Box-shaped pressure vessel for LNG developed by KAIST research team

March 21 2014

This is a photo of the prototype of a box-shaped pressure tank. Credit: KAIST

Earlier today, Korean researchers successfully showcased the installation and operation of a box-shaped, high-pressure tank for the storage of liquefied natural gas in Pohang, Republic of Korea. The development was the first of its kind in the world.

Pressure vessels have many applications and are widely used within the

petrochemical, energy, and other industrial sectors where the transport and storage of many types of pressurized gases and fluids are essential. Pressure vessels must be designed, manufactured, installed, and operated strictly in accordance with the appropriate codes and standards since they can, in cases of leak or rupture, pose considerable health and safety hazards.

Pressure vessels are normally designed in the form of a cylindrical or spherical tank. These shapes are, in principle, highly efficient in withstanding internal pressure, but rather inefficient in terms of space utilization. The tanks fit very poorly within a typically prismatic-shaped room. They cannot be packed closely together, so they do not efficiently utilize the overall space. Moreover, cylindrical or spherical tanks are not easily scalable to very large sizes because the wall thickness of the tank must increase proportionally to its overall radius. Therefore, a large pressure vessel unavoidably will have very thick walls, which are difficult and expensive to manufacture, requiring a great amount of thick-walled steel to be rolled, forged, and welded together.

KAIST researchers, sponsored by POSCO, a multinational steel-making company based in Pohang, Republic of Korea, have taken a turnabout approach to construct a pressure vessel that is neither cylindrical nor spherical. Professors Pål G. Bergan and Daejun Chang and of Ocean Systems Engineering at KAIST developed a box-type, large size pressure vessel for the storage and transportation of liquids such as liquefied petroleum gas (LPG), compressed natural gas (CNG), or liquefied natural gas (LNG).

Above is a container ship having a box-shaped pressure vessel as a fuel tank, and below are traditional cylindrical fuel tanks. Credit: KAIST

The box-shaped pressure vessel has an internal, load-carrying lattice-type structure. The lattice pattern is modular in all three spatial directions, thereby effectively anchoring and balancing pressure forces on the external walls of the vessel. The modular lattice can easily be adapted to prescribed pressure levels as the overall volumetric dimensions are directly linked to the number of repetitive modules. A giant prismatic pressure vessel with a size of 20,000 m3 and a design pressure of 10 atmospheres (10 barg) can be built simply by scaling up a smaller size pressure vessel. It is interesting to note that the thickness of steel walls remains unchanged and that the weight of steel per unit storage volume

goes down as the vessel size increases.

Professor Chang explained the benefit of a prismatic or box-shaped pressure vessel.

"If we use cylindrical pressure vessels to supply LNG fuel for a large container ship, for example, many fuel tanks will be needed. Those tanks will take up large and valuable space onboard because the cylinders have to be lined up. In our case, however, much less space is needed. The operation of a ship becomes simpler with one fuel tank rather than with many. Furthermore, our box-type pressure vessel can be designed with dimensions that precisely fit a ship. For a container ship, there may be room for a substantially higher number of containers to be loaded than when using cylindrical vessels. In a case study on a 13,000 TEU container ship, the value of the increased transport capacity tuned out USD 8.4 million for one year of operation for one ship."

The manufacturing cost of a pressure vessel has been reduced as well. Several types of special steel for cryogenic (low temperature) applications have been investigated in design and analysis studies, and this includes a new type of high-manganese steel that is being developed by POSCO. Regardless of materials, in any instance of large pressure vessels, the new lattice tank technology can offer significant savings of combined capital and operational costs.

Professor Bergan was also upbeat regarding the impact of the KAIST technology innovation.

"Our box-type pressure vessel represents ground-breaking research. This innovative technology will dramatically change the rules of the game for industry concerning production, transportation, and storage of fluids under high pressure and at low temperatures."

The showcased prismatic pressure vessel was a scale-down model with a volume size of 80 m3 and design pressure of 10 atmospheres. The vessel complies with the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (BPVC), the international standard for the appropriateness of design, fabrication, and inspection of boilers and pressure vessels. It passed the 15 pressure testing in January 2014 and received an accreditation from the ASME BPVC (ASME U2 Stamp).

Provided by The Korea Advanced Institute of Science and Technology (KAIST)