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ADDITIVE MANUFACTURING (AM) FOR SUSTAINABLE SHIPBUILDING, OPERATIONS AND REPAIRS

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Abstract

The session on the Additive manufacturing, its application and future impact it will have on the shipbuilding and repairs was deliberated by following four panel members: Mr. Syed Abdi, Mr. Sujoy Seal, Mr. Aditya Chandavarkar, Dr K. Sastry and moderated by Capt. S. Kishore, and Mr Ulhas Kalghatgi acting as an assimilator. After the initial introduction, the moderator made opening remarks on the state of Indian Shipbuilding and its presence in this industry being negligible, except for defence projects and the silver lining was two shipyards; M/s Cochin Shipyard in Kochi, and Chowgule shipyard in Goa, who have orders to deliver autonomous ships. The session commenced with the poser, why Indian shipbuilding has not grown at all? And what role Additive Manufacturing will have in shipbuilding in future? Will it be a solution provider in the longer run? The all-pervading issues which plague Indian shipbuilding industry are the familiar ones known to everyone and the morning session on Maritime Commerce and Economy highlighted the problems facing the Indian Maritime Industry.

Keywords: AM, Additive manufacturing, Shipbuilding, Operations, Reconstruction, Maritime.

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1. CURRENT INDIAN SHIPBUILDING SCENARIO

India with a long coastline of 7517 kilometres is one of the largest maritime nations in the world. The Indian maritime sector with 13 major ports (12 state owned and 1 private) and about 205 notified minor and intermediate ports is responsible of 95% of the trade by volume (according to the Ministry of Shipping). The expansions of international trade have been much advantageous to a developing country like India. The reduction of trade barriers has encouraged India to focus on building infrastructure like roads, ports, waterways along with the development of product storage and the shipment capacity (Dr. A Mourougane, 2020).

1.1 Challenges to Indian Shipbuilding Industry

India has sufficient demand for the shipbuilding, drydocking, repairs industry as there is more than 90% of Indian seaborne trade with the foreign fleet owned by the foreign companies in spite of the competition by far bigger shipyards of China, Japan, South Korea. Some challenges experienced by Indian players in the shipbuilding industry are:

- Prohibitive cost of capital and tax burdens
- Improper logistics, lack of supply chain management, planning, coordination etc. shortage of both men and material
- Non-performing shipyards are declared under IBC by NCLT due to several factors, further COVID having a multiplier effect
- Lack of ancillary support (Jaison, 2021)

As we bring our focus to supply chain management, we explore the primary characteristics of a good supply chain can be listed as:

- Deliverance of high-quality customer responses
- Converting the inputs to outputs efficiently
- Utilization of Assets optimally

The above characteristics are also true for a spare parts supply chain. The main aim of any spare parts supply chain is to respond to customer requests satisfactorily while reducing the operating costs.

Any unpredictability in demand is one of the major issues in such a supply chain. In uncertain situations, to be able to keep up customer requests may mean having higher inventory in more locations. Organizations also need to provide support for previous and current generations of the products. This increases the inventory by many folds. Additionally, the after-sales supply chain requires competent workforce. With these challenges, supply chain managers face difficulty in delivering a high customer service while maintaining low costs. According to a study in 2009, the USA military held a stock of spare parts inventory worth USD 94 billion (Thompson, et al., 2016). These numbers are eye-catching and present an opportunity to optimize the spare parts supply chain.

A study was carried out on the present status of the supply chain management in India and some salient features are listed here:

- The facilities at Indian shipyards are moderate. These facilities combined with the upcoming developments can meet about 10% of the global ship repairs market in the coming few years.
- In India, steel is primarily used for commercial shipbuilding and repair. Quality imported steel and equipment is not commercially competitive.
- Digitized warehouse management is being enabled in most shipyards in India. However, many technologies such as blockchain, internet of things, digital warehousing is not very popular.
- India is unable to produce quality steel for ship repairs at a competitive price.

Considering the challenges and hurdles discussed, the following focus areas identified by a study can be looked into as future policy initiatives and solutions to enhance the shipbuilding and ship repair industry in India (Jaison, 2021):

- Set up an independent and empowered body for navigating the commercial shipbuilding, ship repair industry and ship recycling industry.
- Look into measures to increase availability of cost-effective shipbuilding steel in India.
- Incentivize indigenous production of spare parts equipment to be installed on new ships and replaced on existing ships during repairs. In addition, this will also require a strong technical support at all Indian ports.
- Introduce new technologies for advanced shipbuilding and repair.

2. EXPLORING NEW TECHNOLOGIES – ADDITIVE MANUFACTURING

In the past, manufacturing businesses in the past have used subtractive manufacturing processes which include cutting, drilling, molds, etc. to manufacture equipment. While subtractive process has been extremely popular, new additive style technologies are gradually replacing them. Additive manufacturing is a computer-controlled process of manufacturing a three-dimensional object by compiling layer upon layer of material on a build platform until the final product is finished. The layers can then be set and hardened using lasers or heat. Additive manufacturing has evolved significantly and is a group of technologies (Ziółkowski & Dyl , 2020):

- Binder Jetting
- Directed Energy Deposition (DED)
- Material Extrusion
- Powder Bed Fusion (PBF)
- Sheet Lamination
- Vat Polymerization
- Material Jetting

AM can play a huge role in ship repairs and logistics support. Compared to the invention of new technologies and equipment, the lifecycle of a ship long. As such, ship repairs demand a complicated supply chain management and inventory management. Ship repair industry is also complex due to the breakdowns that happen during sailing and while the geographic distance from any repair center is high. AM offers solutions to manufacture a spare part on demand in just in time

The advantages of additive manufacturing can be concisely summarized as:

2.1 Modern manufacturing:

- Many materials on one printer
- Fast iterations of prototyping
- Monolith manufacturing
- Industry 4.0 implementation

2.2 Cost reduction

- Only one production machine required
- Weight reduction
- Ships can be enabled with AM machines to reduce downtime on yards

2.3 Less space

- Less material needed on stock
- Reduction of warehouse space
- Production on demand

2.4 Environmentally friendly

- No need for global delivery
- Less machines involved in the process
- Waste minimization
- Low power consumption

2.5 Time saving

- Part optimization leads to faster repairs
- Shorter periods on shipyards
- Reduction in delivery times

The panel members did sound optimistic that AM can address few of the hurdles but not definitely all of them. AM cannot be a silver bullet to shipbuilding but may be a game changer in future. It is not panacea for all the ills looming in front of the shipyard. There was a consensus as to how the application of AM can be explored and exploited to gain advantage of the technology, because it is going to stay and gain acceptance from the stakeholders. It is a tool in future. AM can be defined as the process in which a part/component is made, by adding material layer by layer and there is no removal of the material, thus minimising any wastage.

AM has three distinct features; it is a tool to customize. It is a pull technology and not push technology.

- Part to part replacement
- A service provider in digital manufacturing
- A big solution provider, e. g. a failed component can be made with minimum loss of time and at a fraction of the cost, eliminating all the intermediaries.

The common applications are:

- To begin with small components like pump impellers, fuel nozzles could be made gradually moving on to bigger components. GE engines are fitted with nozzles using AM technology.

- There are occasions when ships are held up due to shortage of spares, or spare part not being received awaiting customs clearance, or not being able to connect to the ship at the first available port. Such bottle necks can be avoided, using AM.
- Critical components used in cranes; ship synchro lift can be made using AM. In fact, one of the panel members cited a case where for want of a critical part, synchro lift could not be commissioned delaying further activities.
- India having positioned itself in the software industry can leverage its potential to become a digital hub for manufacturing and provide the knowhow to the other players who are keen to use AM technology. Moreover, it is not capital intensive.
- Application in manufacturing refurbished parts
- Oil and gas sectors and offshore industries have shown acceptance to AM

These are the some of the applications but there is no end to it.

3. CHALLENGES

Decision makers are often skeptic regarding additive manufacturing as against to industrial manufacturing as AM is a relatively young technology. AM is reduced to only a bullet point in futuristic plans rather than any immediate strategies to adopt it. Decision makers are also inclined to rely on traditional methods which are tried and tested for many years since they need to consider safety at sea and possible financial implications of incidents at sea. However, many large organizations are gaining interest and looking into AM as a potential spare parts supply chain to be managed via AM. In addition, the involvement of classification societies in the development of 3D printing in the maritime industry demonstrates the desire to standardize AM and to enable the easy and safe manufacturing of parts by these methods.

Additive manufacturing is still a new group of technologies, but it has the potential to compete with traditional techniques. With more research and study, we can establish the best practices, reliability factors, initiation methods, potential defects for AM. AM in ship repair industry can generate solutions for many of the current issues relating to supply chain, storage space, wait times, costs, optimizing deign, etc. AM also enables parts containing many elements to be bult as a monolith which can highly optimize the parts. The risk of failure which comes with connections, assemblies, etc. can be reduced. AM can also allow for repairs to be carried out on board; thus,

reducing the downtime on yards. With short training initiatives for the ship crew, onboard repairs for specific parts can be easily implemented.

4. CONCLUSIONS

Despite capturing the imagination of the industry, as regards the potential which AM has, the challenges which need to be addressed are:

- Scaling, i. e. making of bigger components.
- Making of complex parts.
- Regulatory issues and approval from classification societies and flag administration.
- IMO needs to be taken on board, though it has selectively accepted smaller components made by AM.

To sum up, Additive manufacturing has the potential to:

- Create a revolution in making custom made spare parts to begin with and then scale up further in ship building
- Reduce cost in ship building, e. g. there are direct and indirect costs. In case of series of ships being built by a shipyard, it invariably happens that parts are replaced from those in stock. When the last of the ship is nearing completion, usually the vessel is short of a machinery component and at this point of time sourcing from OEM is likely to delay the delivery of ship. This is where AM can be used to make a part and commission the machinery.
- Add value to the manufacturing
- Replicate the parts whether made in Korea, India or elsewhere
- Adopt distributed manufacturing, i. e. make parts where needed, unlike digital warehousing, where data is stored in the cloud, which can be shared at cost. Thus, IPR can be protected.
- Change the business model
- Bring about changes in shipping industry in the next 10-20 years horizon.

To gain confidence amongst the stakeholders, regarding AM technology, few ship owners are insisting the OEM to manufacture 10-20% of parts using AM and place it on-board at the time of delivery. It is still a long way to go before AM can gain its full potential, lot of research needs to

be done, classification societies need to develop rules, procedures and guidance notes for its surveyors and the industry, but the industry has started warming up to and accepting new technologies for innovation and leaner systems.

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