Automation of shipbuilding and shiprepairing using Internet of Ships technology

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Abstract. A technology belonging to Industry 4.0, the Internet of Ships (IOS), could improve shipbuilding in the coming years. To this end, the implementation of this technology in ship design tools, also known by the acronym CAD (Computer Aided Design), has been studied over the past few years. The purpose of this study is to explain one of the most interesting technologies available today, the Internet of Ships (IOS), used in the maritime sector. This technology is a complement to other existing technologies known as Industry 4.0, such as digital twin, cloud computing, or augmented reality.

1 Introduction

We will analyse, as an introduction, the current state of functionality that is currently being refined in CAD systems. For example, hull shape fairing or global shape modelling, complex surfaces can be transformed with excellent results, less interaction, high accuracy and complete control. These techniques significantly reduce development time - from a few days to a few minutes, yielding superior results.

A further area of improvement concerns one of the most time-consuming tasks in equipment design, the routing of piping, ducting, and cable trays. The automatic routing option minimises this time, but without compromising the reliability of the design. The complexity of the problem explains why there is no fully satisfactory automated routing solution yet. Current solutions provided by CAD systems solve partial problems, already offering considerable support.

Another area in which CAD companies are very active is virtual reality. The aim is to create a user-friendly environment for users to view, check, get metrics such as project progress, etc. This type of model-checking process does not require the use of design tools, just a simplified tool that provides easy access (viewing) [2]. The 3D visualisation model can also be viewed on a mobile device. Other basic tools available in these programs have different modes and commands, making it possible to measure distances or angles, create sections to access to internal components, etc. The interface with the program is done using the mouse, but virtual reality offers more options, such as protective goggles or headsets.

Advanced browsers allow the use of human models to explore ergonomic aspects, create glare and textures for enhanced visualisation, component movements for modelling, etc.

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Browsers can connect to the project database to access information in real time. In terms of software, the operating systems have been developed specifically adapted to devices (such as Android or iOS) that allow natural interaction using touch gestures. The widespread use of these devices today has accelerated their use by software companies.

CAD systems must process the necessary information to create a collision-free design and generate all manufacturing and assembly information. 3D model information, at the same time, is needed for other activities and other departments involved in shipbuilding, such as planning, procurement, outsourcing, accounting, etc. Usually several designers are working on the same project. It is therefore essential that the 3D model information is shared with them for review. A paradigm of this problem arises when two or more designers, working on the same project, use different CAD tools. In this case, the CAD systems have to provide data exchange between them, which leads to different degrees of integration, such as visualisation, spatial integration and cross fabrication, depending on the characteristics and size of the information transferred from the 3D model. At the very least, this should be geometry and key attributes. A worldwide format for data transfer has not yet been found. Despite recognised international standards, in most cases we see ad hoc formats or separate adaptations of standard formats. The transfer of 3D model information can lead to performance degradation due to the different approaches to representing elements that exist in the two CAD systems. In this case, special solutions need to be made to minimise this impact.

There are many advantages to using CAD in shipbuilding:

-design simplicity,

-construction speed, use and re-use of information, etc.

In the future, CAD tools are expected to evolve further and provide more efficient information management and virtual access via intelligent devices. Overall, CAD systems offer tangible advantages in process optimisation, reduced design and production times.

2 What is IoT and is it applicable to the software world?

IoT is short for Internet of Things, which is known as the technology and process of connecting objects to the Internet. The goal is to get objects to exchange data with the Internet and with each other. The idea behind the technology is to identify all objects and all people by allowing some objects to exchange data with others over the Internet. Object identification was a prerequisite for the Internet of Things. People interact with objects in a more or less direct way. The intellectual properties of objects or devices do not have to be complex and exhaustive [1].

3 Internet of Ships (IOS)

The number of connected devices reached 46 billion in 2021. By comparison, that's 200% more than in 2016. The 5G revolution, which began a few years ago, has generated enormous interest across all industries, and in some of them it is already working with seeming normality. The deployment of 5G networks is having a major impact on high-performance IoT applications related to robotics and automation, virtual and augmented reality and artificial intelligence.

Changes in the creation of global value chains are making the concept of the Internet of Things increasingly important, and this scenario will result in a significant advancement of the digital age in this sector. There is already evidence that the shipbuilding industry is not new to these developments and is already connecting some ship components to the Internet.

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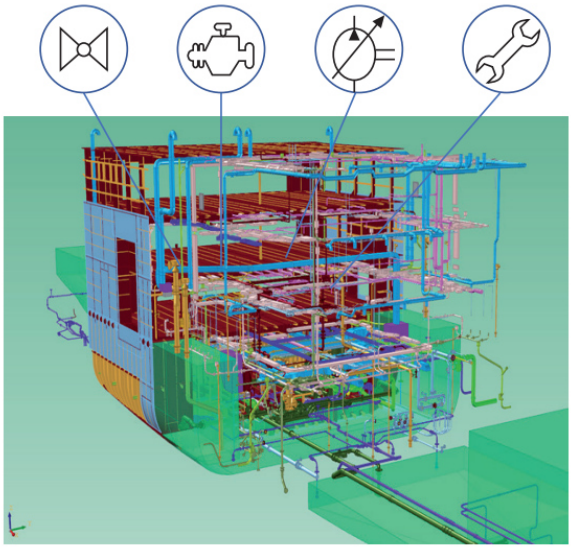

Fig. 1. 3D model with access to various ship components connected to the IoT.

Just as there is a smart home or smartphone, there are new smart boats equipped with a network of sensors that record a variety of information about the voyage, including: location, weather, ocean current, condition of onboard equipment, cargo status.

Shipowners can monitor vessel conditions in real time and perform analysis of historical and current data to make decisions for more efficient operation, saving time and fuel. Sensors and technology facilitate the implementation of new applications at sea, such as energy distribution, water control and purification,

real-time monitoring of equipment. Sensors that, for example, gather information on air quality and are connected to an artificial intelligence system that can switch heating, ventilation and air conditioning systems on and off as required.

The aim is to take advantage of this technological revolution, acting also in the design and production stages to build efficient, safe and sustainable ships. The availability of sensors in the early stages of ship construction will determine whether the ship's design is fully compliant with the design that has been created using CAD [5]. Whether it is possible to reduce the amount of materials or use another if something needs to be adjusted according to the naval architecture calculations. Continuous monitoring with ship design CAD will reduce costs, avoid errors and make decisions in real time at the shipyard, in the design office or at remote locations.

Today, CAD solutions can be used in pocket-sized tools, becoming an indispensable ally in this new technological revolution.

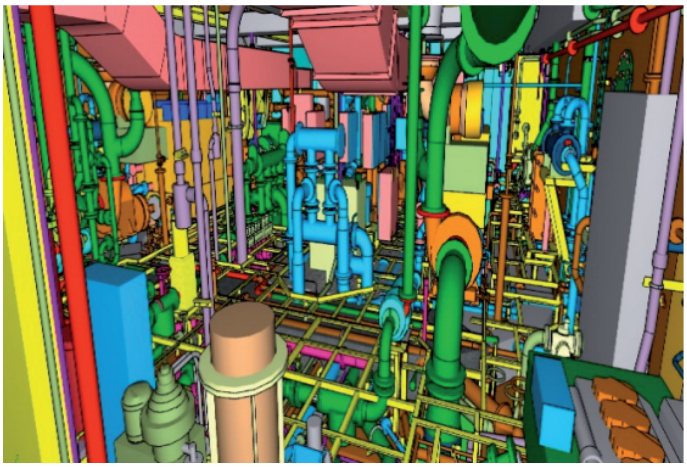

Fig. 2. 3D model in a virtual handheld solution such as tablets or smartphones.

However, data management is only one side of the technology coin. Energy efficiency is also a fundamental aspect in new devices that connect to the network. But IOS encompasses more than just the design or production stages of a ship. Once sensors are installed on the components that one wants to monitor, information can be obtained throughout the life of the ship [4].

IOS is presented as a solution capable of identifying when a piece of equipment is close to failure and needs to be replaced, when it needs to be repaired, when it needs to be repainted, when corrosion has reached a certain limit, all with a pocket tool and with enough advance to avoid delayed or unexpected action.

How could this revolution affect the world of shipbuilding? Ship designs are being developed using CAD platforms, aiming to integrate the CAD system with PLM and be able to create the entire design based on PLM and at the same time control the production and use of the ship. PLM can contain information about all of the ship's systems as well as all of its components. If the components are designed for iOS, they will have the technology to share their status, diagnostics, functionality with PLM system that distributes the original design [7].

PLM can use this information to know if they are working properly or if their performance needs to be improved. It can also determine whether equipment needs maintenance or replacement due to expiry of its service life or due to malfunction.

In the case of a vessel, this link will extend to its commercial operations to operate autonomously under operational conditions. A commercial vessel can communicate its sailing status, cargo status, goods to be landed or reloaded. All this means a wealth of information for management and analysis. New software needs to be developed to make maximum use of this information, so that the ship design can be improved on the basis of real design information and can be maintained in its own right, linked to this vast existing

information in the cloud and thus creating a method in which objects can achieve a degree of intelligence.

The development of the Internet of Ships technology is associated with the increase of information management and big data, except that IOS identifies direction and order information for a specific purpose, whereas the concept of big data is more general. The possibilities are myriad, but the principle is the same. These requirements must be configured

in the initial design, from where they will be extended to the relationships between each with other objects.

4 IOS and CAD systems

Engineers design ships according to shipowner and classification societies' requirements, but some materials change due to new regulations applied during ship design, lack of available materials or obsolete materials. In all these cases, the storage control system (SCS) software should help design teams to easily identify unsuitable materials during 3D modelling, reducing the costs associated with this problem by highlighting them.

To pre-select materials in equipment, intelligent tools connected to the SCS software can calculate the required materials based on the smart diagrams and gauges that use the required materials in the 3D design. These diagrams can consist of two design phases, basic and detailed. The first applies in the initial stages of the project and presents the basic requirements and accessories of the equipment, but the second, applied in 2D or directly in 3D, generates more accurate information. Electrical and electronic systems are based on the same principles and CAD should help designers to avoid design problems and interferences [6].

5 Conclusion

The recent emergence of IoT technologies in various industries has led to shipyards around the world becoming interested in applying the same technology to the maritime industry, and this technology is called the Internet of Ships (IOS). IOS refers to a network of intelligent and interconnected objects, which could be any physical device or infrastructure associated with a shipyard, vessel, port or maritime transport itself. The goal of this technology is to significantly advance the maritime industry towards improvement in terms of safety, efficiency and environmental sustainability.

Forward-looking tools for ship design must be open to the perception of information from smart devices and smart ships, such as the functioning of ship systems and devices, energy consumption, itineraries, etc. This information will enable the creation of new, efficient projects. The information generated by IoT technology must be able to be handled throughout the ship's life cycle, starting from the initial design phase.

CAD tools used in design must provide the appropriate functionality for this. Most of this functionality has not been implemented in existing systems, which makes it one of the most urgent tasks for the industry's specialised software developers. CAD systems must be able to absorb information from ships in service to improve the quality of new designs. The ship model must be able to contain links between internal and external components.

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