Commercial Shipping: An Industry in Need of Change

By Keith Smith

Currently, commercial shipping is one of the least environmentally friendly industries on the planet. Yet still, more than ninety percent of world trade is moved by ship. This remarkable fact demonstrates the urgency with which shipping must change. Since ships spend most of their time on open water, it is incredibly hard to enforce environmental regulations. As a result, it is up to engineers to develop new technologies that are not only environmentally friendly, but budget friendly as well.

Introduction

More than ninety percent of world trade is moved by ship, and that's not changing anytime soon. Seaborne trade has quadrupled in the last forty years and is continuing to increase at an annual rate of 4 percent [1]. This growth has been made possible by the constantly declining price. Having a gallon of gas imported instead of drilled locally adds about 2 cents to the cost. Shipping is so cheap that the cost to ship Scottish cod ten thousand miles to China to be filleted, then shipped back to Scotland, is less than paying Scottish filleters [2, pp.18]. In a world like this, no wonder your shirt is made in China. While monetarily cheap, shipping is certainly still costly. The environmental impact of world trade is enormous and unfortunately, not enough is being done to stop it. Due to the global nature of shipping, it is incredibly hard to regulate. Luckily, engineers are coming up with solutions that are not only good for the environment, but good for the bottom line.

The Environmental Impact of Shipping

One of the reasons shipping is so cheap is that it is far more fuel-efficient than other methods of trade. Shipping produces 11 grams of CO_2 per ton per mile, a tenth the emissions of trucks. Air freight is the least efficient, emitting 1,193 grams of CO_2 per ton per mile [3]. Yet the massive size of the shipping industry still makes the environmental impact a concern. In 2009, John Vidal of *The Guardian* calculated that the world's 15 largest ships might emit as much pollution as all the world's 760 million cars [4]. Some estimates say the shipping industry emits a billion tons of carbon a year and nearly 4% of the world's greenhouse gases [2, pp. 92]. The reason shipping releases so many greenhouse gases is because commercial shipping vessels run on a type of fuel called bunker. Bunker fuel is so unrefined you can walk on it at room temperature. Furthermore, bunker fuel contains a high concentration of sulfur, as high as 45,000 parts per million. To put that in perspective, low-sulfur diesel used in cars is supposed to contain 10 parts per million [2, pp. 92]. Even more alarming is that according to a study done by the University of Delaware, in 2007, ambient particulate matter (more generally referred to as soot) from shipping led to 60,000 cardiopulmonary and lung cancer deaths worldwide [5]. While pollution is inevitable, the amount of unnecessary pollution caused by the shipping industry is alarming considering all of the technological advances engineers have made in recent years.

Ship Design Changes

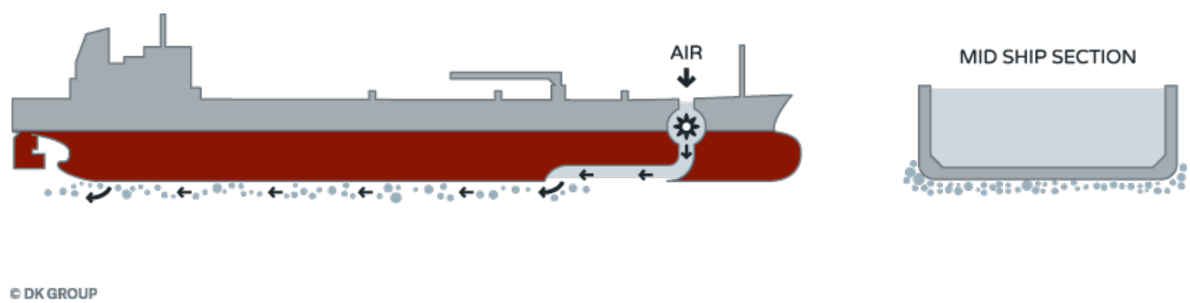
One of the ways technology is advancing is through ship design. The Maersk Triple-E class container ships are a testimony to the current advancements in container ship design. In 2011, Maersk offered a $3.8 billion dollar contract to build twenty Triple-E class ships. As of today, eight of the twenty are built and in service. All twenty are expected to be completed by June 2015 [6]. Triple-E stands for "efficiency, economy of scale, and environment." "Efficiency" means efficiency of storage. As shown in Figure 1, the Triple-E haul is box shaped, not ovular like traditional container ships. While this shape creates extra drag, the designers found that if the ship traveled at a slow enough speed, the increase in drag would be negligible compared to the increased capacity for storing cargo [6]. The Triple-E class also has duel engines. While having two engines may use more fuel than having just one, having two means that the crankshaft of each engine can be shorter. Shorter crankshafts mean the engines sit very close to the back of the ship, allowing space for more cargo. Since the Triple-E is designed for low speeds, the propellers are large and operate at a low rpm, saving on fuel. "Economy of scale" means the Triple-E vessels are the largest ships in the world, also with the largest carrying capacity of 18,000 TEU, or Twenty-foot equivalent units, the standardized size of a shipping box. The improved design of the Triple-E allows it to carry 16% more boxes than the world's previous record holder, the Maersk Emma class, while only being 3m longer and 3m wider [6] [7]. Increasing the number of boxes that a vessel can hold significantly reduces the vessel's CO_2 emissions per pound of cargo, which ultimately is the most useful measurement of environmental friendliness. The Triple-E even has a waste heat recovery system that allows for more fuel efficiency by using the hot exhaust gas to produce extra energy used for propulsion. All of these factors combined mean the Triple-E class uses 50% less CO_2 per container than the Asia-Europe average [6].

http://www.worldslargestship.com/the-ship/#page/efficiency/shape-of-change

Figure 1. Triple-E hull shape compared with traditional container ship hull shape.

Air Lubrication Technology

While impossible to know for sure, it seems that the future of ship design will be based around the idea of air lubrication. For ships, fuel consumption is mostly dependent upon hull water resistance. Up to 90-95% of hull water resistance is due to friction between the hull and the water [8]. Air lubrication creates a layer of air between the hull and the water, reducing the contact area between the two and therefore reducing friction. The only company currently outfitting new and existing large vessels with this technology is Silverstream technologies (formally DK Group). As shown in Figure 2, their patented Air Cavity System works by filling a cavity, which runs along the mid ship from the bow to the stern, with compressed air. This layer of air between the bottom of the hull and the water all but eliminates friction in that part of the ship, leading to an increase in fuel efficiency by up to 10%. Ship owners can expect a return on investment usually between 18-30 months. Silverstream technologies claims it takes 14 days to install, results in no reduction in deadweight capacity, and is a cosmetic rather than structural change to the hull [9].



http://dkgroup.eu/userfiles/images/acs.png

Figure 2. Diagram of Silverstream technologies Air Cavity System.

Other competing air lubrication technologies exist, such as the Mitsubishi Heavy Industries Micro-bubble system and the Stena Bulk Airmax system. However, neither of these systems are commercially available yet [10]. The current trend in container ship design, as shown by the Maersk Triple-E, is shifting away from the more streamlined V hulls to the more space efficient rectangular hulls. This gives air lubrication technologies even more potential for future use, as the data shows that the less hydrodynamic the ship, the more beneficial to fuel efficiency air lubrication will be [10].

Reducing Near Coast Emissions

Ship design is only a small part of the technological advances occurring in the shipping industry. One of the ways old and new ships alike are helping keep our environment safe is hooking up to mainland power lines while loading and unloading. This avoids having to idle while in port, reducing near-coast emissions. Idling in port was the cited as the main contributor to the 60,000 deaths a year due to soot [5]. The International Maritime Organization (IMO), a United Nations specialized agency dedicated to shipping, has also recently placed a limit on the sulfur content of fuel within 200 miles of the US coastline as well as other areas [2, pp.97]. In order to oblige with these new limitations on sulfur content, ships have adopted the practice of switching fuel supplies near coastlines in order to reduce near-coast emissions while maintaining the cost effectiveness of burning dirtier fuels like bunker out on the open ocean [2, pp.97].

Environmentally Friendly Paint

A major way the shipping industry has recently changed was a ban on TBT in 2008. TBT was a chemical used in ship paint to prevent organisms from growing on the side of ships, but was banned by the IMO for its harmful impact on all organisms, including mammals. The cost effectiveness of TBT was so great that prior to 2008, it was used on practically every marine vessel [11]. Since banning TBT, the market has been flooded with new products. The four main types of replacement paint coatings are Self-Polishing Copolymers (SPC), Contact Leeching Systems, Controlled Depletion Polymers (CDP) and Foul Release. The first three types of coatings mentioned are biocide-releasing agents. These coatings stop the buildup of organisms by slowly releasing biocides, or toxic chemical substances, at a slow rate as the ship moves. The biocide is mixed with a binder which controls the release of the biocide. Due to the nature of the binders used with these coatings, in order for biocide-releasing agents to work, the boat must be moving fast enough for the current to dissolve the binder, so ships that spend long periods of time in port will not be able to use this method. The difference types of biocide paint coatings mostly differ only by which type of biocides they release. Foul Release coatings work not by killing organisms, but by preventing the adhesion of organisms to the hull. Organisms that stick to the sides of hulls commonly use organic “glue” to attach themselves. Foul Release coatings lower the surface energy of the hull, making it harder for organisms to hold on. Foul Release coatings have the advantage of lasting longer than biocide-releasing coatings and do not release toxins. However, foul release coatings are potentially not as effective [11].

Shipping Container Advancements

While currently paint coatings are seeing a massive transition phase, soon in the future, shipping containers could also enter a huge transition phase. In 1956, the shipping container was invented by Malcolm McLean and forever changed the shipping industry. Before the shipping container, liquids were shipped in barrels, consumer goods shipped in different sized boxes, and wood and steel shipped in tied together piles. With every type of freight having its own shapes and sizes, the loading and unloading process was extremely inefficient. The standardization of the shipping container reduced the cost of shipping from 25% of an object’s value to the pennies it costs today [2, pp.39] and the original design has gone largely unchanged since then. But now, Dr. Stephan Lechner of the European Commision’s Joint Research Center has proposed that the shipping containers, usually made of steel, could be made from carbon fiber instead [12]. Besides being significantly lighter, the boxes could be designed to fold up, saving space when empty. Dr. Lechner believes it would only take three trips around the world for these boxes to end up being cost-efficient; a small distance when you consider that to cross the Pacific Ocean takes a container ship on average 15 days. Carbon fiber boxes would also make shipping safer, since carbon fiber boxes can be easily searched using what are called “soft” x-rays; much cheaper than the high-powered x-ray machines required to search steel. The shift from steel boxes to carbon fiber would mean not only better fuel efficiency, but also better security for our borders [12].

Political Problems with Regulating the Shipping Industry

Until recently, the shipping industry has remained relatively untouched in terms of environmental regulation. Part of the problem is due to a practice called "flagging out". Since ships are constantly traveling all over the globe, most of the time they can pick which country they choose to call "home". Picking nations that have cheaper taxes and more lenient labor laws as "home" is an advantage. As a result, as of January 2013, the nations with the world's largest fleets in terms of deadweight tonnage were Panama (21.5%), Liberia (12.2%), and the Marshall Islands (8.6%) [13]. Three out of every four ship owners choose to flag out. Owners who choose to fly the flag of their home country typically do so because law requires them to, such as if their ships carry government cargo [13]. When owners flag out, countries with high standards in terms of inspections are rarely picked over countries where evading regulation is much easier, making international regulations difficult to enforce.

The other part of the problem is with the regulations themselves. International regulation of shipping practices primarily comes from the IMO. Environmental laws have not been on the IMO agenda until recently due to the organization prioritizing maritime safety over the environment. 2,000 people die at sea every year and more than two ships a week are lost [2, pp. 69]. With numbers as high as those, it is easy to see why environmental issues have been overlooked in an attempt to save human lives. However, pressure has been growing on them to begin regulating more than just maritime safety, and reducing greenhouse gas emissions is now above safety on their agenda [14]. Recently passed regulations require new ships to increase their fuel efficiency by 10% for 2015. However, ships registered in developing nations, where 75.5% of the world's fleet is registered [13], have until 2019 [2, pp. 94]. In many of these developing nations whose flags the world's ships fly, the inspections will likely not be adequate enough to enforce the new regulations anyway.

Conclusion

As shipping continues to grow, the environmental impact of the industry will only increase. While lawmakers will play a part in helping to protect our environment, the nature of shipping allows for laws and regulations to be easily avoided. Therefore, it is up to engineers to not only create profitable solutions, but to effectively communicate these solutions to the shipping community. New technologies only matter if they are implemented, and therefore communication is equally as important as creation. Hopefully someday soon some of the new technologies mentioned in this article make it into mainstream use.

References

For more information on the shipping industry in general, including excellent chapters on topics not covered in this article such as noise pollution and piracy, see Rose George's book *Ninety Percent of Everything*. To learn more about the Maersk Triple-E, visit http://www.worldslargestship.com/. For more information on alternative hull coatings, visit http://fathomshipping.com/userfiles/files/b85b16066a682bcef16114f6b63c65b2.pdf. For more facts about the shipping industry and international shipping laws visit http://www.imo.org/Pages/home.aspx.

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