quantification of the risks of broaching and capsize, which can reveal the effect of design modifications as well as the effect of changes in the followed method of ship control. Large scale experimental efforts on the mechanisms of ship capsize in astern seas have taken place in Japan which have produced valuable insights and a proposed operational guidance based on polar plots [4-6]. A new perspective for the study of ship capsize in resonant waves has been provided with the emphasis set on transient large-amplitude dynamics [7, 8]. Parametric instability has been studied extensively in Japan and elsewhere [9]. It is self-evident that this new knowledge should constitute a valuable input for any effort to develop more rationally-based intact stability standards.

As far as damage stability is concerned, reference is made to the most recent work of IMO regarding the harmonisation of stability rules of merchant ships on the basis of the probabilistic approach and some preliminary work on the formulation of a rational design procedure for enhanced survivability of naval ships [10].

Finally, we would like to draw some attention on the following points of detail:

1. One cannot disregard the importance of a validated six-degrees of freedom numerical simulator which is an essential element of the presented analysis. However, the authors should pay attention to the fact that reliable indices of performance for multi-degree dynamical systems cannot be derived through a limited number of simulations. Because the initial conditions, design and environmental parameter values to be considered are so numerous that a vast number of simulations is necessary even for a minimum level of reliability. An extra problem is that, for the extreme ('abnormal') conditions usually considered in such studies, it is uncertain whether semi-empirical simulation tools can be used with confidence if no experimental data is available about the examined ship.

2. The authors have summarised the effort of Prof. Pawlowski to improve the stability standard of Sarchin & Goldberg with an ingenious, despite its semi-empirical nature, method of analysis. Closing their summary however, they conclude that the Sarchin & Goldberg criteria are inconsistent in their nature because they are lacking account of the physics and they cannot cope with different seaway conditions. Although this general conclusion may hold true, it cannot be derived from a comparison with another method developed on similar semi-empirical grounds.

3. It was stated in the paper that ships with high GM cannot suffer from parametric instability. However, what is essential here is the build-up of large rolling which depends on the degree of variation of GZ characteristics between a trough and a crest [11]. This is a rather wider issue. Moreover we think that, not only the principal but also the fundamental resonance could lead to capsize.

4. Stable surf-riding is possible to occur only when the middle of the ship is near to a trough Surf-riding near a crest is an unstable motion which cannot be realised in a physical sense; therefore it cannot be 'blamed' as the cause of a capsize. The truly dangerous for capsize type of motion is the so-called asymmetric large-amplitude surging, a peculiar oscillatory-type motion, where the ship is spending long time around the crest and passes very quickly from the trough.

5. The authors developed in great detail a fault tree analysis for the intact capsize of naval ships in extreme, abnormal sea conditions based on ADM Nimitz report of Feb. 13, 1945, regarding damages on USN ships that happened to be hit by a typhoon in the Pacific Ocean. Notwithstanding the importance of the above damage report, it is unclear to what extent the results of the presented fault tree analysis can be generalised and utilised for improved naval ship design and operation, except for the obvious conclusion, that a ship, of limited size and of specific operational characteristics, cannot be designed and should not operate in abnormal 'typhoon like' weather conditions. In any case, the authors rightly recommend proper training and operational guidance to the shipmasters for handling dangerous situations in extreme seas and for clearly identifying the limits of 'safe operation' for the ship they operate ('survival conditions'). This appears feasible by today's tools and practical experience.

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