**PROJECT**

**EROCAV**

Erosion of Ship Propellers and Rudders - the influence of Cavitation on Material Damages

**Funding:** European (5th RTD Framework Programme)

**Duration:** Jan 2001 - Dec 2003

**Status:** Complete with results

**Background & policy context:**

The shipping market shows a strong industrial need for merchant ships with very high efficiency combined with low levels of propeller induced noise and vibrations. The maximum power for single screw ships - which are dominating in the merchant fleet - has grown from 30 to more than 60 MW over the last two decades. In parallel the speed of the ships and therefore the loading on the propeller increased. The interaction of the propeller and the hull is a challenging problem mainly due to the inhomogeneous inflow to the propeller. Cavitation has a severe influence on noise and vibrations, as well as on the propeller performance. Cavitation in fluid flow can additionally cause erosion resulting in severe material damage with a number of negative consequences like damage to propellers (propulsors) which may end even in a total loss of propeller blades, excessive vibrations and loss of efficiency which will increase the impact of emissions on atmospheric pollution.

**Objectives:**

The main aim of the work is to develop a practical tool to assess the risk of erosion on ship propellers in an early design stage. New and improved methods to predict the occurrence of erosion on ship propellers need to be developed. This will lead to improved testing equipment and to new or improved methods for the design of ship propellers and rudders. Improved propeller designs from the erosion point of view will reduce the cost for repair and will lengthen the lifetime of the product propeller. This means that in various cases observations of erosive cavitation have to be made both at model and full scale in order to determine the criteria for erosiveness of cavitation. Prediction methods in model tests need to be defined as well as calculation methods for the assessing of the possibility of cavitation induced erosion.

**Methodology:**

The aims have been reached by extensive full scale and model investigations. Propellers and ships with rudders with severe damages were included in the test cases. Additionally theoretical methods to predict erosion were developed. The main tasks of the research were to:

- Develop the knowledge about the mechanism of cavitation induced erosion;
- Extend the existing method to predict erosion in full scale by modeling the involved mechanism;
- Develop improved experimental test procedures for the reliable prediction of cavitation induced erosion;
- Reproduce in model scale the eroded zones on the propeller blades and rudders observed in full scale;
- Develop a practical estimation procedure based on main propeller parameters; and
- Improve the design procedures for rudders and propellers.

**Related Projects:**

- EFFORT - European Fullscale Flow Research and Technology
LEADING EDGE - Prediction of Leading Edge and Tip Flow for the Design of quiete and efficient Screw Propellers

VIRTUE - The Virtual Tank Utility in Europe

Parent Programmes:
FP5-GROWTH KA3 - Land transport and marine technologies

Institute type: Public institution
Institute name: European Commission, Directorate-General for Research (DG Research)
Funding type: Public (EU)

Partners:

- Hamburgische Schiffbau-Versuchsanstalt GmbH (HSVA);
- Bassin d'Essais des Carenes (BASSIN);
- Chalmers University of Technology (CHALMERS);
- Germanischer Lloyd AG (GL);
- Ship Design and Research Centre (CTO);
- Wärtsilä Propulsion Netherlands BV (WPNL);
- Lloyd’s Register of Shipping (LLOYD’s);
- Maritime Research Institute Netherlands (MARIN);
- Mecklenburger Metallguss GmbH (MMG);
- SSPA Sweden AB (SSPA);
- Walleniusrederierna AB (WALLENIUS).

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Key Results:

One of the main outputs of the project is an extensive database on cases showing erosion damages. The existing databases of the partners have been checked, the main types for erosive cavitation on propellers have been localized as fluctuating sheet and vortex cavitation, cloudy tip vortices and irregular / unstable mid chord cavitation. Also collapsing cavitation, merging into foaming cavitation (small bubbles or clouds) are regarded as being erosive.

One of the aims of the consortium was to develop guidelines based on the results of the work performed and make them available to others. In these guidelines the accumulated knowledge was applied in a practical way and split into three main parts. The first part is related to the design stage before model test results are available, the second part deals with improvements on designs after model test results are available and the third part is related to improvements of existing hardware when damages have been found after some time of operation of the ship. In all three parts, the problems related to propellers and rudders are treated separately.

The full scale work has been carried out very successfully. The cooperation with the owners was very good. Instead of the planned three ships four ships have been investigated. The results available are a set of fully documented cavitation observations and erosion data. This is more or less unique. The results show a variety of mechanism causing erosion on propeller and rudder.
The work on the review and implementations of models concerning the mechanism of cavitation induced erosion covers more than what is traditionally meant by 'mechanism'. Examples of classical hydrodynamical mechanism are the formation of a micro jet at the collapse of a spherical cavity close to a solid body and the formation of a small group or cloud of sub-cavities.

It has been the aim of the research in EROCAV to start from these and look for more large scale mechanism related to erosion that create links between the small scale mechanism mentioned above and the behaviors observable in ordinary model tests to judge propeller and rudder designs. A conceptual model for the hydrodynamics of erosion is introduced and a handbook for observation and analysis of eroding cavitation was written.

Another main objective of the research work was to develop and improve erosion prediction methods based on model tests. Three different test techniques have been investigated in detail, the work went well for the paint test.

**Policy implications**

The EROCAV project showed that the research and development work, done by the European Commission, is helpful for the ship yards and shipowners. Mainly the owners were very much engaged. Through its workshops and open forums the EROCAV consortium succeeded in bringing together a wide range of scientific research units (like model basins, classification societies), ship yards and ship owners and propeller manufacturers. It must be stated that model experiments are and will continue to be the only reasonable way to make predictions, concerning the influence of cavitation on the occurrence of erosion. Besides the detailed observation of the cavitation phenomena, high speed video observation and paint tests are the most reliable tools at the moment. Unfortunately the paint test method up to now does not give reliable results for the prediction of cavitation induced rudder cavitation. Further research is needed to develop an adequate paint.

**Waterborne**

**Key Findings**

No results directly relevant to this theme. However, please note that some findings relevant to the project's key theme (Vehicle Technology) are generically applicable.

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**Policy Implications**

**STRIA Roadmaps:** Vehicle design and manufacturing  
Water transport (sea &

**Transport mode:** inland  
**Transport sectors:** Freight transport  
**Geo-spatial type:** Other