ALLURE: Sailplan Optimization

Sector

Sail - 2015

Project challenges

Optimise sailplan

Improve durability, strength and reliability

Smooth use of in-boom furling,

Keys to success

Ability to run the aerodynamic, structural and aeroelastic analysis of the sail plan in the given sailing conditions

Ability to compare the performance improvements for sailplans realised in the previous year, thanks to the ability to mesh sail shapes available as 3DM files.

Greater collaboration between SMAR R&D team and customer

Results

Significantly improved sail plan performance as drive force

Provision of the trimming conditions to the final customer

Improved durability, strength and reliability

Smooth use of in-boom furling

0 prototyping cost

INTRODUCTION

The goal of this project was to optimize the existing sail plan of the 43m, 240t, aluminium Super Yacht 'Allure', carried out with Paolo Semeraro, managing director of Banks Sails Europe. The existing sails were made as fibre-reinforced membrane.

Mr. Semeraro designs and produces MEMBRANE™ and BFAST™ string sails, the latter with Marco Semeraro. Both BFAST and Bank Sails have been using AzureProject, the software for sail design, for almost a decade. Mr. Semeraro has not only a long experience as designer but also in using that design technology.

With the 'Allure' project, he preferred to get SMAR Azure R&D team to help him, as that project presented numerous challenges and multiple parameters to optimize. The main challenges were not related to the sailplan size, but also the detailed customer requirements, among which were enhance the sails' durability, strength and reliability and smooth use of in-boom furling.

The project successfully achieved all the multiple goals, thanks to the SMAR Azure integrated design and analysis system for fibre-membrane sails -AzureProject and SA Evolution- and the experience of the company R&D team.

INITIAL INPUT

Mr. Paolo Semeraro supplied the initial sail designs and detailed description of the design challenges. As no VPP data was available, the target sailing conditions for the aerodynamic analysis and fibre layout were discussed and agreed in collaboration with Mr. Semeraro. The target sailing conditions were based on the superyacht upwind performance.

A total of 450sqm of upwind sailing area was analysed and optimised. Since the outset, it was decided to use a combination of Dyneema® SK90 and black Twaron® D2226 for the fibre layout, and a double lamination under high pressure plus laminated patches utilizing the same fibres to prevent corner local deformation. A long term vacuumed post-curing period sealed the production phases.

FLUID-STRUCTURAL ANALYSIS

The SMAR Azure design and analysis method for fibre membrane sails – AzureProject and SA Evolution- includes a validated and computationally efficient structural analysis method coupled with a

The Customer VIEW:

Why SMAR Azure?

We have been using SMAR Azure technology for almost a decade however as the project was very challenging and complex; we have decided to get SMAR Azure R&D team on board to help us with this optimisation.

How was working with them?

We have worked with the SMAR Azure R&D team and the cooperation was excellent. They explained their process and reasoning behind changing the parameters.

Is the Allure owner happy?

The owner is very happy and we are considering other projects together.

A final comment…

We are very happy with the outcome and we would recommend SMAR Azure services to anyone!

Paolo Semeraro

Banks Sails Europe

modified vortex lattice method, with wake relaxation, to enable a proper aeroelastic simulation of sails in upwind conditions. The structural analysis method includes the orthotropic and non-linear geometric characteristics of the fibre layout, including fibre types, density and direction.

FIBRE LAYOUT OPTIMISATION

Upon the client's requirement, the fibre layout optimisation aimed to improve the durability of the sails. Therefore, the multi-objective optimisation study aimed to reduce the maximum stress and strain by reducing or maintaining the weight of the sails to its initial value. The maximum stress and strain acceptable values were set to be sensibly smaller values than the fibre breaking tenacity and elongation, respectively.

The optimisation was performed by:

- aligning the fibres along the principal stress directions,
- spreading the fibres toward the most stressed areas;
- varying the fibres density.

In case of the full mainsail (300sqm), the fibre layout optimisation considered the loads evaluated on the sail-set including the full mainsail and yankee. Since the maximum stress and strain calculated for the initial fibre layout were close to an acceptable level, in order to increase the durability, the optimisation loop focused on the further reduction of the stress and strain without increasing the total sail fibre weight. The mainsail fibre layout was then verified for the reefed condition (228sqm). In that case, the structural analysis considered the wind loads on the sail-set including the staysail (134sqm) and reefed mainsail. As the resulting maximum stress and strain values calculated on the reefed mainsail were not acceptable: the optimisation focused on the reduction of those parameters below the maximum acceptable values (maximum stress less than 500 MPa and maximum strain less than 1%), by increasing the weight as less as possible. For the staysail, the parameters of maximum stress and strain were at an acceptable level, therefore the optimisation focused on the further reduction of those parameters keeping the same fibre weight of the sail.

BATTEN POSITIONING

Another design challenge was associated with the batten position to avoid damages to the mainsail and battens, when the mainsail is furled in the boom. In this case, the SMAR Azure design team had to calculate the relative position of the battens on the leech and luff when furled and check whether there was any excessive batten twist. Finally, the position of the battens was adjusted to avoid the overlap between the battens.

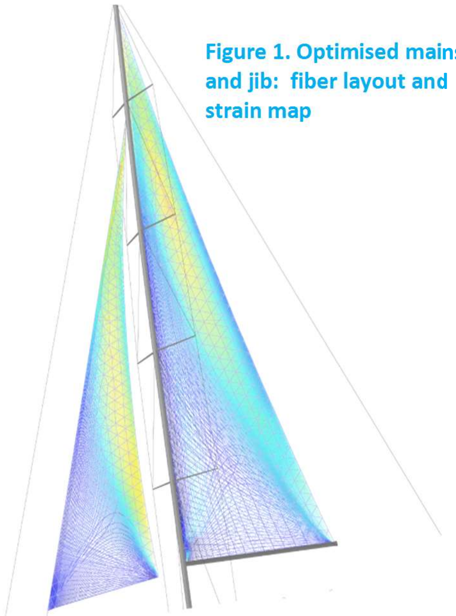

Figure 1. Optimised mainsail and jib: fiber layout and strain map

RESULTS

Zero prototyping cost

No sail prototype had to be produced. The fibre layouts, including patches, were the straight results (provided as dxf file for production) of a fully analytical and engineered process.

Shape holding performance

Following successful sea trials, the optimised sailplan holds the desired shape, as anticipated by the analysis results. That means reduced leech displacements.

Increased durability

The durability of the sails is increased thanks to the reduced stress and strain under sailing loads: sails are stiffer and stronger.