USING CAD/CAM TECHNOLOGY MORE EFFICIENTLY IN CHINESE SHIPYARDS

G. Liu, SENER Ingeniería y Sistemas S.A, Spain and Wuhan University of Technology, P.R.China
X. Zhang, United Force Corporation, P.R.China

SUMMARY

In recent years China has significantly expanded its shipbuilding capacity through the construction of new facilities and the upgrading of existing shipyards, and it is now the world's second largest shipbuilder, surpassed only by South Korea. Moreover, it can be expected that China will take the lead over the next 5-10 years.

An important factor in China’s concerted effort to modernise shipyards and become competitive in the global shipbuilding industry, has been the import of advanced production methods and equipment, in particular computer-aided design and manufacturing (CAD/CAM) systems.

However, most China’s shipbuilders are not yet taking full advantage of the opportunities offered by modern shipbuilding CAD/CAM technology. On the one hand, China is using systems that, although good ten years ago which meet many Chinese shipbuilders’ requirements, are now obsolete. On the other hand, even the best western systems are not conceived for meeting every aspect of the Chinese shipbuilding practice.

This paper discusses the history and current status of using CAD/CAM systems in China, and tries to explore the possible trend or changes of philosophy and mode of ship design and construction in.

1. INTRODUCTION

China’s great economic achievements promote her shipbuilding industry which ranks as the world’s second largest ship builder. The depression of the global shipbuilding industry influenced by the international economic depressions brings difficulties for Chinese ship building industry in takeover, delivery and the capital turnover. To help China shipbuilding industry go out of the cold season, Chinese government issued policies to support Chinese shipbuilding industry including encouraging the financial organizations to increase credit funds for ship export buyers, enlarging home market, encouraging the update of domestic old ships. However, China shipbuilding industry itself should carry out technology reformation such that the dream of being the world’s largest ship builder in 2015 can be realized. The challenges in front of China shipbuilding industry and new philosophy and merits of modern shipbuilding CAD/CAM technology are investigated in this article, which are expected to benefit China shipbuilding industry.

2. BACKGROUND AND CAPACITY OF CHINA SHIPBUILDING INDUSTRY

China is a developing country and significant economic growth has been obtained for more than 10 years, which brings her shipbuilding industry a booming period in recent 10 years. Chinese shipbuilding capabilities, both the design ability and the manufacturing ability, are improved considerably. According to the Clarksons, China overtook Japan as the number two shipbuilder last year. China has 24 percent of the global order book for new ships, South Korea has 33 percent. China’s two largest shipyard groups plan to double capacity by 2010. China plans to take a 30 percent share of the global shipbuilding market within the next ten years. This increase will challenge South Korea as the world’s largest builder of merchant ships. China shipbuilding capability will amount to 21 million deadweight tons, sharing over 25% of total world market till 2010; and will reach 28 million deadweight tons in 2015. By the Clarksons’ statistics of the world’s total shipbuilding output in 2008, the market shares of Chinese accomplished shipbuilding output, newly undertook ship orders and ship orders in hand accounted for 29.5%, 37.7% and 35.5% in the world, respectively.

China shipbuilding industry is also harmed by the global financial crisis in 2008-2009, especially the small-sized private enterprises. In February 2009, Chinese government issued the Adjustment and Revitalization Plans of Chinese Shipping Industry which shows the Chinese government’s determination to support shipbuilding industry. The plans emphasis on the points as following: firstly, to stabilize the production; secondly, to enlarge the market demand; thirdly, to develop marine engineering equipment; fourthly, to actively promote the ship repairing; fifthly, to support the merge & acquisition; sixthly, to strengthen the technical innovations.

Facing the challenges and worldwide competition, China is encouraging ship production and related developments in several categories:
(1) Design and manufacturing of high-tech, high-performance and special-purpose ships, and large ships of 100,000 deadweight tons and larger.
(2) Construction of passenger ships, passenger-cargo ships, and train ferries.
(3) Construction of liquid natural gas ships with a capacity of 5,000 cubic meters and larger.
3.2 EVOLUTION OF THE CONCEPT OF SHIPBUILDING CAD/CAM SYSTEMS

The changes/evolutions display in the following four phases
- Computer application phase

At the beginning of computer emergence, computer application is seemed as computerization and digitization. Drafting with computer, i.e., the implementation of drafting software, was the trend at that era, which is also called discarding the drafting board.
- 3D technology era

In 1990s, 3D modelling was considered as real digitization in order to improve design quality and competitiveness. Most Chinese designers’ model only detailed 3D structure model.
- Improvement of design efficiency and quality

In the past five years, dramatic achievements have been obtained in the shipbuilding industry. Chinese shipyards and design institutes are expecting that shipbuilding CAD/CAM systems can help them to obtain the biggest profit. Chinese shipbuilder requests full-ship 3D product model, including structure, outfitting, electric, etc.
- Management

Nowadays, Chinese CAD/CAM customer’s expectation on CAD/CAM technology is not only computer-aided design but also PDM solution as calculation, documentation management and control. Shipbuilding CAD/CAM systems are expected to have these functions or interfaces with other ERP and PDM software. However, customers are awaiting CAD/CAM applications with functions of ERP and PDM applications since ERP and PDM applications are very expensive.

3.3 DEFECTS OF FOREIGN CAD/CAM SYSTEMS

 Whereas, due to the language restrictions and differences of production ability level, production organization and construction mode, there exists unsatisfied aspects in the application of foreign software systems as below.
- Non Chinese interface and disability of Chinese input/output

Most professional softwares don’t have a localized language interface for certain countries as there are only very few users for these softwares in each of those countries. Even some softwares newly, entering China shipbuilding industry, don’t have the ability of Chinese input/output.
- High price

Due to the currency exchange rate, the price of introducing foreign 3D shipbuilding software into China is around very high. Furthermore, the software user should pay certain (big) amount of maintenance fees annually. However, the price of domestic software is much lower than that of foreign software, sometimes just small percent. The high price of foreign software is a big burden for Chinese media-sized and small-sized enterprises, which is also an obstacle for foreign software’s implementation.
- Low openness

Re-developments on ship CAD/CAM system, such as post-processing and data interface and so on, are also required due to different requirements of production method and technique. The lack of data openness of...
foreign shipbuilding system increases the difficulties of system reformation and re-development.

- Difference of technique processes
Foreign shipbuilding systems cannot meet Chinese industry reality in the implementation because of the differences of organization, management, culture and working procedure between China and foreign countries. Foreign systems much be customized to meet Chinese industry situation.
- Imperfect information integration
Although comprehensive shipbuilding CAD/CAM systems have already started development of interface with management systems, however few achievements have been obtained. There is a high demand of integration between CAD/CAM systems and management systems.

3.4 ANTICIPATIONS OF SHIPBUILDING CAD/CAM SYSTEMS

China shipbuilding industry is expecting excellent shipbuilding CAD/CAM systems, both foreign systems and domestic ones, which can promote her competitiveness on the following aspects.

- Promote shipbuilding technology and shipbuilding industry
2009 will be the most difficult year for China shipbuilding industry due to the global financial crisis which brings the difficulties of ship delivery, new orders and financing. According to the analysis of China Association of the National Shipbuilding Industry, China newly undertook ship orders in 2009 will decrease 65.6% to 48.4% comparing to last year. Influenced by the global financial crisis, China shipbuilding industry is facing problems such as obvious decreasing of new orders, order cancellation, surplus of productivity and lack of innovation ability. In this situation, new technology is expected to reinforce the country’s shipbuilding ability.

- Challenges to the dream of being the world’s largest shipbuilder
China shipbuilding industry has proposed the aim to be the world’s first shipbuilder in 2015. The biggest challenge in front of the aim is low production efficiency. Information technology is an important factor to efficiency improvement. It can force the change of shipbuilding mode, which has significant role for improving enterprise’s competitiveness and obtaining competition superiority.

- Implementation of new shipbuilding philosophy and shipbuilding mode based on IT technology
Modern shipbuilding requires shipbuilding software to adopt new philosophy which can bring new shipbuilding mode into practice, such as integrated hull, outfitting and painting” and “integrated design and construction”.

- Development of new type of ships (ocean engineering vessels) and equipments with proprietary intellectual property rights
Chinese government encourages projects on platforms, piping vessels, ocean engineering vessels and related equipments owning proprietary intellectual property rights.

4. PHILOSOPHY AND MAIN PHASES OF CHINESE SHIP DESIGN

Modern shipbuilding technology is a process integrating construction, outfitting and painting. Accordingly, ship design in China can be divided into the following phases.

- Initial design
At this phase, calculations on the main principles, general arrangement, main performance, structure, outfitting, machinery, electricity, ventilation, remote control, and automation etc. should be carried out taking into account the ship owner’s requirements. A reasonable scheme satisfying or over-satisfying ship owner’s requirements should be given through drafting and analysis of schemes. Documents that should be provided after this stage include design specification, general arrangement drawing, mid-section drawing, machinery arrangement drawing, equipment suppliers list, accommodation arrangement drawing, power loading specification, main system principle drawing. Main drawings and technique documents should be accepted by the ship owner, which will be the criteria for the work in the next stage.

- Detail design
Design in detail about the design scheme should be carried out in this stage, including detailed drawings’ generation, calculation documents’ compiling. Some projects may need to do model test and make test report. Finally, accurate and complete drawings and technique documents should be provided. The main drawings and technique documents created in this phase should be submitted to classification societies, authorized bureaus and ship owner for approving upon the requests of relevant conventions, rules and ship owner’s demanding. Corresponding modifications should be made according to the comments after the approval. The finalized materials are the base for production design, construction and delivery.

- Production design
All the production drawings for ship construction, working schedules, technical procedures and related technical documents are created according to the yard’s conditions where the ship is going to be constructed.

- Completion documents generation
In this stage, completion drawings are made according to the arrangement, structures, material and equipments employed in practice. Test report and trial report should be compiled. Completion calculation report of general performance should be formed according to the actual ship lines value, loading and result of inclined test. User’s manual and guidance of sailing and operation should also be given according to the requirements.

The design phases described above are changing forced by two main factors, one is the requirement (by instruction from government organization, and the desire of shipyards and design offices) of “integrated hull,
outfitting and painting” and “integrated design and construction”. Another is the capability provided by new design systems as FORAN.

The philosophy of “integrated design and construction” and “integrated hull, outfitting and painting” are well known by Chinese ship builder. This philosophy means a new mode of ship design and construction. To achieve the objective, a plenty of changes is needed. The architecture of new shipbuilding software systems like FORAN is built up based on this philosophy and it is an effective enabler for the objective.

Now almost all leading shipyards and design offices are using 3D shipbuilding systems for their design. The significant difference between new modes and old ones is that the 3D product model is used as the base of the whole product definition. All design messages are loaded and transferred by 3D model rather than 2D drawings during all design phases and drawings are used only as the final instructions for workers. The 3D model provides complete product definition/attributes including all parts even if a bolt, all assembly relevant and processes with accurate size and production information (e.g. margins). 2D drawings generated from 3D models reduce/avoid re-work maximally which can decrease design modifications.

All the processes of ship design will be an integrated design process based on 3D model. The edge between different traditional phases will be not clear. A 3D model will be effective/validation throughout contract design, classification design, detail design and production design. Finally, the ship society, designer, producer will work on the same accurate ship model. The design information and production information will be added into different phases but be kept in consistence, and then the whole design will be kept right. For design offices, that means to carry out deeper design and to charge more design fee, and in same time for shipyard, that means to get a higher design quality to increase productivity and reduce the cost of materials and man-hours.

Accurate full-ship model and technical procedure based on it can be created in the design phase, which can satisfy the requirements of “integrated hull, outfitting and painting”. Assembly margins, pipe connections, assembly procedures can be figured out accurately in design phase, which can cut re-work thoroughly. FORAN is an ideal platform fitting this philosophy and mode with its entire ship model and function of building strategy.

Building strategy can be obtained according to shipyard’s construction procedure, space arrangement, equipment ability and human ability. Even several different strategies can be obtained for optimization analysis. This can help the shipyard to optimize management and production procedure, reduce material cost and work-hours. Thus the whole production efficiency, product quality, and the enterprise’s competitiveness and profit can be improved.

FORAN system has the above mentioned capability. Each piece, pipe, equipment can be defined in the full-ship 3D model including their accurate sizes and margins. Different block division and assembly procedure can be planned according to different requirements.

5. FORAN SOLUTION

From the first stage of the conceptual design, through the initial and classification designs to the detail engineering, FORAN is a fundamental tool to reduce costs and to improve the productivity in the design and construction of vessels.

The System is applicable to all types of ships, regardless of their size, and can be fully customised to the particular requirements of each user. FORAN represents the leading edge CAD/CAM technology in shipbuilding, providing an integrated solution for the complete design of the ship, including hull forms definition, naval architecture, hull structure, outfitting, electrical and accommodation spaces, which allows the application of the concurrent engineering concept in a distributed design office environment.

Being aware of the powerful advantage of completely integrated design, manufacturing and production applications, shipbuilders and ship designers require high quality IT solutions to stay competitive. Ranging from conceptual through classification and production phases and supporting all design disciplines, FORAN provides the solution expected.

SENER with a clearly defined strategy focused on innovation and customer requirements is always looking ahead, and is continuously developing and improving all FORAN disciplines using state-of-the-art technologies.

5.1 PRODUCT OVERVIEW

FORAN, which has been continuously developed by SENER for more than 45 years ad it is at the forefront of technology, was created for the design, engineering and production of ships and off-shore platform and it is currently licensed in more than 150 shipyards and technical offices in 30 countries. Figure 1 shows FORAN solution for ship design and manufacturing, which has the following characts:

- Integrated, robust and multi-task
- Easy to install, learn and operate
- Quick and advanced modelling
- High performance, scalability and data integrity
- Open to other systems and applications
- Concurrent and distributed engineering
- Automation oriented
5.2 FORAN KEY FEATURES

- Flexible
  FORAN offers maximum adaptability, providing shipyards of any size and organization with customized solutions to design and produce all kinds of ships. Its modular structure allows for a flexible and gradual implementation.

- Optimal for modelling, drawing and reporting
  FORAN features full 2D drafting functionality and offers world-class 3D design capabilities (Figure 2), robust part modelling, 2D-3D transparency, large assembly management, simulation and product data management, all in a single full-ship product model database.

- Easy to use
  An extremely friendly graphic user interface and a shipbuilding-specific approach make FORAN a System that ship designers can easily learn, implement and operate with minimal IT support.

- Reliable
  Accurate shop-floor-ready information is generated for individual structures or outfitting parts manufacturing and also for assembling, which is the central activity in the shipyards.

- Efficient
  Significant reduction in design man-hours and material costs can be obtained, while the production quality improves thanks to the integration of all design disciplines and phases and the automatic generation of customised workshop information.

- Collaborative
  FORAN allows the carrying out of true collaborative engineering by shipyards, partners and subcontractors, using either a concurrent or a distributed environment. All users can perform concurrent design by accessing to the same database, and in addition to LAN and WAN scenarios, there is a third one based in the use of Terminal Servers (TS) technology as shown in Figure 3. The risk of incompatibility is eliminated and the coordination among design teams is kept simple.

- Open
  Exchange of data with technical and management information systems is easy thanks to the open database structure, system architecture and standard or ad hoc interfaces of FORAN.

- Innovative
  FORAN offers quick response to new user requirements thanks to its solid and powerful development platform, within a context of permanent evaluation of technological innovations in shipbuilding, hardware and software. The capabilities of FORAN are strongly supported by advanced information technologies related to data management, visualization, geometric modelling and by other technologies specifically related to ship design and manufacturing.

- Proprietary kernel
  At the core of the System, an in-house kernel, finely-tuned for the demands of users in the shipbuilding industry, provides command handling, advanced surface and solid geometric modelling, topological relationships, real time clash detection and interactive 3D visualization. The development of its own shipbuilding-specific kernel gives SENER an edge in the market and ensures the compatibility and control of future developments.

- Best-in-class components
  The architecture of the System combines SENER kernel with commercial-off-the-shelf basic software components in a layered distribution which is easy to maintain and compatible with future innovations. High-performance application development frameworks provide a common look and feel to the modern modules of FORAN and include tools for embedded development and internationalization. The data management layer is built on top of the Oracle® database server, which ensures high scalability, high reliability, data integrity, comprehensive administration and powerful configuration. A robust drafting kernel provides the
ability to integrate 2D drawings and 3D model and full compatibility with industry standards.

- Standard hardware
  FORAN pioneered shipbuilding CAD ability to run under Microsoft Windows® and continues to offer enhanced capabilities that enable ship designers to take advantage of the ever-increasing processing power of modern computers and graphics cards. Other platforms can be supported on demand.

- Multi-site operation
  FORAN supports the broadest range of concurrent and distributed engineering environments, from WAN through terminal servers to multi-site synchronous database replication. These possibilities allow designers and builders to efficiently share the 3D model from different sites when multiple teams are working on the same project.

- Enterprise IT infrastructure
  As an integral part of the enterprise IT infrastructure, FORAN offers the possibility of expanding ship design and engineering data throughout the organization, by interfacing with existing legacy software, PLM, ERP and MM systems, FEM structural analysis tools and other specific CAE applications. FORAN can exchange data in multiple formats such as DWG, DXF, IGES, VDA, VRML and XML. It is also ready to use the STEP application protocols being introduced in the shipbuilding industry.

- Production technology
  FORAN incorporates many advanced CIM features to help shipyards optimize fabrication and can be customised for any type of production equipment or process, including but not limited to plate marking and cutting; plate bending by roll or line-heating; profile marking, cutting and bending; welding robots; panel lines; pin or plate jigs for curved panels; grinding; painting; dimensional control; and pipe cutting and bending.

- Virtual reality & design review
  New solutions are available for model visualization, design review and virtual navigation. Some specific options to query the model and to simulate dismounting operations are included.

- Build strategy
  FORAN offers a solution to set up the build strategy according to the ship production process with the aim of obtaining accurate information for assembling and mounting. The build strategy is defined by arranging hierarchical trees describing the breakdown of the ship under different aspects as shown in Figure 5.

5.3 FORAN CUSTOMER CARE STRATEGIES

All FORAN-related services are provided by the Customer Support Group, staffed by dedicated engineers with expertise and experience in both ship design and System operation.

- Implementation and Start-up Assistance
  After installation, usually carried out by the users themselves, SENER offers optional technical assistance during the start-up period, at customer premises or remotely, to prepare the initial configuration of FORAN (libraries of standards, material specifications, output templates, development and testing of production links) according to the procedures and methods of each shipyard.

- Training
  With the aim of providing users with all the technical and functional skills and knowledge needed for an efficient use of FORAN, SENER offers a wide range of training courses on demand as well as pre-scheduled training courses open to individuals and companies.

- Maintenance
  In its determination to keep close contact with customers and to continually improve FORAN, SENER provides a maintenance service that includes a yearly new release and permanent technical assistance via internet (Web Support Desk and Web Meetings), phone and e-mail.

- On-site Technical Assistance
  Upon request, SENER also provides on-site technical assistance for users to reinforce their knowledge, achieve optimal operational skills or become acquainted with the improvements and new functionalities introduced in new releases.

- Specific Developments
  By using the FORAN integrated development environment (FDE), users can extract configurable product data and also create a wide range of features to improve their design efficiency, from small scripts for the automation of repetitive tasks through commands to
perform fairly complex operations. In addition, SENER can develop tailor-made software extensions upon request.

- Ship Design and Engineering Support
SENER uses FORAN for real ship design in-house, which reflects in the quality of the personnel associated with the system, very responsive in all disciplines, and with the capability to help customer shipyards with their own projects.

- Communication
SENER recognises the importance of feedback from users to provide understanding of the real efficiency of the System and to focus for future developments. The FORAN Users Meeting (FORUM) and the FORAN Users Group (FGROUP) are held periodically at different locations.

- Internationalization and Localization
SENER insists on the system innovation. Upon the market request, FORAN system’s internationalization is being carried out. The prototype for supporting double-byte character input/output has been developed. FORAN new modules already have the ability of Chinese (also other double-byte languages) input/output as shown in Figure 6 and Figure 7.

Chinese shipbuilding users hope that the foreign shipbuilding CAD/CAM software can satisfy their workflow, moreover can improve their design quality and save more time. At one time, they can master rapidly and enjoy it. FORAN also considers other desires requested by clients. For instance, FORAN has been developed to be able to use double bulb profit for projects upon Chinese clients’ demand. New version FORAN system will fully support double-byte character input/output capability, which is the strong wish of Chinese market.

6. RECOMMENDATIONS TO CHINA SOFTWARE USERS AND SOFTWARE PROVIDERS FOR EFFICIENT UTILIZATION OF THE CAD/CAM SYSTEMS

- Full training and maintenance service.
Due to high competitiveness of software, CAD/CAM software companies offer their products to Chinese shipyards/design institutes with very low prices in order to enter China market, even without training fees and maintenance fees. Thus no good training and maintenance service are provided to some customers. Thus, some customers cannot take full advantage of the latest innovation of the software. It is obligatory to get full training and maintenance service in order to use CAD/CAM technology efficiently.

- BBS service.
BBS is a very useful way for exchanging/sharing experiences. Local technical engineers using the software can ask/answer technical questions that they meet. It can help to use the software more properly and efficiently.

- Attend user's meeting.
Attend user's meeting. User's meeting is a forum for exchanging impressions on the software among users. Attending users meeting can let users know the latest technological improvements and future developments of the software which will be discussed in the meeting. However, due to high travel expenses and complicated visa application process, China users rarely attend.
software users meeting. It is a possible way to include user's meeting attendance in the software services or host local user's meeting in China territory.

- Provide good self-learning material with complete examples.

Most software companies provide CAD/CAM system to China shipyards with complete user's manual instead of good tutorial with complete examples. But the user's manual is not easy to understand for non-professional people.

- Software internationalization.

Most technical engineers in Chinese shipyard have no high English level. Moreover, almost all the first-line workers in Chinese shipyards have no English command. It is impossible for them to understand technical drawings with only English explanation. So it is absolutely essential for the software to support Chinese characters.

7. CONCLUSIONS

Facing the global financial crisis and shipbuilding industry crisis, China shipbuilding industry should take full advantages of modern CAD/CAM technology to perform philosophy innovation and mode transformation in order to consolidate her worldwide competitiveness. To reach her dream of the world’s first ship builder, China shipbuilding industry should make achievements in the following aspects.

- Improve technology capability and develop high value-added and high technology content ships and relative equipments rapidly.
- Implement the most worldwide advanced shipbuilding CAD/CAM software.
- Fulfil the requirements of “integrated hull, outfitting and painting” and “integrated design and construction” technology.
- Set up a whole integrate digital shipbuilding platform based on the PLM system applying open CAD as upstream design tool and manufacture process management software MPM as downstream manufacturing tool. Furthermore, the platform should be integrated with ERP, CRM, SCM and MES systems. Figure 8 is the structure of modern digital shipbuilding platform.

8. ACKNOWLEDGEMENTS

The authors would like to express sincere gratitude to their respective organizations for providing the support and information for this paper.

9. REFERENCES


10. AUTHORS BIOGRAPHY

Guangwu Liu, PhD from Huazhong University of Science and Technology and MSc from Wuhan University of Technology, holds the current position of Area Manager of Asia Pacific at Sener. His previous experience includes a lecturer in Wuhan University of Technology, GENCAT fellow in Spain and 6 months design experience in a ship design institute in China.

Xinhua Zhang, holds the current position of Technical Manager of Marine Department at UNITED FORCE CORPORATION.