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Computer software system for determining the pressure field resulting from hull flow and operation of the marine propeller

SUMMARY

In the paper CISAKU software system for calculating the pressure field resulting from hull flow and operation of the marine propeller is shortly described as well as a thorough analysis of calculation results obtained by means of it. An influence of the secondary wave system, water depth and bottom-reflection coefficient, fluid viscosity and propeller operation on the pressure field around the hull, as well as influence of propeller operation on the acoustic pressure field is presented.

The system's theoretical background was already published in the previous issue of this quarterly.

INTRODUCTION

In the previous paper [8] the theoretical background was presented of the computation models used for the computer programs which form the CISAKU software system for calculating the pressure field resulting from hull flow and operation of the marine propeller. A theoretical model of the potential flow around the hull moving with steady speed on the inflexible water surface over flat sea bed as well as a model for determination of the secondary wave system connected with the flexibility restoration of the surface was described. A computation model of the hull boundary layer, assumed in the program was also presented, results of which are used to modify the hull form (its enlargement by the displacement boundary layer thickness) and to determine the velocity field in the region of propeller operation.

A computation model of the propeller was also described, based on the deformable lifting surface theory adapted to analyzing the propeller performance within non-uniform velocity field behind the hull, with ability of detecting the cavitation and determining the pressure induced by it.

CISAKU software system was written in the FORTRAN language and it can be used on Pentium-based personal computers.

CISAKU SOFTWARE SYSTEM

On the basis of the computation models several programs forming the CISAKU software system were elaborated. Many calculation versions (options) of different degree of computation model development, can be carried out by means of it as follows :

- the potential flow around the hull on the inflexible water surface, without propeller effect
- the potential flow around the hull on the flexible water surface (with accounting for the secondary wave system)
- the viscous flow (with accounting for the boundary layer), without propeller effect
- the viscous flow, with propeller effect.

Each of the specified versions is calculated with taking into account a limited water depth and assumed value of the coefficient of reflection from the bottom α_{odb}. The case of unlimited water region is obtained by assuming the coefficient value equal zero.

Calculating process by means of CISAKU system is commenced by calling all the system's programs in a strictly determined sequence, by means of the input file. The calculations can be performed only when a file exists of the correctly determined mesh coordinates of the quadrilateral elements which wetted surface of the hull was divided into during hull panelization. For the panelization it is possible to make use of special systems for defining and correcting the hull form (e.g. NAPA system) or of the PANEL program, especially elaborated for CISAKU, which makes panelization of the hull directly on the basis of the standard-form body lines (of 14 to 24 frame sections) possible. In the PANEL program computer graphics and automatic reading the node coordinates from the lines drawings displayed on the monitor screen is applied. Second file necessary to perform calculations by means of CISAKU is **dzerys.dat** file which contains normalized coordinates of the single-pressure-impulse wave system.

Third file which contains the propeller geometry, can be optionally introduced in the case of carrying out calculations of a version with propeller. The remaining data are input through the monitor screen.

The system starts calculating with the use of PHS1computer program by which :

- elements of the matrix A_{ij} are determined (see eq. (3) in [8])
- the equation system for determining the distribution of source density on the double hull with double bottom reflection is solved as well as

- source-induced velocities in the check points on the hull surface are determined.

The water surface around the hull is panelized by using FSPAX1 computer program and velocities induced by the sources distributed on all three double hulls are calculated by means of it.

SIATKA1 program is arranged to determine the primary wave system (Bernoulli wave) and secondary wave system on the water surface around the hull.

The pressure field on the hull is determined by applying FALA1 program.

This relatively short, calculation stage (potential flow only) provides the output files which can be easily checked by means of graphic programs, and at this moment it is also possible, by using CISZ-C program, to determine the pressure field of potential flow at cross-section planes below water surface (at horizontal or vertical sections).

At the next calculation stage liquid viscosity is already taken into account, and optionally, if the calculations have to be carried out for a version with propeller effect, also influence of the propeller onto flow around the stern part of the hull can be taken into account.

The streamlines on the hull, boundary layer parameters and corrected data of the extended hull form (due to accounting for the boundary layer) are determined with the use of STRIMZ program.

Further calculations are performed in the same way as at the first stage (potential flow).

PHS2, FSPAX2, SIATKA2 and FALA2 programs are the equivalents to the above characterized programs accordingly modified to continue calculations on the extended hull and with accounting for the propeller. If the calculation options with propeller have to be used a value of the effective wake coefficient is estimated by means of approximate formulas at the very beginning of STRIMZ program run and the calculations with propeller are next carried out. The calculations provide data about the velocity field induced by the propeller on the hull as well as the streamlines and boundary layer parameters calculated with the influence of the propeller accounted for.

In the end of this calculation stage components of the velocity field in the propeller disc are exactly determined by means of POLEP program. To start running the program, data of the boundary layer on the stern part of the hull and the velocity field of potential flow around the hull are necessary [8]. When the calculations by using POLEP program are completed this calculation stage is ended and its results can be checked by means of graphic programs, then calculations can be continued with the use of CISZ-C program to determine the pressure field below the water surface with accounting for viscosity. When the velocity field over the propeller disc is known more accurate calculations with the propeller can be performed and the boundary layer calculations repeated with taking into account the propeller influence more accurately. For the calculations the same programs as those used at the second stage are applied.

An analysis of the obtained results reveals that **in the case of determining the pressure field around the hull** the calculations can be terminated after third stage without any need of more accurate recalculations. The results obtained at the third stage make it possible to determine, by means of CISZ-C program, the hull-flow-induced pressure field on horizontal or vertical planes below the water surface with accounting for the secondary wave system, viscosity and, indirectly, propeller (by effect of the propeller on hull flow). If components of the velocity field in the propeller disc are known a propeller operation analysis in view of acoustic pressures can be performed. Two programs : KAWIRKC [1] and APSET [10] are applied for this purpose. KAWIRKC program detects vortex cavitation and determines values of the acoustic pressure generated by this mode of cavitation. APSET program determines different modes of propeller blade cavitation and values of the acoustic pressures due to these cavitation modes.

The vortex cavitation is determined in the program by applying a simple computation model [10].

In result of the basic calculations a dozen or so numerical files with **.dat** extension are obtained as well as the file which contains information dealing with local magnitudes on the hull and with the input data file and computation path. The numerical files are the basis for operation of the graphic programs, e.g. GRAFCIS program by which the pressure field can be presented in the form of isobars.

A scheme of CISAKU system is shown in Fig. 1.

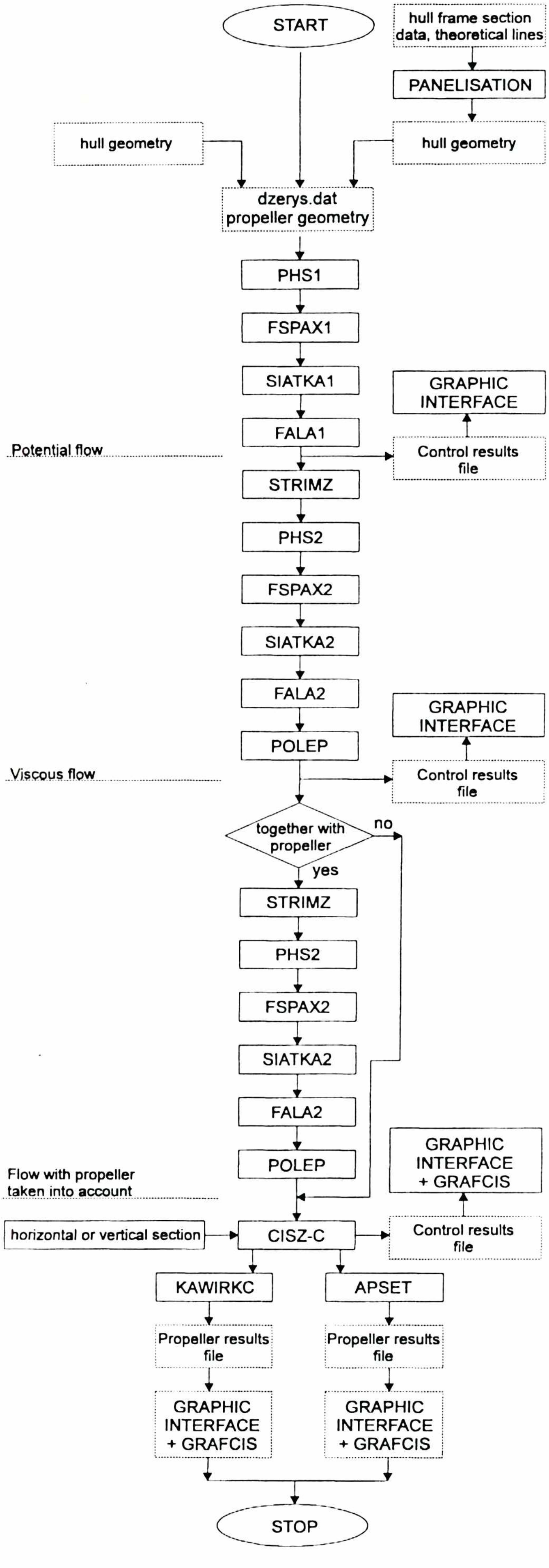

Fig. 1. Flow chart of CISAKU computer system

It is possible to carry out detail influence analyses of different factors which affect the pressure field around the hull as the calculations can be terminated at different levels of the computation model expansion.

INFLUENCE OF THE SECONDARY WAVE SYSTEM ON THE HYDRODYNAMIC PRESSURE FIELD

The potential hull flow with the inflexible water surface and without the propeller induces the pressure field around it characterized by bow and stern peaks. In Fig.2 the pressure distribution under the hull is presented in the form of isobars, and in Fig.3 the pressure distribution in function of the time t in the points on the hull plane of symmetry.

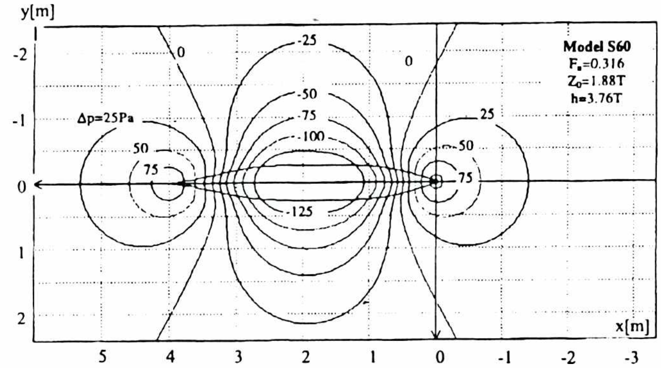

Fig.2. Hydrodynamic pressure distribution in the form of isobars under moving hull. (Calculated for the potential flow without accounting for the secondary wave system)

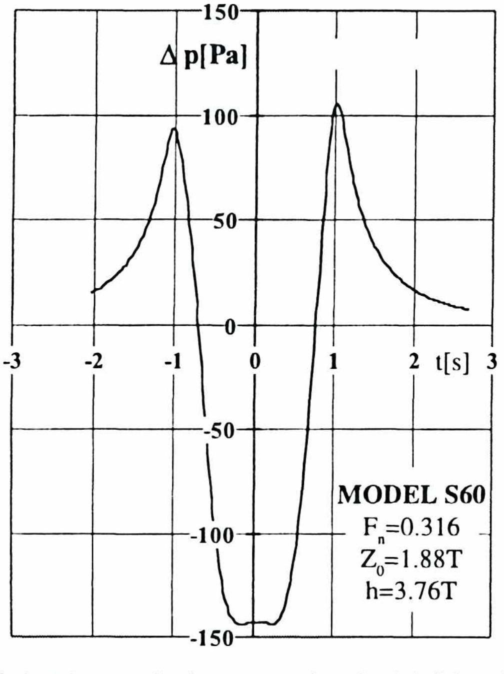

Fig.3. Hydrodynamic pressure distribution in a point located on the hull plane of symmetry. (Calculated for the potential flow without accounting for the secondary wave system)

The calculation points are placed at the depth Z_0=1.88 T while the water depth is h = 3.76 T.

In this case (of the potential flow with the inflexible water surface) the pressure distribution is independent of the hull speed V_0, and the pressure coefficient :

$$C_p = \frac{\Delta p}{\frac{1}{2}\rho V_0^2}$$

solely depends on the hull form, water depth and location of a considered point relative to the hull.

Fig.4 exemplifies the pressure change Δp in function of the relative water depth h/T in three points located on the hull plane of symmetry at the depth Z_0=1.88 T without accounting for the secondary wave system.

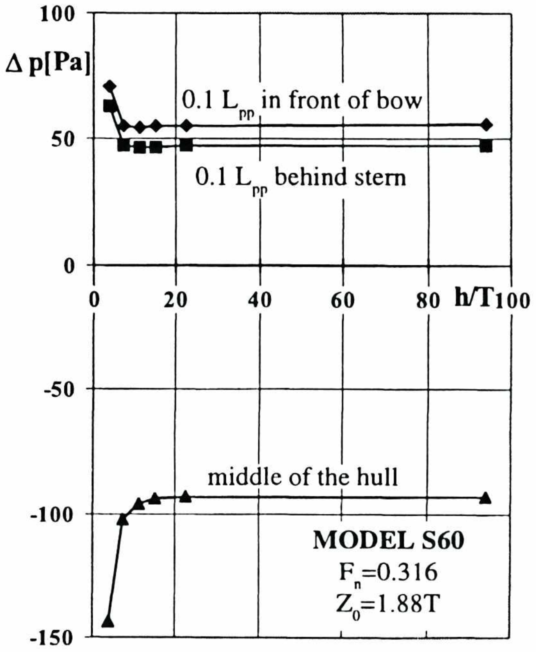

Fig.4. The hydrodynamic pressure change versus water depth, in three points located on the hull plane of symmetry. (Calculated for the potential flow without accounting for the secondary wave system)

It can be concluded from the analysis of the presented curves that the influence of the water bed on the magnitude of the hydrodynamic pressures can be observed only at the depths less than 10 T (ten hull draughts), which is confirmed by other calculations and tests. At the water depths greater than 20 T the water region can be considered unlimited (h = ∞). At the values of the coefficient of reflection from the bottom α_{odb} less than 1 the above mentioned limit values are lower.

Pressure images similar to those presented in Fig.2 and 3 can be achieved by applying the simple methods based on the source system distributed solely along the straight line resulted from the intersection of the hull plane of symmetry and waterplane. Source intensity is determined on the basis of the frame section areas of the underwater part of the hull [9].

The model of hull flow with the inflexible water surface is of a limited importance. It provides relatively correct results at lower Froude number values only. Restoration of the water surface flexibility induces the secondary wave system on it, which is brought down under the water surface in accordance with the exponential relationship :

$$e^{\frac{-gz}{V_0^2}}$$

where the depth z is related to the water surface.

CISAKU software makes investigating the secondary wave system effect on the pressure field around the hull possible. The calculations can be performed for both the potential and viscous flow.

In Fig.5 an example of the secondary wave system effect on the hydrodynamic pressure magnitude and distribution is shown, for the point at the depth Z_0=1.88 T under the model of S60 series and at the Froude number F_n = 0.316. In Fig.6 another example is presented of the pressure change Δp along with Froude number variability. It can be stated in result of an analysis of these and similar calculation results that the influence of the secondary wave system for F_n < 0.2 is negligible, for F_n > 0.3 is significant, and for F_n > 0.45 it decisively affects the pressure change magnitudes and direction. This is confirmed experimentally.

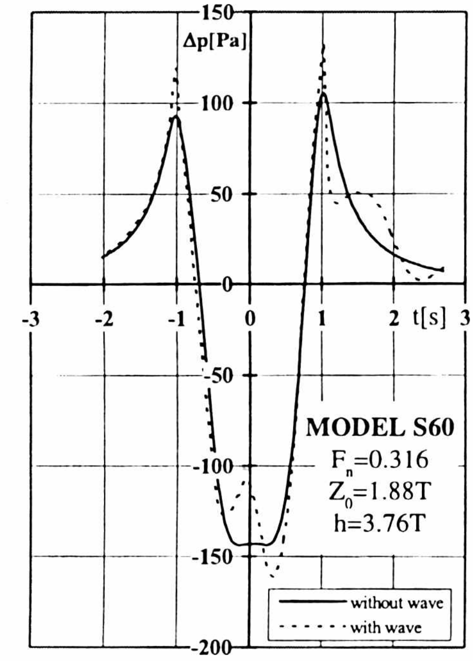

Fig.5. Influence of the secondary wave system on the hydrodynamic pressure distribution under a model of S60 series

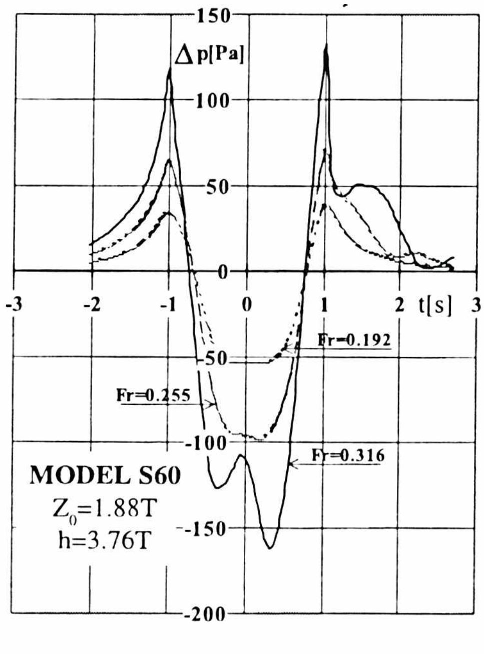

Fig.6. Influence of the secondary wave system on the hydrodynamic pressure distribution under the hull at different Froude number values

In Fig.7 and 8 results are compared of the tests and calculations for the case of the inflexible and flexible water surface.

The tests were carried out on theWigley model of the main particulars as follows :

- *length between perpendiculars* L_{pp} = 2.000 m
- *hull breadth* B = 0.200 m
- *hull draught* T = 0.125 m
- *block coefficient* C_B = 0.444

The measurement point was located at the depth Z_0= 4 T and the distance y = 0.115 m from the plane of symmetry, at the model speed corresponding to F_n = 0.413. The water depth h = 12 T.

The presented example confirms that accounting for the secondary wave system in the hydrodynamic pressure field calculations is absolutely necessary, although perfect coherence of the calculation and test results has not been achieved (the calculation model of the secondary wave system still requires further improvements).

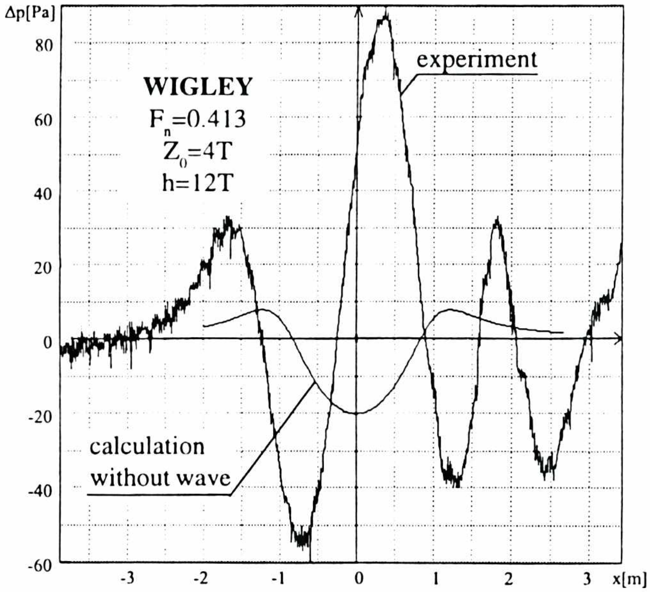

Fig.7. Comparison of results of the tests and calculations of hydrodynamic pressure distribution under Wigley's hull model.
(Calculations without accounting for the secondary wave system)

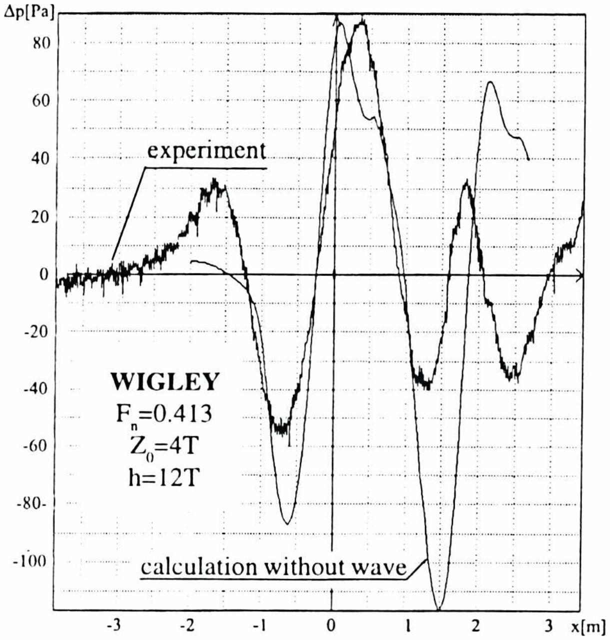

Fig.8. Comparison of results of the tests and calculations of hydrodynamic pressure distribution under Wigley's hull model.
(Calculations with accounting for the secondary wave system)

INFLUENCE OF THE WATER DEPTH AND BOTTOM - REFLECTION COEFFICIENT ON THE HYDRODYNAMIC PRESSURE FIELD

On the basis of the potential flow around the hull an influence analysis of the water depth and bottom-reflection coefficient α_{odb} on the hydrodynamic pressure field around the hull can be performed.

The correction factor which characterizes acoustic wave reflection from the real sea bed (the bottom-reflection coefficient α_{odb}) is introduced to the computational model to make the calculation results closer to the experimental ones. Its role is to distinguish reflections from different types of sea bed, e.g. to disclose difference between the sludge, sand or rocky bed, as well as to be able to distinguish the bed configuration, e.g. that flat and parallel to the water surface from the folded bed. Full reflection of the acoustic waves, i.e.

when the coefficient $\alpha_{odb} = 1.0$, very rarely happens in real conditions. However in the towing tanks its value close to one can be achieved almost in any case. But in sea conditions it obtains the level of about $\alpha_{odb} = 0.40$, and it can get even very small values, for instance in the case of the sludge bed : $\alpha_{odb} = 0.05$.

The reflection coefficient α_{odb} is introduced to the computation model as a multiplier of the potential of mirror-reflections from the bottom. If $\alpha_{odb} = 0$ is assumed the case of the infinite water depth is obtained. In Fig.9 for instance, calculation results of distribution of the pressure Δp in function of time t is shown for the hull model of S60 series, in the point located on the hull plane of symmetry at the depth Z_0=1.88 T, for several values of the relative water depth h/T.

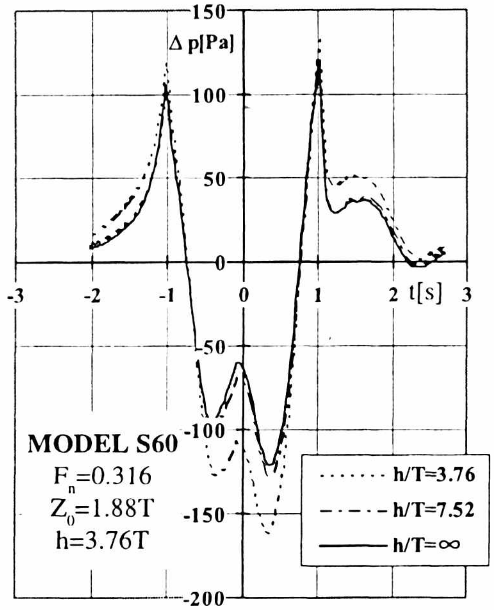

Fig.9. Influence of the relative water depth h/T on the hydrodynamic pressure field under the hull of Wigley's model. (Calculations of the potential flow with accounting for the secondary wave system)

In Fig.10 the pressure change Δp is presented versus the relative water depth h/T for three selected points located on the hull plane of symmetry at the same depth, i.e. Z_0=1.88 T. In both cases the bottom-reflection coefficient $\alpha_{odb} = 1.0$.

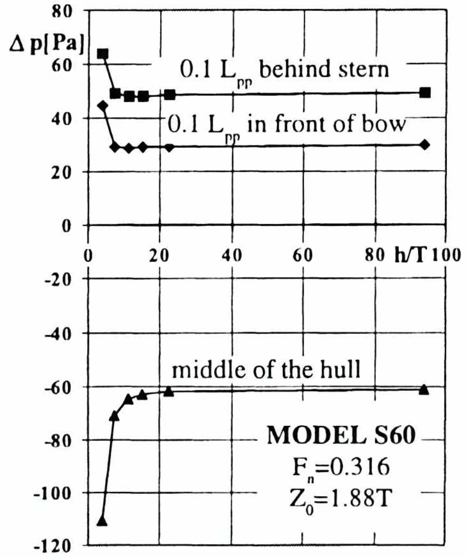

Fig.10. The hydrodynamic pressure change Δp versus the relative water depth h/T at three points located on the hull plane of symmetry. (Calculations with accounting for the secondary wave system)

It can be stated, in result of an analysis of the presented results, that the influence of α_{odb} on the pressure values is negligible , at least if the considerations are commenced from some relatively large value of the water depth. In the case of the presented diagram the water depth of 15 hull draughts may be taken as that value. However the pressure changes are more distinct at the water depth values less than 10 hull draughts. The respective limits are lower in the real conditions where the bottom-reflection coefficient value becomes less than one. In Fig.11 calculation results are presented of Δp pressure distribution in function of time t (carried out for the same hull and location of the point as in Fig.9) in dependence on the bottom-reflection coefficient α_{odb}.

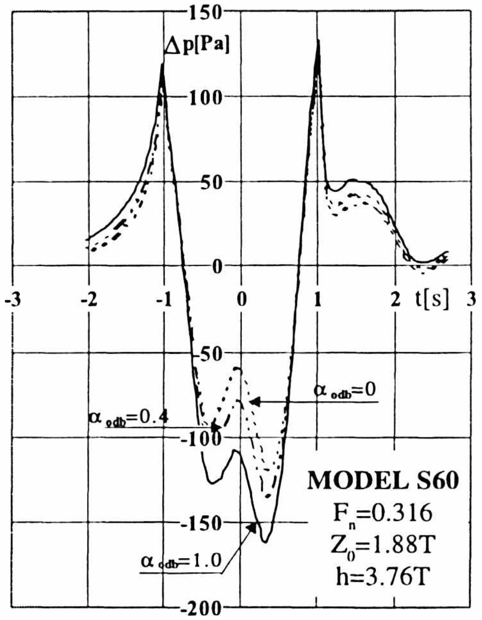

Fig.11. Influence of the bottom-reflection coefficient α_{odb} on the hydrodynamic pressure field under the hull of S60 model

The limits of pressure changes in respect to the bottom-reflection coefficient are determined by two curves for $\alpha_{odb} = 1.0$ (full reflection) and $\alpha_{odb} = 0$ (infinite water depth). The pressure change Δp and bottom-reflection coefficient α_{odb} relationship is linear (see Fig.12) so that having the two limiting curves one can easily determine pressure values for a selected value of the bottom-reflection coefficient α_{odb}.

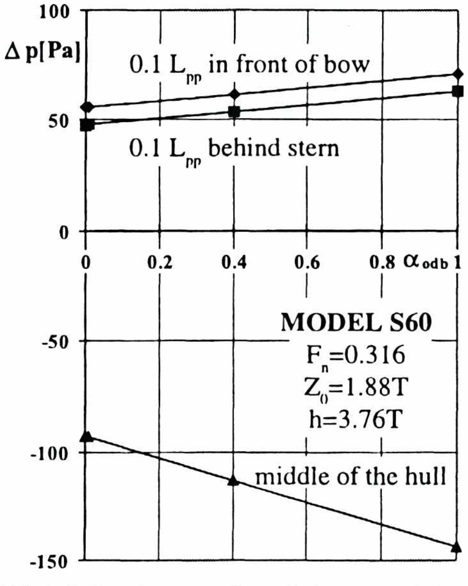

Fig.12. The hydrodynamic pressure change Δp in respect to the bottom-reflection coefficient α_{odb} for the points located on the hull plane of symmetry of S60 model

A comparative analysis of similar calculations with the accounting for liquid viscosity and operation of the propeller revealed that these factors did not introduce any important correction to the above presented statements.

LIQUID VISCOSITY INFLUENCE ON THE HYDRODYNAMIC PRESSURE FIELD

The viscous liquid flow around the hull can affect the hydrodynamic and acoustic pressure field, in comparison to the potential flow, by an apparent change of hull form due to growing boundary layer and by possible flow separation as well as first of all by influencing the form of the velocity field in the stream behind the hull and, indirectly, due to the effect of the operating propeller in the stream.

Viscosity of the liquid can cause bilge vortices to appear which may become a direct or indirect source of the pressure field around the hull. This phenomenon (bilge vortices) is not accounted for in the actual version of CISAKU software, only the event of flow separation from the hull is signalized. The effect of viscosity on the hydrodynamic pressure field discussed in this section is limited to the influence of the apparent change of hull form caused by growing boundary layer.

In Fig.13 distributions of the pressure Δp versus time t are presented both with and without taking into account viscosity for S60 model (C_B = 0.60) at the point located under the hull. The similar diagram for Wigley's model is shown in Fig.14.

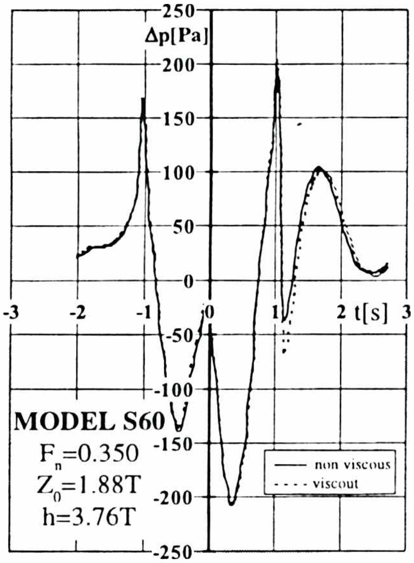

Fig.13. Liquid viscosity influence (apparent extension of the hull form) on the hydrodynamic pressure field under the hull of S60 model

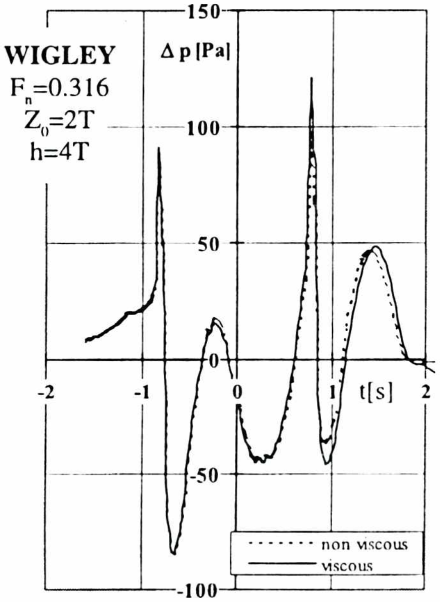

Fig.14. Liquid viscosity influence (apparent extension of the hull form) on the hydrodynamic pressure field under the hull of Wigley's model

A comparison of both curves in Fig.13 and 14 reveals that the liquid viscosity expressed by the apparent hull form extension due to growing boundary layer thickness very little affects the magnitude and distribution of the hydrodynamic pressure under the hull.

The presented calculation results deal with the hull models. However it can be concluded from the boundary layer theory that, in the case of natural scale when ship speed is scaled in compliance with Froude law, the viscosity influence on distribution of the hydrodynamic pressure would be even smaller.

Therefore the conclusion is that the viscosity influence defined by the apparent hull form change only slightly affects magnitude and distribution of the hydrodynamic pressure under the hull. In spite of that the boundary layer is required to be calculated in order to get the velocity field of the stream behind the hull in the region of propeller operation, and in this way to obtain data necessary for analyzing the propeller performance.

In most cases the propeller is the main source of the acoustic pressures induced by the ship.

PROPELLER OPERATION INFLUENCE ON THE HYDRODYNAMIC PRESSURE FIELD

The influence of propeller operation on the acoustic pressure field induced by the propeller is quite well recognized. However the propeller operation influence on the hydrodynamic pressure field is much less investigated both theoretically and experimentally.

Propeller operation affects the hydrodynamic pressure field in two ways :

- indirectly by changing the around-hull flow
- directly as a source of the steady pressure or low-frequency pressure field (within 10 Hz).

The indirect interaction is accounted for in the computation algorithm in the form of the average (in respect to time) propeller-induced velocity field in the check points on the hull by introducing them to the boundary condition on the surface of the flown-around body. The propeller-hull interaction is a well known phenomenon and the thrust deduction factor which characterizes an increase of hull resistance is important so that its value is determined during each propulsion test in the towing tank [5].

The hydrodynamic pressure field under a containership model, on the plane placed at the depth Z_0= 2 T at h = 4 T, without and with propeller interaction is presented in Fig.15a and 15b respectively.

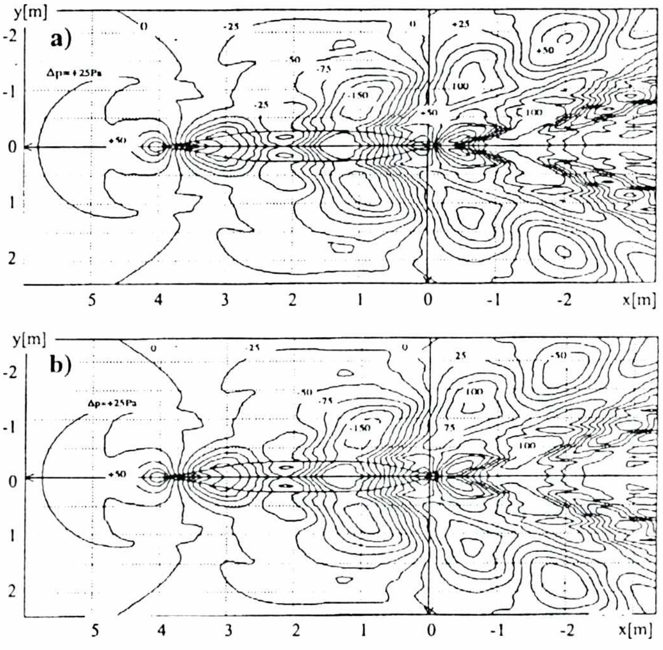

Fig.15. The hydrodynamic pressure field under a containership model, calculated for the depth h = 4 T and at Z_0= 2 T : a) without propeller effect, b) with indirect propeller effect

Analyzing the location of isobars on both diagrams one can observe small differences of the curve courses in the stern part of the hull and behind it. The differences are better distinguishable in Fig.16 where the same calculation results are presented in the form of the pressure change Δp in function of time t and with operating propeller (it is easy to transform the time function onto running distance function if the model speed is known).

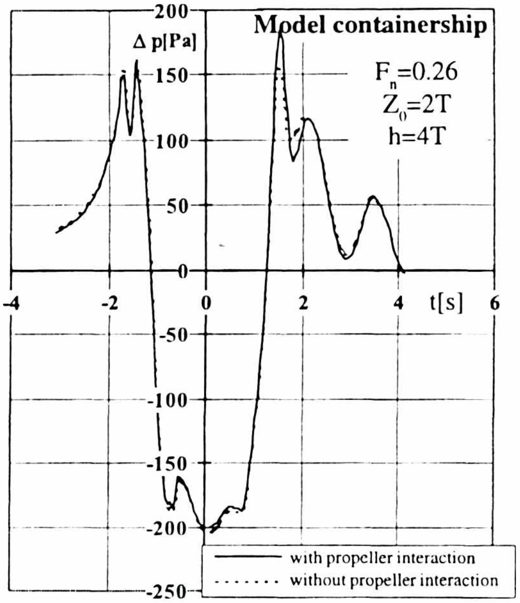

Fig.16. Indirect propeller effect on the hydrodynamic pressure distribution under a containership model

The similar diagram for Wigley model is presented in Fig.17.

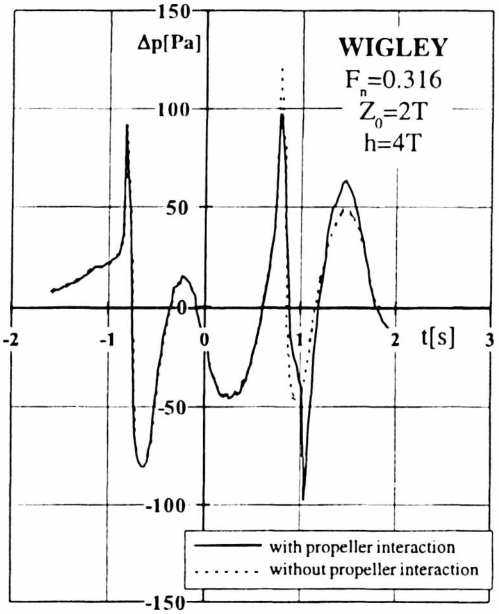

Fig.17. Indirect propeller effect on the hydrodynamic pressure distribution under Wigley model

Analyzing the presented results one can conclude that the indirect propeller effect on the hydrodynamic pressure field is weak relative to the pressure of the hull itself. Correctness of this result was checked by analyzing the pressure field on the hull and determining the thrust deduction factor. It was possible to do so as the computation model and algorithm of the pressure field was one and the same for the points directly located on the hull and in the surrounding space as well. The calculated thrust deduction factors are of values close to those obtained experimentally [5]. It means that the hydrodynamic pressure changes shown in Fig.15 and 16 are credible.

By using CISAKU software the hydrodynamic pressure field directly induced by the propeller can be obtained in the form of zero term of the Fourier series which represents the propeller-induced pressure at a given point of the space surrounding the hull. These average pressures induced by non-cavitating propellers are of very low values even less than those arising from the indirect interaction. The so defined pressure field induced by a non-cavitating propeller on the S60 model is shown in Fig.18. The maximum pressure values are at least two orders lower than the hydrodynamic pressures induced by the hull itself. Much higher values were obtained for a cavitating propeller.

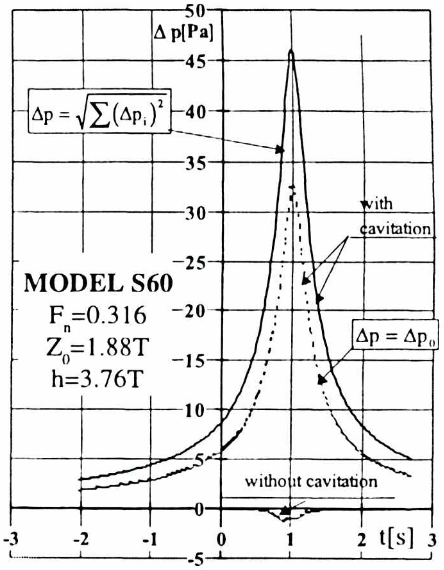

Fig.18. Distributions of the hydrodynamic pressures directly induced by a non-cavitating and cavitating propeller in the point located at the depth Z_0=1.88 T

In Fig.18 the curve $\Delta p=\Delta p_0$ represents the zero term of the Fourier series which the pressure induced by the cavitating propeller is developed to, and the curve $\Delta p=\sqrt{\sum(\Delta p_i)^2}$ represents the root-mean-square value of the pressure. It can be concluded from the figure that the propeller cavitation is able to change the hydrodynamic pressure field around the hull stern in a very distinct way. Such changes are illustrated in Fig.19.

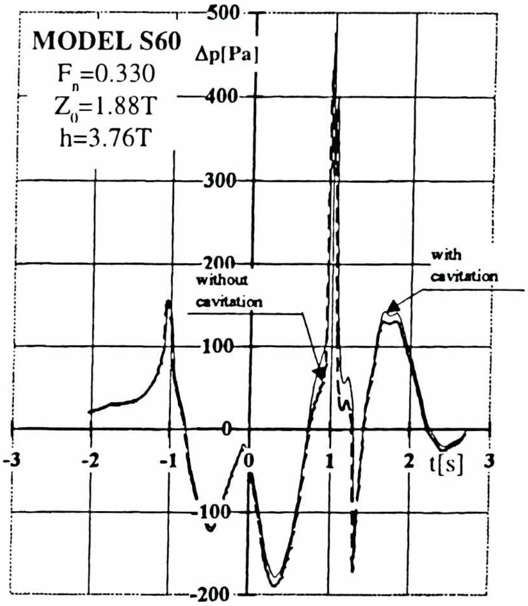

Fig.19. Distributions of the hydrodynamic pressures under S60 hull model, indirectly and directly affected by a cavitating propeller

PROPELLER OPERATION INFLUENCE ON THE ACOUSTIC PRESSURE FIELD

The propeller which operates behind the hull induces a strongly time-variable pressure field. The field variability is dependent on the number of blades, number of revolutions, circumferantial non-uniformity of the velocity field in the behind-hull stream as well as on the form and intensity of cavitation. The time-variable pressure field at a given point of the space can be developed into Fourier series by determining the harmonic components connected with number of revolutions and blades, as well as the average pressure value in that point (used for hydrodynamic pressure determination). The amplitudes of the harmonics and relevant phase shifts univocally describe the time-variable pressure field. CISAKU system determines the acoustic pressure field in an arbitrary point of the space surrounding the propeller and hull by developing it into Fourier series. It can be optionally determined in the same points in which the hydrodynamic pressures are determined, i.e. on a horizontal plane parallel to the water surface, placed at a given depth between the hull bottom and sea bed (for 141 x 31 points altogether) or on a vertical plane parallel to the hull plane of symmetry (for 141 x 20 points altogether). Results of calculations have the tabular form which enables to present the results in various configurations.

For instance calculation results for a containership are presented in Fig. 19 and 20 in the form of distributions of consecutive harmonic components at the ship plane of symmetry.

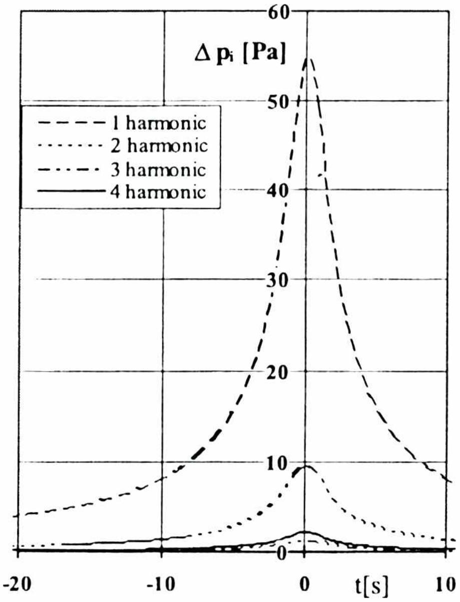

Fig.20. Distributions of the acoustic pressures for a slight cavitating propeller (tip vortex canvitation only). Full scale containership

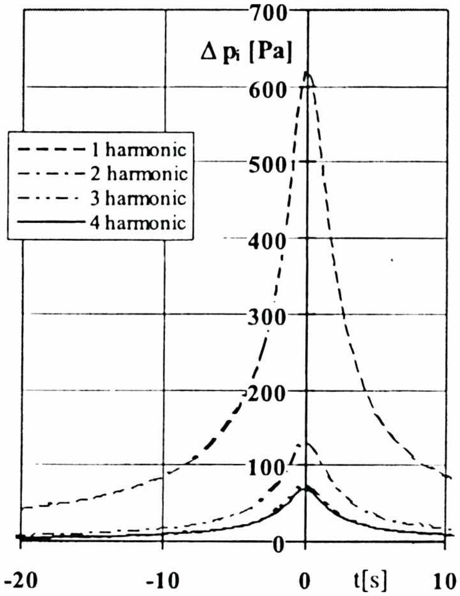

Fig.21. Distributions of the acoustic pressures for a full cavitating propeller. Full scale containership

In Fig.20 calculation results are illustrated of 4 first harmonic components of the acoustic pressures induced by the propeller affected by the tip vortex cavitation only, and in Fig.21 additionally by sheet and cloud cavitations. In this case the acoustic pressure level was ten times greater. The result coincides with relevant observations and measurements on full scale ships.

FINAL REMARKS

CISAKU software system was developed within the scope of KBN (The State Committee for Scientific Research) research project No 9T 12C 003 08. The system makes it possible to determine analytically the hydrodynamic pressure field (within field change frequency up to 10 Hz) and acoustic pressure field (with the frequency above 10 Hz) around the hull and co-operating propeller. The supporting graphic programs allow to present calculation results quickly and clearly. CISAKU system has been arranged to serve for assessing the hydrodynamic and acoustic pressures at the ship designing phase and thus for optimizing the hull and propeller form with the aim of minimization of ship-induced noise. It makes also possible to assess pressure levels on the existing ships. Moreover it also enables analyzing the influence of different factors affecting the flow around the hull and propeller on the pressure field around them.

The following are some original results achieved during development of the software system :

- The entire system may be recognized as an original achievement because the applied calculation models are of a quite new quality in ship hydrodynamics in relation to those known till now.
- The very important influence of the secondary wave system (generated by the hull-propeller system) on the hydrodynamic pressure field under the hull was demonstrated. The pressure field under the hull for the Froude numbers higher than 0.3 is strongly affected by the secondary wave system.
- The software allows to perform optionally several calculation versions based on different extension levels of the calculation model. It makes analyzing the influence of different factors on the hydrodynamic and acoustic pressure field generated by the hull and co-operating propeller possible. Results of such analysis are a novelty in ship hydrodynamics.
- CISAKU system allows to account the sea bed effect on calculation results. This is also a novelty in ship hydroacoustics.

The computation models applied in the component programs of CISAKU system require further improvements. In particular it concerns the secondary wave system especially in relation to the fast and multi-hull craft and propellers working close to the water surface.

NOMENCLATURE

A_{ij} - matrix elements
B - ship breadth
C_B - block coefficient
C_p - pressure coefficient
F_n - Froude number
g - acceleration of gravity
h - water depth
L_{pp} - hull length between perpendiculars
p - pressure
p_∞ - undisturbed flow pressure
$\Delta p = p - p_\infty$ - pressure difference (change)
Δp_i - i-th harmonic amplitude of the propeller-induced pressure
Δp_0 - zero term of Fourier series describing the propeller-induced pressure
t - time
T - ship draught
V_0 - hull speed
x, y, z - rectangular coordinates of the reference system connected with the hull
α_{odb} - bottom-reflection coefficient
ρ - liquid density

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Conferences

MARITIME MEDICINE

On 11÷12 September 1997 the Symposium on Maritime Medicine was held at the Institute of Maritime and Tropical Medicine, Gdynia. 22 papers were presented dealing mainly with medical problems of marine and underwater operations. They were prepared by representatives of :

- Institute of Maritime and Tropical Medicine, Gdynia
- Several specialty divisions of Medical Academy of Gdańsk and Military Medical Academy of Lódź
- Division of Diving Equipment and Underwater Operation Technique of Polish Naval Academy, Gdynia
- Sanitary and Epidemiology Stations of Gdynia, Gdańsk, Puck and Świnoujście
- Navy Hospital, Gdańsk
- Labour Medicine Centre, Gdańsk.

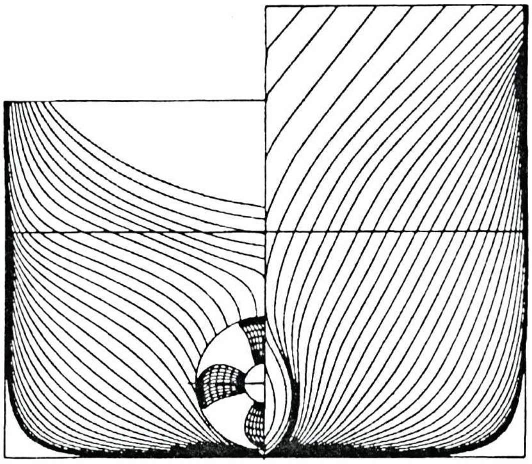
A very wide scope of topics of the Symposium's papers can be classified into the following groups :

- Living and working conditions of seamen and their health problems (4 papers)
- Occupational deaseases of seamen and fishermen (2 papers)
- Accidents, injures and death cases among seamen on ships and their prevention (3 papers)
- Influence of age, work experience and smoking on body mass of seamen and fishermen (3 papers)
- Selected problems connected with the diseases of chewing organ, digestive tract and blood circulation system appearing among seamen (3 papers)
- Selected problems of diving technique and medical assurance of diving (3 papers)
- Hypothermia during diving and sea rescue operations (3 papers)
- Exposure to action of sunk toxic warfare agents (2 papers)

Conferences

Technical University of Wrocław

HYDRONAV '97



TWELFTH INTERNATIONAL CONFERENCE ON HYDRODYNAMICS IN SHIP DESIGN

On 17÷19 September 1997, XII International Conference on Hydrodynamics in Ship Design was held in Szklarska Poręba, organized by Institute of Machine Construction and Operation, Technical University of Wrocław.

During the conference 34 papers were presented, of which the following - at the plenary session :

- „Slamming" by Odd Faltinsen (Norway)
- „Unsymmetrical catamarans" by Heinrich Söding (Germany)
- „Some aspects of the effective mean velocity determination" by Henryk Jarzyna (Poland)
- „Prediction of manoeuvring characteristics in ship design" by Lech Kobyliński (Poland) and Gholamreza Zolfaghari (Iran)

The rest of the papers were read at six topic sessions :

- Ship Resistance and Propulsion (7 papers)
- Experimental and Theoretical Methods (4 papers)
- Inland Navigation (4 papers)
- Ship Motion (8 papers)
- Multi-Hulls and High Speed Ships (4 papers)
- Submerged Cables (3 papers)

13 papers were prepared by scientists (as authors or co-authors) from the research centres in Newcastle, Trondheim, Hamburg, Skovlunde, Bossum, Duisburg, Genova, Izmir, St. John's and Potsdam.

Apart from 56 participants who represented 6 Polish universities and research centres and 5 marine enterprises and institutions 10 foreign specialists took part in the conference from Great Britain, Denmark, Holland, Canada, Germany, Norway, Turkey and Italy.