Berthing the world's largest vessels

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Historically, port infrastructure has been designed to accommodate a certain size and type of vessel. However, with vessel sizes steadily rising, many have had to reassess and ultimately upgrade their infrastructure, and many are still in the process of doing so.

Trelleborg's 2014 Barometer Report found that, when it comes to upgrading port infrastructure to accommodate larger vessels, 52% of people surveyed feel the industry is only keeping up reactively well. When the report was carried out in 2013, the majority of respondents believed that increasing vessel sizes meant ports would need to upgrade infrastructure.

It's clear that the new era of mega-ships brings with it a new set of challenges in the design of port infrastructure, and marine fenders are a key component in this evolution. Far from being the commodity products they have been perceived to be in the past, highly engineered solutions are required to berth this new breed of ship efficiently and safely. As vessels continue to grow larger and more diverse, so too do the demands on fenders.

Assured performance

The life expectancy and performance of fender systems is highly dependent on the rubber element. From the ingredients used – the type of rubber and the fillers used to reinforce it – to their formulation and manufacturing process, all must be considered in order to guarantee a product that will perform over a long and arduous service life.

The ingredients used

The ingredients used to produce the rubber element in marine fender systems are critical in ensuring the quality of the fender's rubber component. Firstly, natural or virgin rubber is superior to reclaimed or recycled. The recycling of rubber is an energy intensive process in which rubber powder is cooked with aggressive chemicals. This process breaks long rubber molecules into shorter ones, thus reducing their physical properties. Usually the tensile strength of recycled rubber is one-third of natural virgin rubber.

Raw and virgin rubbers are soft; they don't have sufficient mechanical strength to produce commercial products that can safely berth the world's largest vessels. To strengthen the rubber, carbon black is needed – a reinforcing filler that improves mechanical properties many-fold and transforms rubber into a product suitable for commercial applications. Carbon black reinforces the rubber through the formation of its molecular network in the vulcanisation process – resulting in a substantial increase in stiffness, tensile strength and abrasion resistance.

As well as the ingredients used, the ratio of ingredients is important too. A superior compound formulation suitable for fender applications comprises a minimum of 45% raw rubber and 20% carbon black, a maximum of 5% ash, oil and other ingredients.

The mixing cycle

A critical factor in guaranteeing the performance of the fender is ensuring the uniform distribution of carbon black within the rubber. The carbon black has to penetrate the long molecular chains of the rubber, which isn't easy to achieve as raw rubbers are solid and carbon black is a powder.

An adequately equipped and robust mixer is essential to facilitate a high quality mixing process, which uniformly disperses the carbon black within the rubber. There are a number of mixer related parameters which have a direct impact on mixing quality.

Firstly, the ram, which is used to drive the raw materials into the mixing chamber needs to exert sufficient, controlled pressure. The rotors used in the machine should be manufactured from high quality steel to ensure strength and enable the effective tearing and shearing of the rubber. They should also have variable speeds, so that the viscosity and temperature of the process can be controlled.

The jackets or sides of the machine, the discharge door and the bed plates should be manufactured from high quality steel for strength. The chamber itself requires some specific features too. For example, the cooling system is extremely important in guarding against hotspots and ensuring a uniform batch temperature.

The quality of the mixing process can be determined using the dispersion rating: a measurement of the uniformity of the carbon black distribution into the rubber's molecular chains. Poor dispersion highlights an inferior mixing cycle and a less robust compound, which jeopardises the quality and performance of the final product.

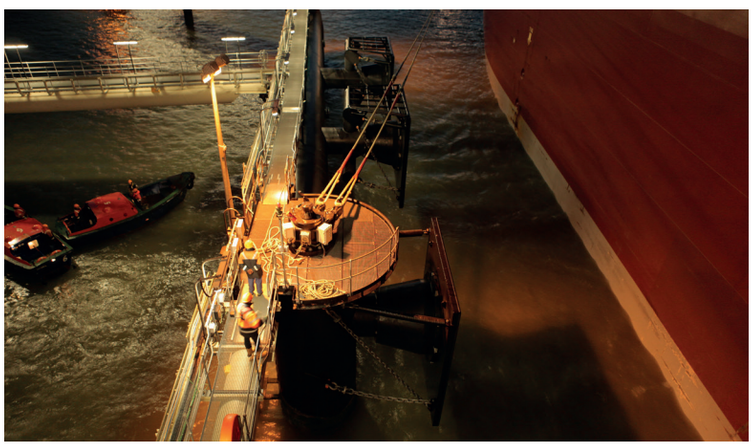
There is a direct correlation between dispersion and the other physical properties of the rubber compound, and therefore between dispersion and the performance of the fender system.

Controlling the variables in the mixing process

Being able to continuously monitor the mixing process as it is undertaken in the chamber is invaluable to ensure control of all the variables. All of these elements have to be considered in manufacturing marine fenders with performance characteristics capable of berthing the new era of mega-ships.

Trelleborg's marine operation suggests that the industry should begin to move towards measuring the dispersion of carbon black within the rubber chains, and using a dispergrader provides a straightforward opportunity to do so.

Taking the pressure off the infrastructure



The rubber component of the fender system can be developed in other ways too, and can even lessen the burden on other port equipment in accommodating mega-ships. Some port operators think that equipping ports for larger ships equates to larger fenders and the issue of insufficient crane outreach is growing. Replacing cranes or extending existing ones can be a costly affair, so fender solutions with a smaller profile and more efficient performance provide an effective, lower cost alternative.

The question has been asked whether fenders with smaller profiles are capable of providing increased performance efficiency, given the presumption that larger vessels require larger fenders with greater load-bearing capabilities. The solution lies within both enhanced rubber composition as well as improved fender efficiency, through better geometry design of the rubber fender.

The biggest challenge is designing a fender solution that will ultimately perform just as successfully with smaller ships as they do with the largest of vessels. In designing such a system, it is essential that the rubber compound is fine-tuned to absorb energy from smaller vessels as well as from larger ships.

To achieve this, manufacturers must adapt design based on operational conditions such as berthing speed, berthing angle, temperature, velocity, and required energy absorption. The properties of the rubber element must be hard enough to withstand the high loads from larger vessel, yet soft enough to accept the loads from smaller vessels.

Testing at full-scale

To accommodate the new breed of mega-ships safely, full scale testing is critical, in addition to materials testing. With higher

forces coming in to berth, the pressure exerted on the fender system is greater than ever, and manufacturers need to be able to prove beyond doubt that systems can cope with this and protect the port environment.

Trelleborg has recently invested in a new, custom-built high speed test rig, which is capable of testing both rubber and foam fenders. Once complete, this will be the biggest fender test rig in operation in the industry.

Whilst most industry test presses are only able to test using a constant velocity (CV) method of two to eight millimeters per second, the new rig allows for real-time testing at up to 150 millimeters per second compression speed, using a decreasing velocity (DV) method, in line with PIANC's 2002 guidelines. This will allow Trelleborg to undertake full scale testing at speeds that accurately reflect onsite berthing conditions, without relying on extrapolated data from two to eight millimeters per second test speeds and applying velocity factors.

Conclusion

There are many innovative ways that fender manufacturers can help port owners and operators to berth the new breed of megaships. The key to this innovation though, is quality. With bigger vessels, come bigger demands and bigger consequences when things go wrong. By working closely with suppliers to capitalise on the latest technologies and evolutions in engineering, port owners and operators will be better placed to insure themselves against these increased risks.

About the author

Richard Hepworth is a chartered mechanical engineer. Having studied for his degree at the University of Manchester Institute of Science and Technology, he now holds the position of Business Unit President for Trelleborg Marine Systems. Before moving to Dubai in 2013 to spearhead a new, centralised Trelleborg Marine Systems headquarters, Hepworth spent a number of years in Singapore, establishing an effective, integrated sales and production network. Hepworth has over 20 years' experience working in the offshore and marine construction industry and has held a number of roles both within Trelleborg and other large engineering companies in these sectors, covering engineering, project management sales, business development and general management.

About the organisation

TRELLEBORG

Trelleborg Marine Systems designs, manufactures and installs bespoke fender systems, docking and mooring equipment, oil and gas transfer technology and vessel efficiency technology for marine environments all over the world. Trelleborg works with specifiers on a project-by-project basis to determine best-fit solutions and supply fully integrated systems to fulfil even the most demanding specifications.

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