Preliminary techno-economy study on application of fast ferries to West Baltic routes

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Abstract

In the paper, at first, South-West Baltic Sea environmental and transportation conditions are described. Then a present situation in the passenger and vehicle transportation is overviewed based on the situation of Polish and foreign ferry companies. The techno-economical considerations for the passenger/car ferry for Szczecin-Malmoe route are later discussed. Then main particulars of various craft types are proposed. The safety and ecological problems are overviewed in the final part of the study. Conclusions and some remarks for future work are given at the end of the paper.

1 Introduction

Increasing demand for the transportation ability on maritime routes may be fulfilled either by increased size and volume of ferries or by their increased speed. The second way has been proved to be efficient by many studies and by increasing number of high speed ferries in service presently (more than 1300 fast craft in operation by the end of 1996). Fast marine transportation becomes also more and more frequently discussed subject in research works and press publications related to the development of the transportation systems between the North and South Europe. It concerns also the west part of the Baltic Sea [1]. As the Szczecin-Swinoujscie harbour complex is planned to be one of the two starting points of a new highway system in Poland at the Baltic Coast, the passenger/car ferry routes from Poland to the Scandinavian terminals become an interesting subject of studies for possible application of fast craft.

Usually a fast craft is defined to be a craft of the speed over 20 knots. But the limit speed defined by the IMO HSC Code-95 [2], which distinguishes the slow and fast ships, is a function of the ship displacement. It means that it also depends on the craft length and type [3]. Most of commonly built ships are of
30 knots and over, of 50-100 meters of length and they are capable to carry 400-600 passengers. Fast ships are unconventional not only due to their speed but also their hull configuration and specific space layout. They are also characterised by the high weight sensitivity what means that for a required payload, and restricted main dimensions and displacement - the high speed may be achieved only for a ship of relatively low lightweight. That is why they are usually built of aluminium alloys or of composites (FRP). The high speed is also connected with a high power of main drivers which may be up to 30000 - 40000 kW (diesel engines and gas turbines). Among the design and exploitation criteria the minimal acceleration and good course-keeping stability of a craft are the most important ones. But also the strength criteria for unconventional hull configurations and high dynamic forces require a special approach. Therefore the design on the base of classification societies rules such as [4,5] is sufficient in the first step of project only. Further analytical and model studies are usually indispensable for a new design.

The population of fast craft has dynamically increased during the last decade. New craft types of the greater and greater dimensions and power are designed each year. The most common ships in service nowadays are passenger ferries but passenger/car ferries have also been more often used recently. The monohulls, catamarans and SES (Surface Effect Ship) are the most popular. The other types such as hydrofoils, hovercrafts and SWATHs (Small Waterplane Area Twin Hull) are also proposed but as passenger carriers mainly. A craft type selection for the specified sea route requires marketing, economy and technical investigations. There is also a need to take into consideration the special safety and ecology aspects when the fast marine transportation is studied for real environmental conditions.

2 Environment of the Baltic Sea

2.1 General

Four sub regions can be distinguished in the Baltic Sea Region: The Northern, Central, Eastern and South-Western Sub-Regions. They are different due to their hydrological and climate conditions and by the level of economy and its perspectives of development.

The South-Western Sub-Region (SWS-Region) plays an important function of a natural link on the lines from the North to South and from the West to East Europe. The economy of that region in its different parts is not at uniform level. The high activity is concentrated mainly around the big towns such as Copenhagen, Malmoe, Hamburg-Lubeck, Berlin and Szczecin. In the SWS-Region there are also several important sea ports and terminals well equipped with ferry facilities: Kiel, Lubeck, Rostock, Sassnitz, Copenhagen, Malmoe, Ystad, Trelleborg, Karlskrona and Swinoujscie. In the SWS-Region the transportation infrastructure is relatively well developed and the transport and communication network requires of further improvements. In the last years new
enterprises in the fast transportation systems concerning the existing and new highways and marine routes have been proposed.

2.2 Hydrology characteristics

The South Baltic Sea is characterised by climate fluctuations, influenced mainly by the Atlantic Ocean. All over a year the windy weather is observed. The dangerous winds for the navigation are those over 6° of Boufort scale. The highest probability of strong and stormy winds (25-35 %) is in January/February and November/December. Winds over 6° B practically were not observed in June, July and August (probability less then 2.4 %).

The dynamics of the Baltic is formed by wind waving. The streams and tides are very small. The Baltic Sea has rather bad opinion concerning waves but it is not confirmed by the hydrological statistics [6,7]. Sometimes the wave height may increase very quickly thus an early warning system for future fast sea transportation will be indispensable. The development of the wind-generated surface waves in the Baltic Sea is limited by the fetch which does not allow a fully developed sea to occur for the wind force above 7° B. For the wind force of 7° - 8° B, the expected wave characteristics after 24 hours of its action are: mean wave height 4.5 m, mean wave length 80 m, mean period 8.7 s. The highest frequency for the occurrence of the stormy waving is for the autumn (8.1 %) and winter (7.5 %).

Icing of the sea is a serious navigation problem in the Baltic Sea. Probability of icing during the winter in the SWS-Region is nearly 100 % at the Polish shore and from 25 to 75 % at the Swedish and Danish coasts. In the open areas, even in mild winters, the floating ice occurs at the coastal zone of the South-West Baltic and especially in the shielded water region of the Szczecin Transgression the icing process is much more intensive. The number of days with ice is 60-70 per year and the thickness of the ice cover is 50-60 cm. The ice cumulating may be here even progressed by of ice-floes on the Odra River. In the Polish open coastal waters the average year number of days with the ice is 10 but it can be augmented up to 70-80 in extremely frosty winters. The water areas in some distance from the shores are covered with ice (ice-floes and ice-discs) nearly every year because of shallow water. Sometimes the ice-bridges may be observed between Sweden and the Danish Islands and Jutland Peninsula. The measured maximal thickness of ice was abt. 70 cm there but the hummock may even arise up to several meters.

2.3 Network of transportation system

Poland started with implementation of a long term program of highways and soon will run the biggest highway projects in Europe [8,9]. It is thought to be a unique opportunity to set up a transport system suitable for Polish needs and European conditions. The programme was initiated at the end of 1995. The particular attention is attributed to the A-1 (Helsinki-Gdansk-Lodz-Katowice-
Ostrawa) and A-3 (Szczecin-Zielona Góra-Legnica-Praga) transeuropean highways which aims to connect Scandinavian countries with the central and southern parts of Europe. They will be supplemented by the highway around the Baltic - the "Via Hanzeatica" (Królewiec-Elblag-Gdańsk-Szczecin-Hamburg) and they are to be connected with appropriately developed marine transportation routes. That is why a special attention is paid to the sea connection between the Polish and the Swedish ports: from Swinoujscie to Ystad or Malmö (90 nautical miles) and from Szczecin to Malmo (130 nautical miles).

3 Present situation in fast ferries on West Baltic

More than 130 ferries operate today on the Baltic routes, including several fast ferries. The nearest future plans concern also car-passenger ferries and fast cargo craft. The typical fast craft on the Baltic is a catamaran but also some monohulls are in service. The largest fast craft on the Baltic today seems to be the passenger-car catamaran DELPHIN operated from 13 May 1996 by TT-Line on the route from Trelleborg to Travemünde (the connection parallel to the Ystad-Swinoujscie line).

The first Polish international Baltic ferry connection was open in 1966-67 but the first Polish projects for fast marine transportation were announced not earlier than in 1994. But the final decision concerning new construction or chartering a fast ferry by Polish ferry operators has been unknown until now. One of the interesting development discussed lately was that by the Unity Line in 1996 concerning the catamaran passenger-car ferry of a new configuration and construction. In several projects there is not only Swinoujscie-Ystad line which is taken into consideration but some other connections are proved to be interesting such as to Szczecin, Malmö and Bornholm. Especially changing of the basic Polish connection to Scandinavia from Swinoujscie-Ystad to Szczecin-Malmo seems to be substantial due to local infrastructure of the both big cities and very interesting commercial results of Polish Baltic Ship Company in the exploitation of conventional ferries on the rout from Swinoujscie to Malmo in 1996.

4 Fast ferries for Szczecin-Malmö route

4.1 Techno-economy considerations

Some technical and economical problems of the introduction of fast ferries on the Swinoujscie/Szczecin - Ystad/Malmö route were already discussed in a few papers [10,11]. The commercial and technical operation advantages of fast craft in comparison with the conventional ships were well proved there, knowing from the experiences of some foreign owners, that the investment costs may be fully returned in 4-5 years. Till now only the catamaran craft type was proposed.
and investigated due to some advantages when it is compared with the other fast craft types.

The economical efficiency of a high speed craft is strongly dependant on the number of passengers on a specific line. In the Baltic routes the fluctuation of the passengers number is very sensitive to the year seasons. That is due to strong influence of the climate and icing conditions. In Fig.1 and Fig.2 assumed statistics are presented concerning the traffic pattern on the Szczecin-Malmoe route. The total number of passengers on that line was estimated as 600 thousand travellers per year by the year 2000. It seems to be a realistic figure according to the passengers traffic noted in the latest years. In Fig.1 the monthly passengers distribution is shown. It can be seen that the four summer months (from June to September) cumulate abt. 50% of the whole year passenger traffic. In Fig.2 the average numbers of passengers per day are shown. Those figures are taken into consideration for the ferries selection.

Figure 1. Monthly distribution of passengers on Szczecin-Malmoe route
4.2 Proposals of craft types and dimensions

The assumed passengers traffic on the route from Szczecin to Malmoe was used to estimate the necessary number of ships and their transportation capacity. Four traffic periods of transportation of passengers and cars, according to the year seasons, may be distinguished: the high season - in summer, shoulder seasons - in autumn and in spring and low season - in winter. It may be assumed that minimum 3 or even 4 low speed conventional ferries of abt. 20 knots with the passenger capacity of 800-1000 each may be required in the high season (July-September). They may be replaced by equivalent fast craft of the same total passenger transportation capability but of the speed of abt. 40 knots.

High speed craft present many advantages when are compared with the conventional ferries operated up to now. The invested capital may be lower for high speed vessels - the ship price may be much lower due to avoiding costly cabin and due to the increased transport capacity (1000 passengers at 40 knots = 2000 passengers at 20 knots). Additionally more frequent sailing give the travellers more choice.

On the investigated rout the fast craft fleet may be composed either by four ships of capacity of 400-500 each or only by two larger craft of the same capacity as the conventional ferries. The first solution - four craft of 400-500 passenger capacity seems to be more rational from the economical and technical reasons and is proposed in this study. Such ferry due to traffic character has also to be able to take 120-150 cars. And according to the special climate and technical conditions on the route in SWS-Region not only catamaran craft type are to be a subject of further studies. To take into account in the future investigations also the other possible non-conventional solutions of fast craft such as monohull, SWATH, hovercraft and SES can be advisable. Their main
characteristics are proposed in Table 1. In the table the coefficients of transportation efficiency are also given for preliminary comparisons.

Table 1. Main characteristics of fast ferries for Szczecin-Malmoe route. Craft of transportation capacity of 400-500 passengers and 120-150 cars

<table>
<thead>
<tr>
<th>No</th>
<th>TYPE OF CRAFT</th>
<th>LENGTH $L_{max}$, m</th>
<th>DRAUGHT $T$, m</th>
<th>SPEED $v$, kn</th>
<th>POWER $N_e$, kW</th>
<th>COEFF. $k_1$</th>
<th>COEFF. $k_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MONOHULL</td>
<td>96−105</td>
<td>2.1−3.5</td>
<td>35−40</td>
<td>22000−26000</td>
<td>40−60</td>
<td>1.05−1.40</td>
</tr>
<tr>
<td>2</td>
<td>CATAMARAN</td>
<td>70−85</td>
<td>2.0−3.2</td>
<td>35−40</td>
<td>15000−26000</td>
<td>25−40</td>
<td>0.70−1.30</td>
</tr>
<tr>
<td>3</td>
<td>SWATH</td>
<td>50−60</td>
<td>4.5−6.5</td>
<td>30−40</td>
<td>20000−23000</td>
<td>35−40</td>
<td>0.90−1.20</td>
</tr>
<tr>
<td>4</td>
<td>HOVERCRAFT</td>
<td>55−65</td>
<td>-</td>
<td>40−50</td>
<td>12000−16000</td>
<td>30−40</td>
<td>0.55+0.75</td>
</tr>
<tr>
<td>5</td>
<td>SES</td>
<td>70−90</td>
<td>2.5−3.5</td>
<td>35−50</td>
<td>18000−30000</td>
<td>35−50</td>
<td>0.75+1.20</td>
</tr>
</tbody>
</table>

1) $k_1 = \frac{N_e}{(number \ of \ passangers)}$ - kW/pass,

2) $k_2 = \frac{N_e}{(number \ of \ passangers)} \cdot v$ - kW/pass-kn.

4.3 Safety and environmental considerations

The Baltic Sea due to its closed area belongs to the regions of the special environmental protection [11]. It concerns also the negative influence which may be expected from the maritime transportation. Therefore careful considerations are to be given to many ecological and safety aspects such as: sea and air pollution, disposal of garbage, ballast water management, use of antifouling paints, safety measures against sea collisions, fire protection and many others. The increasing number of fast craft on the Baltic routes involves a new approach to those problems. It may results in some new low and safety requirements. Searching for new technical solutions of safety and environment friendly ships is getting a subject of many studies. A new term the ‘environmental ship’ is more and more frequently used in new designs.

A significant declining of standards of safety is observed around the coasts of many countries. The same problem concerns also many of the states situated at the Baltic Sea. It concerns the responsibility of the authorities and actions in case of a catastrophe which causes the minor sea pollution. The safe management and new legislation in the domain of coastline protection are required in the nearest future also with respect to the Baltic marine transportation routes for fast ferries. One of the ways of safety improvements is a special approach to ship management. More and more frequent tragic marine incidents and collisions were the casualties which had drawn the IMO to agree upon the International Safety Management Code (ISM) obliging all shipowners...
and managers to have a safety management and environment protection system. The Code concerns all ship types including high speed craft and it will be effectively in force by the 1st July 2002. It describes suitable means for safe operation of ships and for pollution prevention. The requirements of the Code should be a subject of the further investigation when implemented for the fast craft.

Fire is by far the most serious threat to the safety of life onboard vessels and this threat is heightened on fast craft and other vessels where thousand of people's lives would be at risk in a fire situation. New regulations and proposals of life safety management (LSM) systems, such as that by [12], constitute the answer on the increased demand in that respect. The philosophy of the system gives the operator an efficient way of carrying any action in fire situation by quick analysis of data.

5 Conclusions

Some technical, economy and environment problems connected with the introduction of fast craft on the South-West Baltic routes were discussed in the paper. The proposition of several types of passenger/car craft for the line from Szczecin to Malmoe was also given. Further detailed studies are necessary to select the ship dimensions, power and structural materials in connection with ship types and economical considerations of the ship for a specific sea route. It is also evident that the influence of ecology and international rules safety criteria on the design and economy will be greater and greater in accordance with the increasing number of fast craft in service.

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