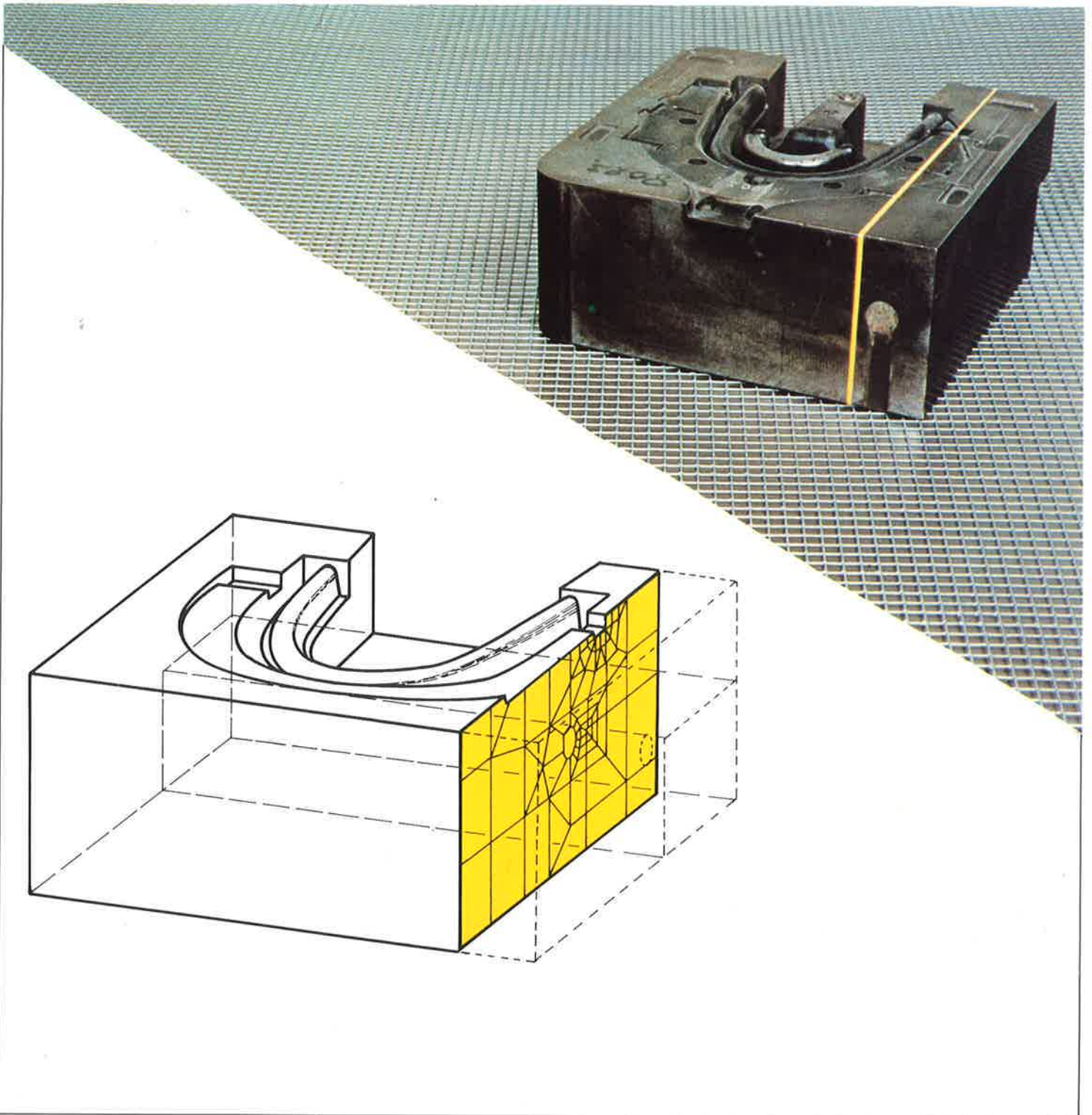


Structural Mechanics



Structural Mechanics

In recent years, theoretical stress, vibration and stability analysis have become increasingly important to come up to high demands regarding strength, stiffness and vibration.

Accordingly, the development and improvement of methods and procedures for carrying out such analyses are important activities of the institute.

Stress analyses for simple geometries can be carried out with analytical methods. However, when the geometry becomes more complex, as in ship structures, pressure-vessels etc., analytical methods are less attractive because over-simplification has to be applied and usually it is also more efficient to use numerical methods. The most important numerical method is the FINITE ELEMENT METHOD; a structure is then divided into a usually large number of finite elements. In this way, the problem reduces to solving a set of linear or non-linear equations with stresses and/or displacements as unknowns. For complex structures, this method leads to a large number of equations. These can only be solved efficiently by the modern digital computers.

The institute has the soft- and hardware for solving stress as well as vibration and stability problems. To determine the reliability of structures inelastic material behaviour, such as creep and/or plastic deformation, fracture analysis and statistical methods are included. During the last ten years many orders from both industry and public authorities have been carried out. They included the analysis of a wide variety of designs such as foundations, pumps, storage-tanks, pressure vessel components, ship structures – for example a complete container ship – propeller nozzle vibrations, cutter dredger vibration, heat conduction problems, collision analysis etc. Such analyses have been carried out using general purpose computer programmes like ASKA, NASTRAN and MARC soft-ware packages. In addition, special purpose computer programmes have been developed, for example, to investigate the added mass of structures vibrating in water and the CYPLAST programme for cyclic plasticity and creep problems and for crack growth evaluation for high temperature components.

Numerical methods are also used for the dynamics of rotating machinery, for pipe-laying in deep waters, for collision problems etc. Only recently, research has started on the use of modern numerical methods in Computer Aided Design as well as for life expectancy of new and existing structures.

About the Institute:

The institute belongs to the organization TNO, which is the Dutch abbreviation for applied scientific research. The institute has a staff of about 100 of which some 35 are qualified mechanical engineers and scientists.

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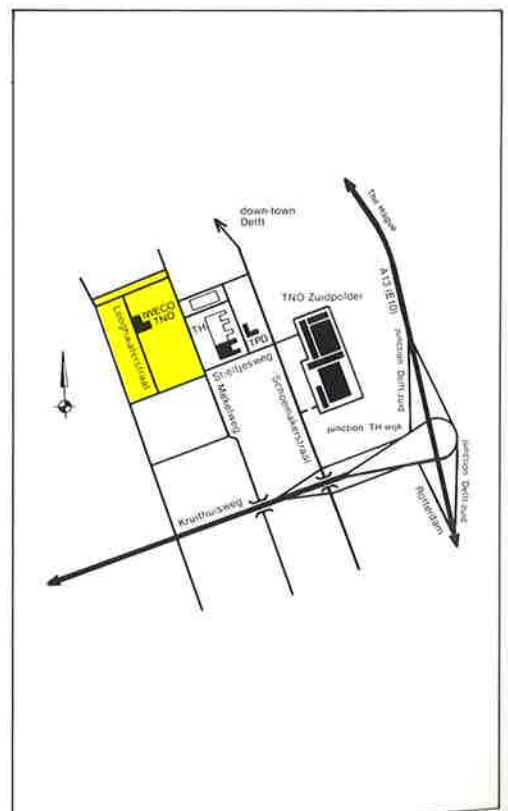
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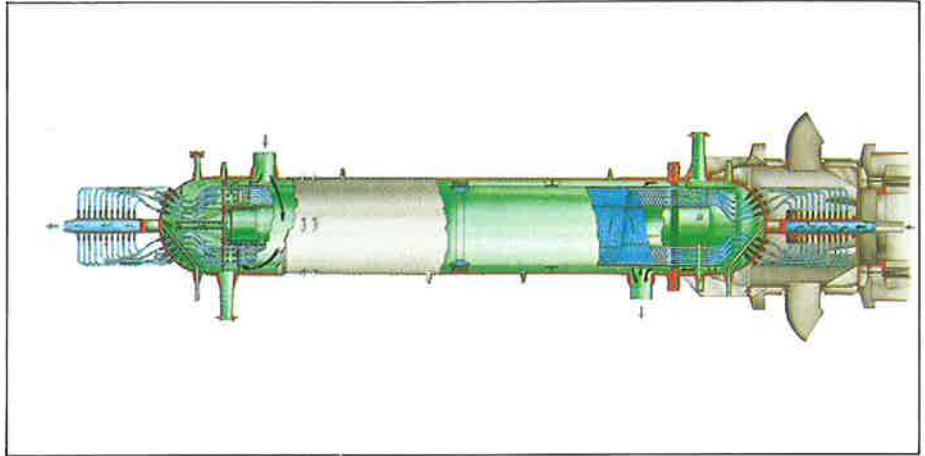
Enquiries on structural mechanics

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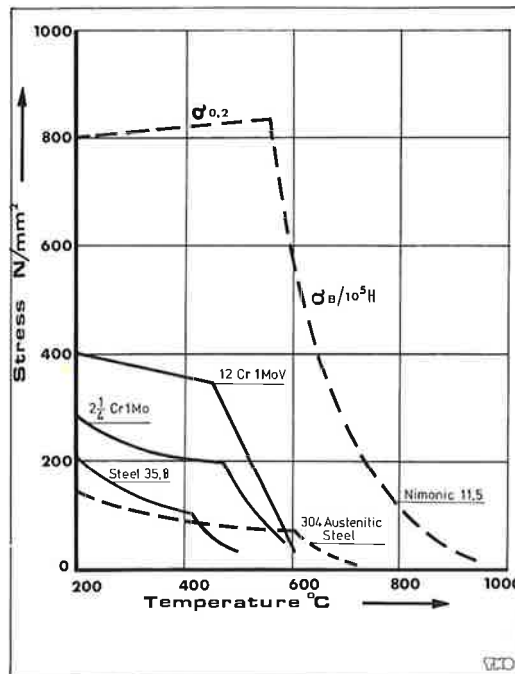


Inelastic Analysis

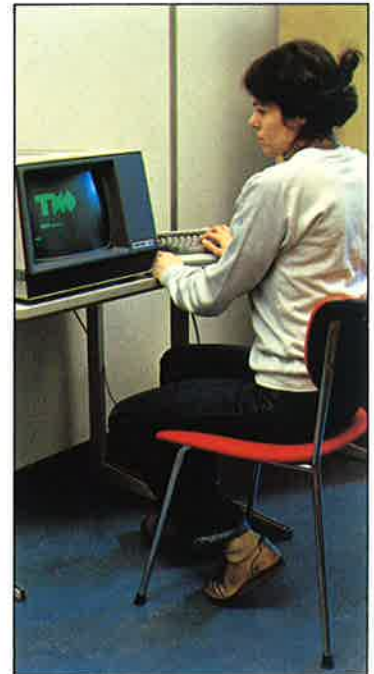
When designing high temperature components the influence of temperature on the yield strength and the increase of creep deformations pose a problem. The stress-level and the deformations in the structure are then not only determined by mechanical loads but also by thermal loads. And both of them are usually variable loads. By licensing authorities limits are set to these inelastic deformations. This is, of course, to ensure proper functioning and to prevent failure by plastic collapse, creep rupture, fatigue and the interaction of creep and fatigue. To tackle such problems accurate numerical models have been developed to describe the behaviour of the material under such circumstances; centred around the so-called OVERLAY MODEL. In addition, criteria for the assessment of the calculated inelastic deformation have been developed. This resulted in modified multi-axial criteria for low-cycle fatigue. A special purpose finite-element computer programme CYPLAST has been set-up, mainly for axi-symmetrical or two-dimensional problems. For any thermal or mechanical loading programme elastic-plastic or creep calculations can be carried out. The programme has already been applied several times to nuclear components and it is continuously refined. Finally, work is going on in the field of creep damage and fracture mechanics in full plastic and creep ranges. And finally the incorporation of probabilistic methods in the design in order to determine the structural reliability and/or safety of land and marine structures.



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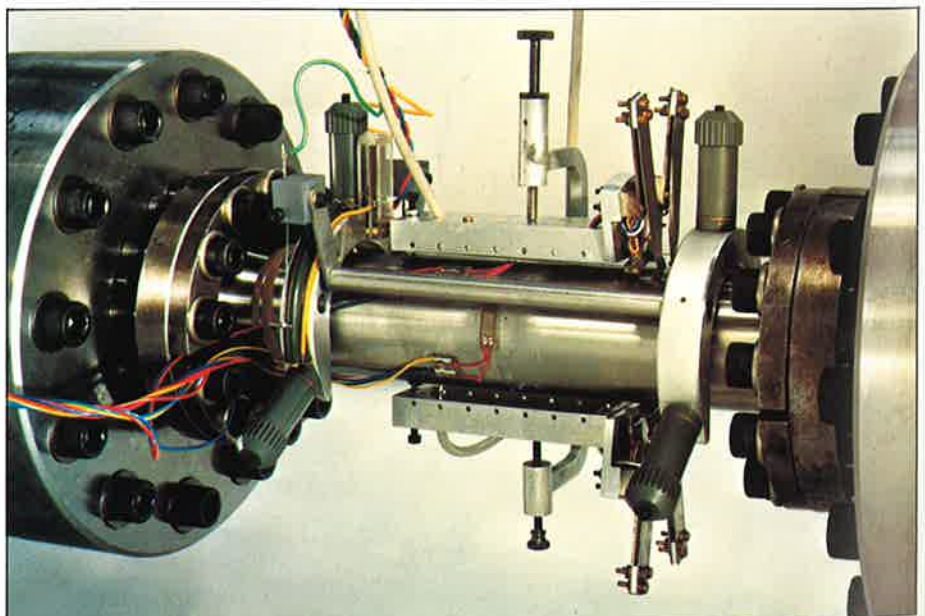


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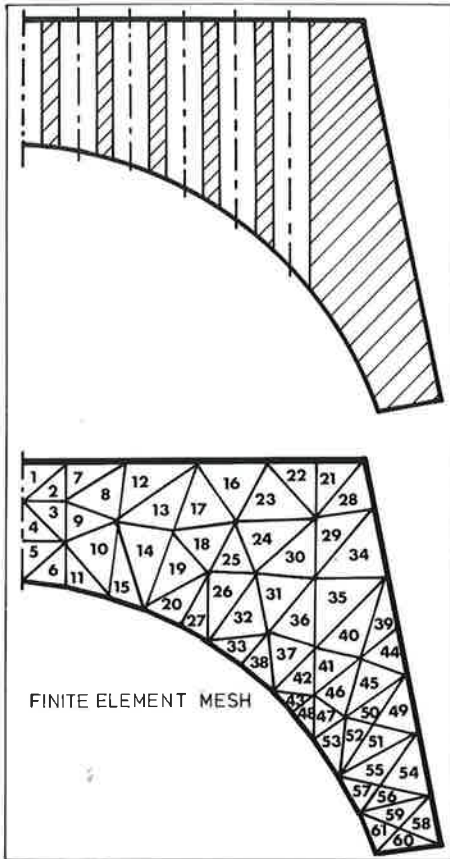


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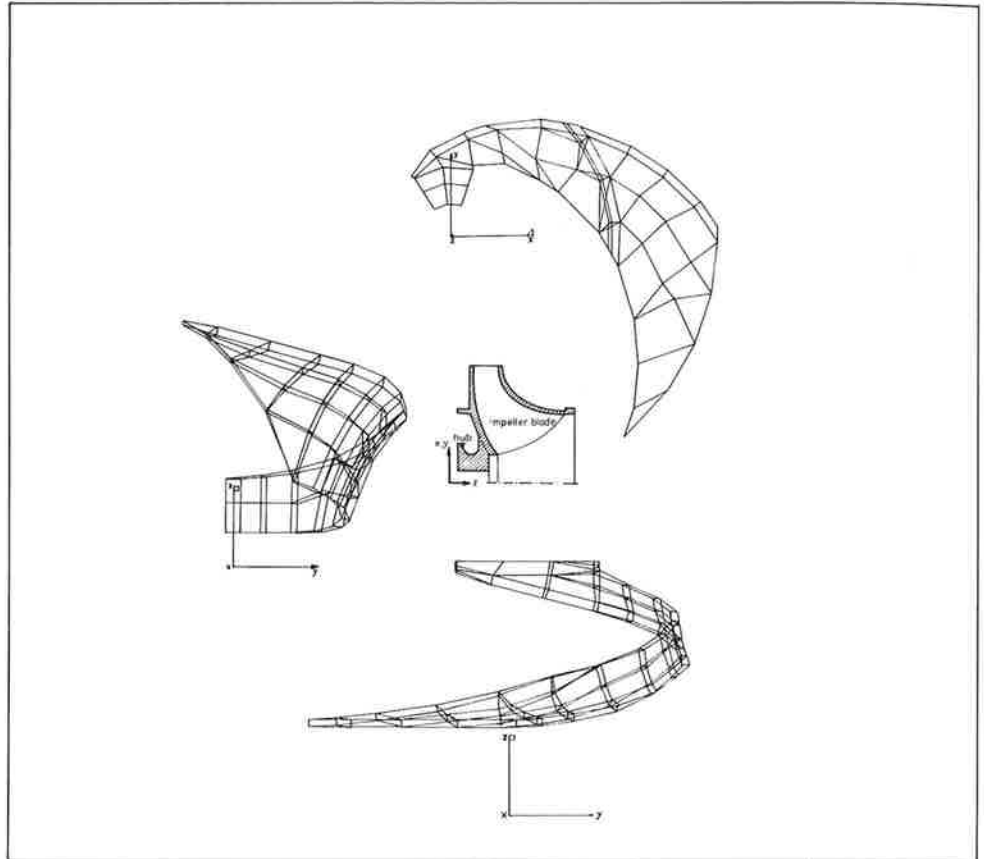
1. Evaporator for nuclear power system
2. Influence of temperature on material strength.
3. Preparations for finite element calculations.
4. Strain measurements at a biaxial plasticity test.
5. Inelastic analysis of tube-sheets and other parts of heat-exchangers.
6. High temperature stress analysis of the propeller of a sodium pump (part of structure and finite element model).
7. Crack growth tests for correlation with calculations.
8. Calculated plastic deformations around a crack tip.
9. Elastic-plastic analysis of a tubular low-cycle fatigue specimen.



4



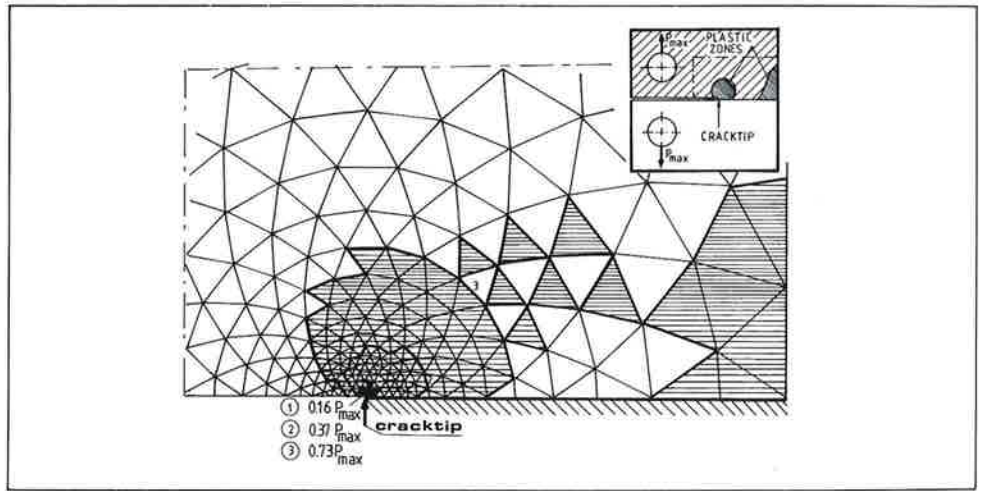
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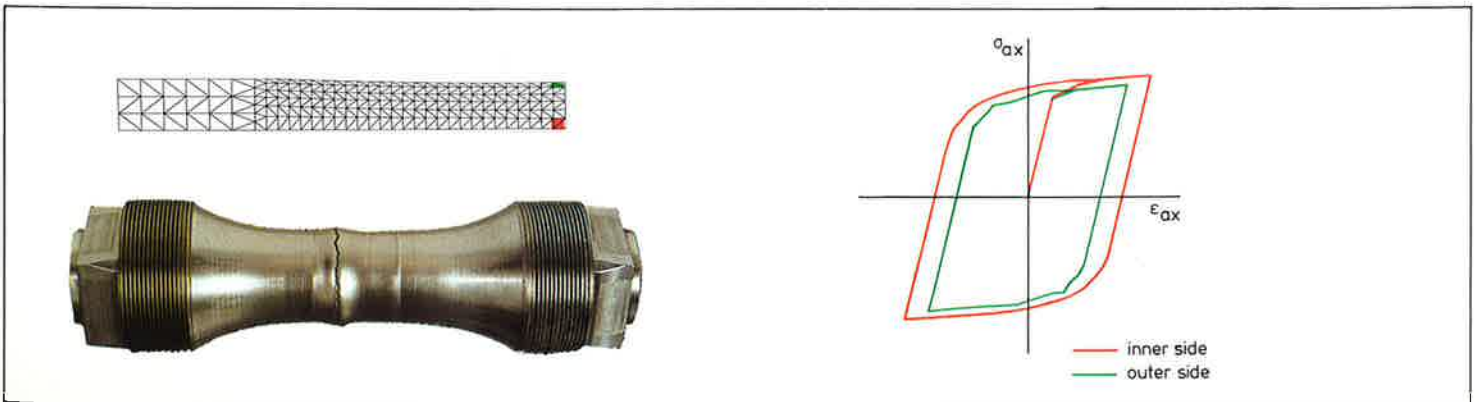
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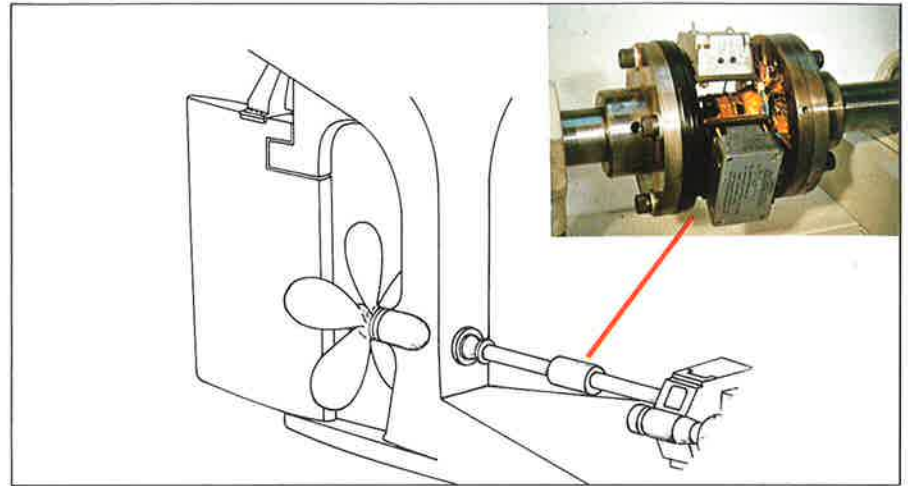
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Special problems

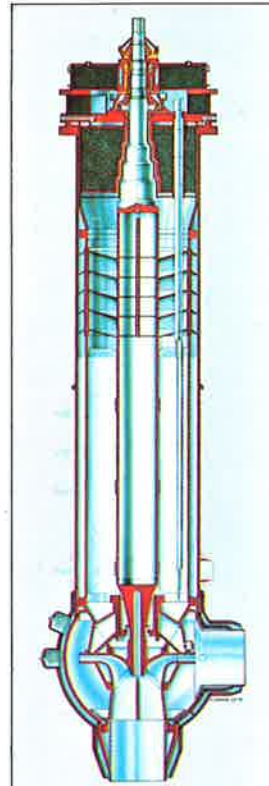
An important part of our work consists of orders from land and marine sectors of industry and public authorities. This concerns the analysis of widely different designs which very often pose practical problems. Part of this work concerns the unknown elastic-dynamic or buckling behaviour of structural components. In other cases there is a demand for the development or refinement of theoretical models or special purpose computer programmes.

Some of the activities in this field are:

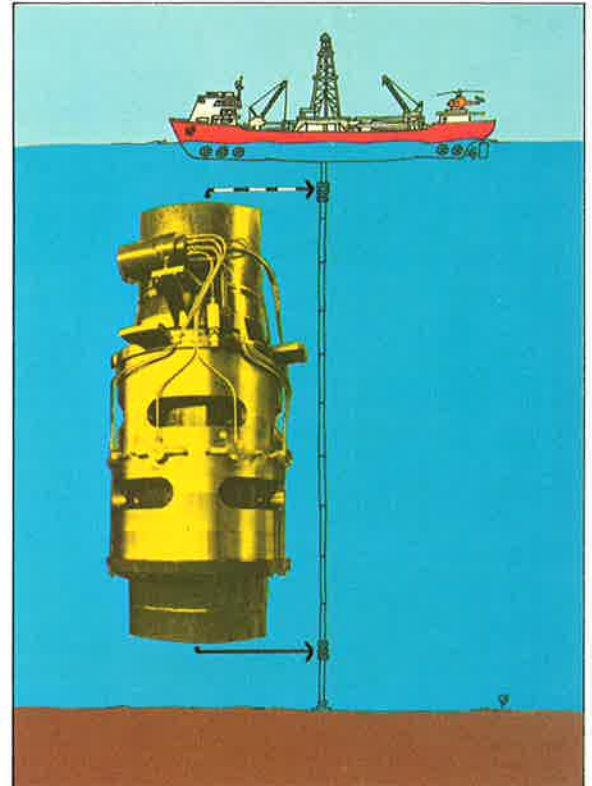
- development of an Instrumented Riser Joint (force sensor in riser pipe)
- methods to determine forces and moments in propeller shafts of ships
- heat conduction and thermal stress problems
- dynamic problems in civil engineering
- calculation of fatigue and crack growth e.g. in tubular joints as used in the offshore industry
- structural behaviour of components made from non-ferrous or composite materials
- optimization of structures etc.



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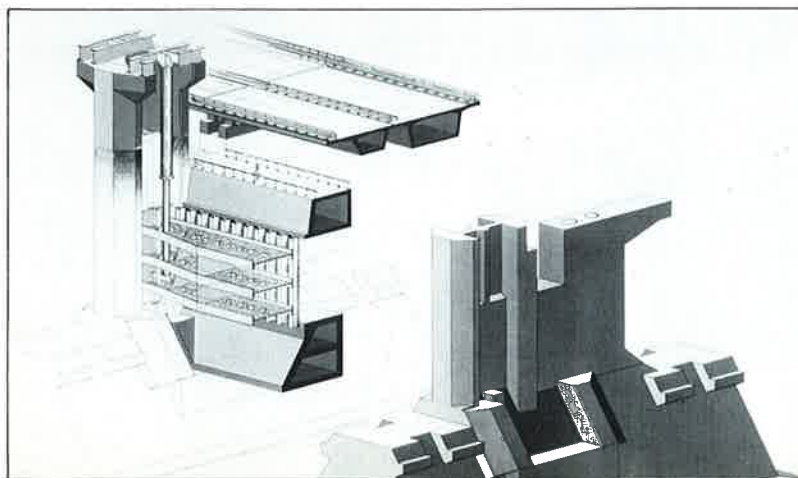


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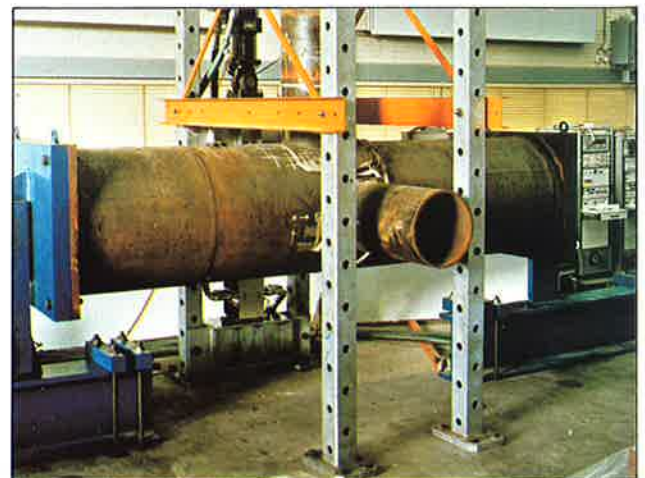


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- 10. Torque and thrust measuring device for propeller shafts of ships
- 11. Sodium pump for nuclear reactor
- 12. Instrumented Riser Joint
- 13. 'Oosterschelde' flood barrier dam
- 14. Crack growth prediction in a tubular joint



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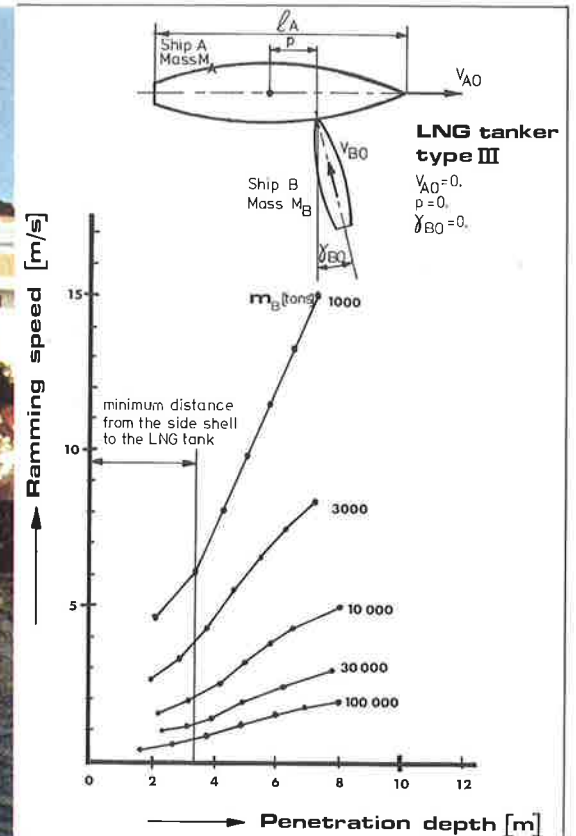


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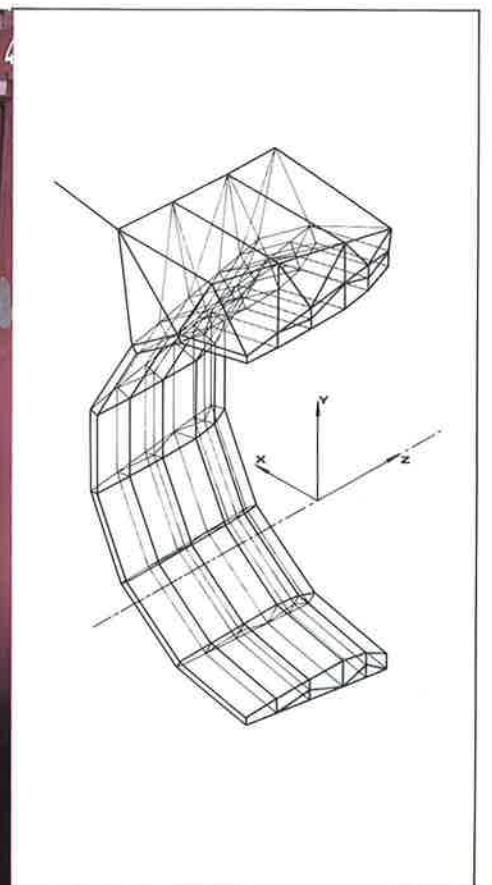
Marine research

The research and development in relation to ship building mainly concerns analysis of linear and dynamic response including buckling of complicated structures. To this end finite element methods are extensively used. Both deterministic and stochastic loads are dealt with and thus the behaviour of complex structures may be predicted. Some examples are shaft vibration analyses, prediction of structural response of complete ships and/or specific parts of the ship such as deck-houses, propeller-nozzle configurations, cutter dredger parts etc. When dealing with structures surrounded by water the (frequency dependent) added mass of this water plays an important part in the dynamic behaviour. To include this effect in the analysis a special purpose computer programme has been developed. This enables to calculate the added mass of arbitrary bodies surrounded by a liquid. By non-linear analysis in this field the structural integrity is determined. In such cases the mathematical model deals with failure modes such as: high-cycle fatigue, low-cycle fatigue, fatigue crack growth and final collapse due to plastic instability or unstable crack growth.

Applications concern buckling strength, prediction of collision damage of ships, or of structural behaviour when exposed to blast, etc. A new activity concerns the prediction of non-linear dynamic behaviour of pipe lines during pipe laying in deep waters. For this purpose a special computer programme has been prepared. It will be further improved for wider application.



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15. Analysis of collision problems and damage prediction
16. Investigation of the dynamic behaviour of a propeller duct system

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