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Study on the evolution of large yacht project and construction as consequence of environmental rules.

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Abstract

Italy is a leader in the production of yachts, especially in the range between 50 and 70 m, but with the capability to deliver yachts of over 100 m

Internationally this field of industry, internationally, has to deal with the environmental rules, and these have a severe impact on the project and the industrial choices.

The paper aims at presenting a study about the main rules that became effective in last years, especially the ones becoming operational in 2020 and the consequent impacts in the methodology of project and construction. As a case study I examined a project, where the yachts examined are sister ships, delivered in last 5 years, where the ship and the project have been modified from the first yacht to the following, in order to already respect some of the criteria expected (exhaust pollution with SCR, ballast water treatment etc) in order to verify the changes in design and impact in the construction.

Keywords: yacht design, safety rules, pollution, environmental protection.

1. Main text

Italy is one of the leader manufacturer of large yachts: the Italian shipyard are, according to the latest data, realizing an impressive production of yachts in the range 30-140 m, with a benefit on the National economy of several hundreds millions of euros and giving occupation to thousands of people.

In general, the construction of Yachts had and impressive growth in last decades: of course the concept of "yacht" intended as a private ship, designed to carry people for pleasure, and with the specific target to show the economical power of the Owner, is centuries old, passing from the Ship's properties of Kings, Emperors, Nations, to the modern yachts owned by tycoons of finance.

Fig. 1 The "Bucintoro" raprehesentative ship of Venice

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To give an idea of the speed of market change we can say that only 20 years ago the 100th place in the "top yacht list" was of a Yacht of about 55 mt, and the 2nd largest yacht built in Italy in the 90's , the El Bravo III was 63.5 m. at the 50th position in the "top 100" list. Now the 200th yacht is over 75 m and this classification is changing very fast, probably in few years the top 200 will be constituted only by Yachts over 80 m..

Fig.2 – The M/y Ocean Victory 148 m, built by Fincantieri

This aspect can appear as a simple statistic, but the evolution had a serious impact on the project because important factors now must be considered: the increase of sizes leaded a new development of Rules, the attention to the pollution and environmental protection, the transformation of a product , that is always "custom made", from "small production" to "industrial production", with all the consequences in terms of planning, quality management, etc. typical of an industry.

The development of new Rules , as said, leaded as consequence that the yacht now is basically considered a ship, it is no more a "private object", also the market moved to the use of the yachts for charter , with the consequences of the project obliged to follow the, very strict, Rules of MARPOL and SOLAS, developed for commercial passenger ships, and the yacht construction has to deal with all the requirements of industrial production.

The quoted second main factor: the attention to the environment, was undoubtedly the challenge for the designers of the present times, a series of Rules has been enforced during the last years with a series of requests covering different aspects of the engineering systems.

In particular I will examine, as a case study, the reduction of pollution for the Engines, with the adoption of systems for SCR for main engines and generators. All those systems have to be adapted at the above mentioned Rules for the stability and subdivision, Rules requiring basically an increase of watertight compartments and a subdivision of the hull more fragmented, with a series of smaller compartments. This increased subdivision is obviously an obstacle for the installation on board of complex systems of filtering, pumps, actuators etc.

What is more important, as consequence of these Rules, and in correlation with a concept of Industry 4.0, is the change in the philosophy and methodology of design, abandoning the traditional "design spiral" approach to adopt a 360° approach, with a deep interaction with the possible new rules to be adopted in the future.

2. The change in design and construction philosophy: an industrial approach.

As mentioned, Italy is one of the leading countries in the construction of large yachts, and according to the last estimation is the world leader in construction among 40-70 m. with some excellences in the field of yachts over 100 m

The impact on Italian economy can be estimated in billions of euros considering that the construction of a yacht usually involves about 500-1000 people in all the aspects: project, design, carpentry, nesting, piping cohordinates, piping realization, electrical systems, survey, classification register etc etc.

The original system for project [1], adopted for centuries and still valid was the so called "spiral design" (Fig.3) , where the designer started from some data to move to define some parameters, then some others then verifying again the first data, making some adjustments, then beginning again the whole process.

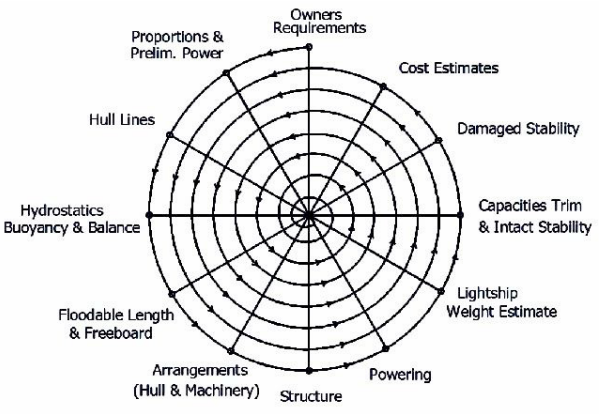

Fig. 3 – The design spiral

This kind of approach, as said, it is undoubtedly still valid and can considered as a milestone in the formation of Naval architects, but it has the limits of requiring usually a strict planning of the project, with steps already defined.

The limitations, nowadays, can come as a consequence of the fast changings in term of Rules and, in the specific situations for Yachts form, the changes often required "in construction" by the owners, with the result that the final approach for the Designer (intended as Naval Architect) and the shipyard is often such as in Fig.4:

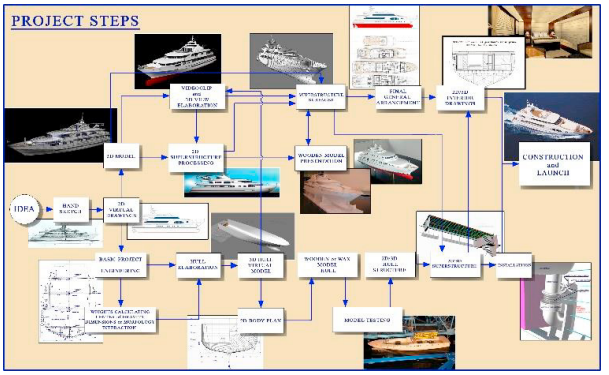

Fig. 4 – evolution of the project

It is easy to note how the development is not so "linear" and defined.

This situation has produced as consequences: the study of the academic community to develop different approaches for optimizations of several details, mutuating from commercial vessels [2-10] and has also forced the yacht industry to adopt a very particular approach: one side it is following the strict rules of a typical Industrial construction, with a "just in time" organization of the parts, on the other side it has got an organization extremely reactive, typical of tailored realizations, able to react in short time to the request. An example of what happened in a situation where the project was defined, but the shipyard has to quickly adapt to it, in advance with the times, will be described in the following part.

3. Reference to the main Rules adopted.

3.1. Nox and IMO TIER

In this part a situation of change to the a project, already under construction will be described, to follow the owner requests anticipating the new Rules becoming active.

The construction of a Yacht, in the dimension range described, usually takes 36-40 months from the signature of the contract. In this time besides the requests of the Owner, it is possible to have new Rules for pollution and environmental protection according to the general situation already described.

The more important Rules, that became active lately, are all the Rules about the year 2020, considered as a beginning of a "new era" in terms of pollution.

Now it is necessary the description of the structure of the Rules about the reduction of NOx and Sox and their implementation by the IMO. [11-16]

The (IMO) International Maritime Organization is one of the Agencies of the United Nations and works to promote Maritime Safety.

The IMO ship pollution rules are contained in the "International Convention on the Prevention of Pollution from Ships", known as MARPOL 73/78. The MARPOL Convention (as other IMO Rules) is continuously amended trough the years.

In this case, the MARPOL Annex VI (1997) takes care of limits on NOx and SOx emissions from ship exhausts, and prohibits deliberate emissions of ozone depleting substances.

The IMO emission standards are indicated usually as Tier I...III standards.

The main steps for IMO TIER are

TIER I - 1997: The "1997 Protocol" to MARPOL, which includes Annex VI, became effective 12 months after being accepted. It was accepted originally by 15 States, controlling more than 50% of world merchant shipping tonnage. The 15th was Samoa (in 2004) the others are Bahamas, Bangladesh, Barbados, Denmark, Germany, Greece, Liberia, Marshal Islands, Norway, Panama, Singapore, Spain, Sweden, and Vanuatu.

At that date, Annex VI was ratified by States with 54.57% of world merchant shipping tonnage.

The Annex VI became valid on 19 May 2005: it applies retroactively to new engines bigger than 130 kW, and for vessels built on or after January 1, 2000 or which undergo a major conversion after that date. Of course, knowing that, most manifacturers started to build engines already compliant with those rules.

Tier II/III -2008 —Annex VI amendments adopted in October 2008 introduced new fuel quality requirements beginning from July 2010, Tier II and III NOx emission standards for new engines, and Tier I NOx requirements for existing pre-2000 engines.

This new edition of Annex VI was fully ratified in October 2008 and was ratified by more than 50 countries (including the Unites States), representing more than 80% of tonnage.

Emission Control Areas. The Annex VI defines 2 different sets of of emission/fuel quality and areas, a Global Area and more restricted areas. It also introduces differences for SOx and NOx

An ECA (Emission Control Area) can have values of emission of Sox, PM, or NOx, or all three types of emissions from ships. Actually the Emission Control Areas are : (first date adoption of the rule/second entered in force)

Baltic Sea (SOx: 1997 /2005; NOx: 2016/2021)

North Sea (SOx: 2005/2006; NOx: 2016/2021)

North American ECA, including most of US and Canadian coasts (NOx & SOx: 2010/2012).

US Caribbean ECA, including Puerto Rico and the US Virgin Islands (NOx & SOx: 2011/2014).

Fig. 5 Emission control areas

Tier I and Tier II limits are global, while the Tier III standards apply only in NOx Emission Control Areas.

The adoption of those Rules leaded to the need of adopting engines already “clean” in terms of combustion or to adopt systems to reduce the pollution, operating on the exhausts.

4. Case study.

Describing how to meet the standards would require a complete examination of theory of engines, involving descriptions of the combustion processes. Basically we can resume and describe dividing the system in 2 main branches: Control of combustion processes with impact on mechanical characteristics of engine, heavy redesign of pistons, crankshaft, injection system etc.

Use of addictive, as SCR system to post treat the exhausts. The main is the Selective Catalityc reduction system, who uses Urea as to produce Nitrogen, Water and CO2 .

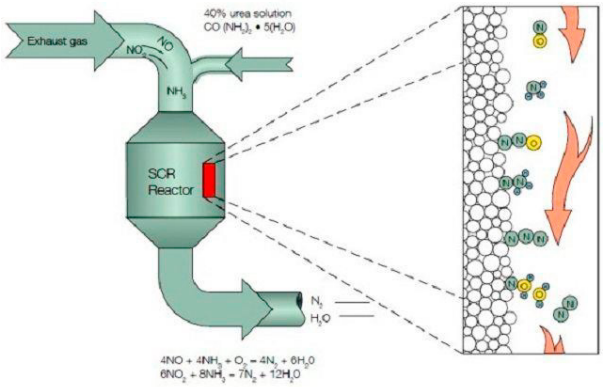

Fig. 6 – SCR principle

Actually, it is important to say that the most important part of Yachts over 500 GT uses high/medium speed diesel engines, that is engines with a operational range of rpm between 1600 and 2300 rpm, with an average power (depending from the speed and performance requested) spanning from 800 to 2500 kW. On those engines is still used the SCR system, and now we will see how the size of the treatment system can impact on the arrangement.

The average size of the engine in this range can be resumed as follows:

Length = 3-6 m.
Width = 1-2 m.
Height =2-2.5 m
Weight = 3-12 t.

The weight and size of a system for a 1800 kW engine, so in the middle of our range , can be

L = 2800 mm
B = 700 mm
H = 700 mm
Weight = 400 kg

In addition a tank must be installed for the liquid with a volume of about 1500 ltrs for each engine, in order to guarantee a range of about 2000 nm,

The case study moved from the analysis of 2 sisterships under construction, with expected deliveries for 2015 and 2017, but with keels laid in 2012, so the Shipyard decided, with the hull structures already defined and completed, to install an SCR system to make the yachts compliant with new Rules, even if not strictly required.

It is interesting to see how this is a “typical” for of change that requires a dramatic change in the arrangement of the Engine room with deep modifications.

The system adopted was a complete SCR post combustion system, with the dimensions described above, that created a serious problem of installation on board.

The layouts of the engine rooms will basically change as follows:

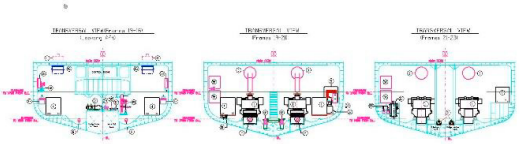

Fig. 7 – Layout of E.R. before

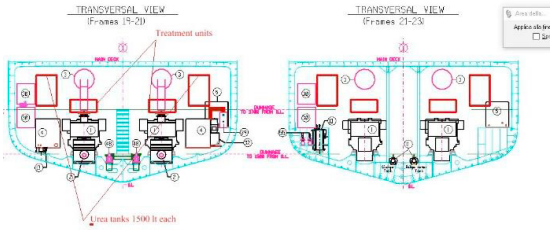

Fig. 8 – Layout of E.R. after

Is it possible to see that the Engine Room become even more crowded, the system with the annexed piping makes the maintenance on the higher part of the engines very difficult.

The Fig. 9 and 10, show the impact on the engine room of the yacht equipped with SCR system, and the consequent need, on the other hulls of the series to improuve the hull height, to improve the ergonomics and maintenance.

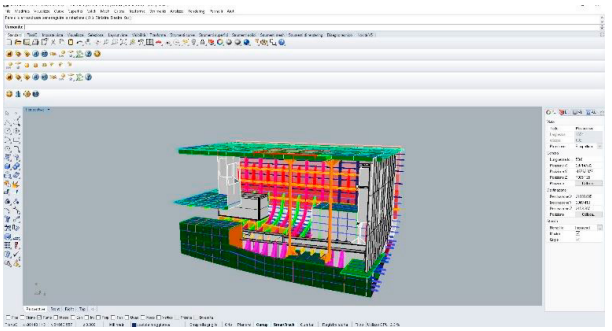

Fig. 9 – Engine room structure

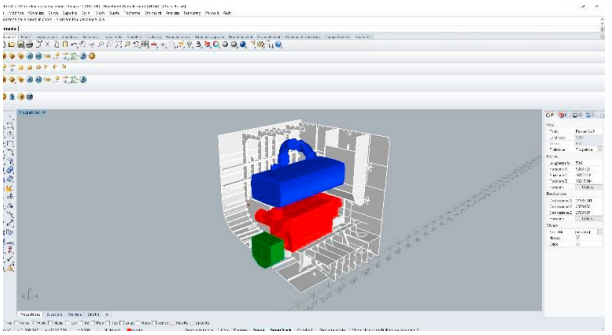

Fig. 10 Engine room with SCR system

Considering a series of Yacht to be built in this way, the adoption of those systems for the following ships, required a redesign of the hull, with an increase of the height of about 200 mm, with consequent impact on stability[17,18], and an additional costs of the hull

5. Conclusions.

The analysis of the actual situation of methodology for project and construction in the specific field of industry of large yachts, showed that the industrial process is subject to a lot of variables, and there is not yet a definitive path to follow for the designers in order to organize the production, despite the extremely good results obtained by the Italian Yacht industry all over the world.

Some studies have been performed to improve the “design spiral approach”, adopting the system called Blackboard [6] with special application to safety. A possible conclusion could be needed to integrate the two systems: Design spiral and Blackboard, modifying the input for the Naval Architect and the shipyard with a time horizon considering all the new Rules adopted for passenger vessels and commercial ships, because there is no doubt that the time gap between the application of Rules for passenger vessels and commercial ships and large yachts is very quickly decreasing.

Another aspect, not yet deeply examined, is the life cycle of large yachts, with consequent problems of recycling and so on. In fact, the actual fleet of large yachts is increasing quickly with a present average life of 10-15 years. Considering the average life of a passenger ship (the more similar category) in 25-30 years soon we will have the problem of the dismantling and recycling in a safe manner of thousand of tons of ships. Surely this aspect deserves to be examined carefully by the industry.

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