©SNAK, 2014

Int. J. Nav. Archit. Ocean Eng. (2014) 6:392~405
http://dx.doi.org/10.2478/IJNAOE-2013-0187
pISSN: 2092-6782, eISSN: 2092-6790

Hydrodynamic optimization of twin-skeg LNG ships by CFD and model testing

Keunjae Kim, Fabian Tillig, Nicolas Bathfield and Hans Liljenberg

SSPA Sweden AB, Sweden

ABSTRACT: *SSPA experiences a growing interest in twin skeg ships as one attractive green ship solution. The twin skeg concept is well proven with obvious advantages for the design of ships with full hull forms, restricted draft or highly loaded propellers. SSPA has conducted extensive hull optimizations studies of LNG ships of different size based on an extensive hull data base with over 7,000 models tested, including over 400 twin skeg hull forms. Main hull dimensions and different hull concepts such as twin skeg and single screw were of main interest in the studies. In the present paper, one twin skeg and one single screw 170 K LNG ship were designed for optimally selected main dimension parameters. The twin skeg hull was further optimized and evaluated using SHIPFLOW FRIENDSHIP design package by performing parameter variation in order to modify the shape and positions of the skegs. The finally optimized models were then built and tested in order to confirm the lower power demand of twin skeg designed compaed with the signle screw design. This paper is a full description of one of the design developments of a LNG twin skeg hull, from early dimensional parameter study, through design optimization phase towards the confirmation by model tests.*

KEY WORDS: Twin-skeg; Single screw; LNG ship; Dimensional parameter study; Hull design parameter optimization; Computational fluid dynamic (CFD); Model testing.

INTRODUCTION

SSPA experiences a growing interest in twin skeg ship as one attractive green ship solution. The twin skeg concept is well proven with obvious advantages for the design of ships with full hull forms, restricted draft or highly loaded propellers. SSPA statistics, based on over 400 different twin skeg configurations in 200 projects, show that twin skeg hull forms in general require 6% lower propulsion power compared with a single screw ship with the same cargo capacity. For the best quartile of the same statistics the twin skeg hull forms still require 2-3% less propulsive power than the corresponding single screw designs. In addition, the maneuverability and lateral stability are improved, redundancy is added and the risk of excessive propeller induced pressure pulses can be reduced. Some of SSPA research works have been reported by Williams (1975; 1980) and Berlekom (1985).

In recent years large LNG ships with cargo capacity of 150,000m^3 up to 260,000m^3 have been built both as single screw and as twin skeg ships. More than 50% of all LNG projects in the world and totally 30 LNG projects with single screw and twin skeg comparison studies have been completed at SSPA since 1990. The power demand for a single screw versus twin skeg

Corresponding author: *Keunjae Kim*, e-mail: *keunjae.kim@sspa.se*

This paper has been selected from the Proceedings of PRADS 2013, reviewed by referees and modified to meet guidelines for publication in IJNAOE.

LNG is highly dependent on the ship size, restrictions in ship draught, and minimum available propeller rpm. Statistically the twin skeg concept applied to large size ships reduces the propulsive power by up to several percent in relation to conventional single screw ships.

As part of our first dimensional parametric study, LNG ships with payloads between 150-250,000m^3, for standard lengths of each payload size and with draughts of 11.5, 12.0 and 12.5 meters were investigated. The results of this study indicated that the performance advantage of the twin skeg concept increases as the cargo capacity growths, but also that there is a break-even point where the single screw concept gets more beneficial. From the dimensional study, ships with a cargo capacity of 170,000 m^3 and a draught of 11.7m have been selected for the design development of the twin skeg hull and comparison of the power performance with the corresponding single screw design.

After selecting the main hull parameters, an optimization was carried out in the second phase. The key to design good twin skeg hull forms is the optimum selection and combination of all relevant design parameters, for instance skeg shape, skeg vertical and toe angle as well as distance between the skeg by taking advantage of the balance between pre-rotation, resistance and propulsion efficiency. However, designing an optimum twin skeg hull form still is a difficult task because a clear understanding of the influence of all design parameters discussed above on ship propulsion performances has not been available. SSPA has a long experience in developing twin skeg hull forms since the first design was tested in 1943 and SSPA has also been involved in many commercial/research projects in designing and testing twin skeg hull form designs. Until recently, however, the design of twin skeg hull form has been based on model tests together with accumulated knowledge and experiences. This approach cannot guarantee to obtain a globally optimal twin skeg hull configuration since the number of design parameter variations in model tests are limited due to cost and time. CFD is then considered a good complementary tool to help evaluating more variants in a cost effective manner at design stage.

Along with continuous development of the RANSE solver of SHIPFLOW (CHAPMAN) by FLOWTECH (2009), extensive commercial/research works have been performed making use of the full functionalities of resistance computations as well as self-propulsion simulation for twin skeg hull configurations either by zonal or global approach and at model or full scale Reynolds number.

The first CFD work presented here is a model scale performance predictions in order to select the best twin skeg design among 11 different skeg configurations designed through a systematic variation of design parameters. Optimum rudder angles were also investigated in combination with propeller turning directions. This type of CFD computation is very challenging since it requires the full simulation of propeller open water characteristics, resistance and self-propulsion tests with a high level of accuracy that is capable of predicting small differences in flow characteristics, as well as the relative ranking of propulsion efficiency due to small variations in design parameters for the twin skeg shape.

Based on the evaluation of the power demand, detail analysis of flow characteristics and considering all design constraints, the most promising and suitable twin skeg design was selected for the comparison of the power performance with a single screw ship.

Full scale simulations were made for a twin skeg and a single screw LNG having the same Lpp, B and draft. The ships were then built and tested at SSPA (Lundström, 2011a; 2011b) in order to confirm the achievable power saving with the twin skeg design when compared to the conventional single screw hull.

The optimized twin skeg hull form showed 13% lower propulsion power compared with a single screw ship with the same cargo capacity.

The present paper includes only the design development of a 170,000m^3 LNG twin skeg hull, from early dimensional parameter study, design optimization phase, and confirmation by model tests for the comparison of speed power performance with a conventional single screw design. For other design aspects of LNG ships, for instance safety, operational analysis, maneuverability, risk assessment and performance of the LNG twin skeg concept have been discussed by Andreasson et al. (2005).

MAIN DIMENSION PARAMETER STUDY

SSPA has an extensive hull data base with over 7000 models tested, including over 400 twin skeg hull forms. The data bank contains information about every single hull form tested such as main dimensions, hull characteristics and – most importantly - resistance/propulsion performance, to which the results of an actual test can be compared, thereby establishing a sort of resistance and propulsion quality of the hull.