Sinking Caspian Sea needs innovations

The vast majority of higher-class icebreaking vessels working in the region have been designed by Aker Arctic. The Mangystau class vessels have a draught of 2.5 metres.

Water levels in the Caspian Sea have fluctuated for centuries. However, the continuously falling water levels of the past decades have worried investors about the possibility of continuing sea logistic activities in the Northern Caspian Sea. Dredging and vessels with lower draughts offer possible solutions to the problem.

The Caspian Sea is the world's largest enclosed basin of water. Its main source is the Volga River, but it also receives water from the Ural, Kura and Terek Rivers. With no connection to the global oceans, the average Caspian Sea level is about 27 metres below mean ocean level.

Over the past centuries, the water level has fluctuated significantly, including changes of several metres within the past decades. The historical causes are uncertain, but increased evaporation rates over the Caspian Sea are believed to have played a dominant role during more recent times. The current long-term decline is expected to continue into the future, under global warming scenarios, according to research.

Shallow waters

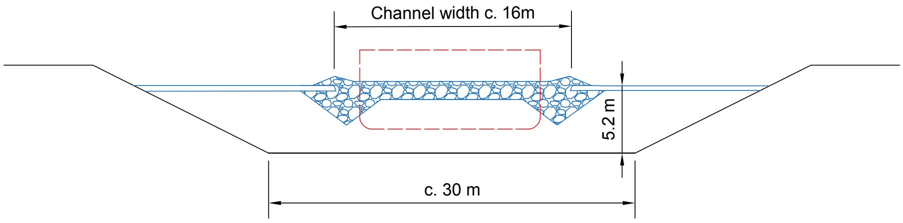
In addition to falling water levels, the Caspian Sea has many areas of shallow water. The northern part of the Caspian Sea is the coldest and most shallow area with a depth of only three to four metres. During winter, the sea freezes due to low salinity levels and subarctic temperatures down to –30 °C, and the support of icebreaking tugs is needed to transport goods and material between the artificial islands of the Kashagan oil field located in the area.

The highly pressurized Kashagan reservoir contains high levels of toxic hydrogen sulphide (H_2S) as well as carbon dioxide (CO_2). The development of the Kashagan field therefore presents a unique combination of technical complexity and supply-chain coordination in the harsh offshore environment.

The shallow-water field is currently in its first phase of development. Two additional phases are under discussion with authorities, in order to bring the asset to an output of 1.1 million barrels per day by 2055 or later.

Dredging channels

In April 2021, the Kazakhstan authorities gave Kashagan operator North Caspian Operating Company NCOC permission to execute a dredging project to dredge navigation channels from the deeper water area to the existing artificial production islands.



During winter, after icebreaking, the surface of the channel is a mixture of ice sheets and sludge. Every time the ice is broken, the ice sheets and sludge are mixed increasing the formation of new ice. Therefore, the ice formation in a canal is heavily dependent on the frequency of the ice-breaking.

The dredged channels will help NCOC to extend the use of its actual fleet to transport personnel, supplies and equipment to the field's D-island and four satellite islands. The work will be divided into two phases: construction of a long navigation channel to reach deeper waters and a connecting channel to link the islands together, including vessel-turning basins. The total length of all dredged ship channels will be about 45 kilometres.

Challenging winter operations

However, operating in dredged channels during winter presents a further challenge.

In an ice channel, each passing vessel breaks the insulating ice shield, which leads to a heat loss from the water mass. This heat loss accelerates the ice formation, firstly increasing the thickness of the ice sheet or the brash ice layer, and secondly creating ever larger ice blocks, hindering the flow of the traffic.

According to an Aker Arctic study, the passing of four vessels a day may increase the ice formation five times higher than it would be without any traffic. A snow cover further influences navigation, as snow easily turns into ice when coming into contact with cold water.

Ice thickness grows

The ongoing navigation also affects the thickness of the ice layer. Each vessel pushes brash ice to the sides of the channel, increasing the ice layer thickness. This brash ice layer typically reaches a width of one vessel breadth on each side and its thickness may be two to three times the thickness of the brash ice layer in the middle of the channel. The ice collars on both sides of the vessel make navigation even more difficult and increase the risk of collision when other ships are passing by.

The ice mass in the channel grows with time, increasing the vessels' resistance. As a vessel moves in the channel it pushes ice blocks under the hull and in shallow waters the ice mass, though loose, may reach to the bottom and prevent vessels from continuing.

Furthermore, if the channel moves because of currents and winds, and the vessel needs to get out of the brash ice to remain in the dredged channel, the vessel will have to penetrate the thick side walls.

Shallow draught icebreakers

Designing vessels for icebreaking in shallow water is not only about the hull form. Shallow water also has a big effect on various other functions of the vessel, particularly on propulsion efficiency and propeller thrust. Thick, brash ice in connection with shallow water can dramatically reduce propulsion efficiency, resulting in poor vessel performance.

Weight control becomes critical, and understanding the effect of different technical solutions and their effect on weight, such as the steel structure and the use of lighter materials, is vital.

Other important aspects to consider are a shaft-line sealing system for protection, the cooling water intake, and the location of air intakes to ensure minimum freeboard.

Lastly, an important fact to highlight is that shallow water areas are often characterised by a fragile environment, with possibly an ecosystem that is maintained through a delicate equilibrium. Therefore, it is crucial to reduce the local emissions caused by the icebreaker as much as possible. This is done in the design phase, choosing environmentally-friendly propulsion and applying zero-discharge policies, but also during operations, avoiding the most fragile areas when navigating. ■

Aker Arctic shallow draught icebreaking vessels

Aker Arctic has designed shallow draught icebreaking vessels since the 1970s, especially for shallow Arctic rivers in the Soviet Union and operations in the Caspian Sea, gaining solid experience in the field.

"The vast majority of higher-class icebreaking vessels working in the region have been designed by Aker Arctic," says Sales Manager Arto Uuskallio.

"The draught trend has continually moved towards even more shallow vessels, beginning with a three-metre draught in the 1970s to a possible ultra-shallow 1.5 metres today."

The development has so far resulted in four different designs for various purposes totalling 21 vessels.

Kapitan Chechkin class (1970s)

- 6 vessels
- draught 3.25 m
- icebreaking capability 0.7 m
- three 1.17 MW shaft lines

Kapitan Evdokimov class (1980s)

- 8 vessels
- draught 2.5 m
- icebreaking capability 0.9 m
- four 0.95 MW shaft lines

Antarcticaborg class (1998)

- 2 vessels
- draught 2.9 m
- icebreaking capability 0.9 m
- two 1.62 MW azimuthing propulsion units

Mangystau class (2010—2011)

- 5 vessels
- draught 2.5 m
- icebreaking capability 0.6 m
- three 1.6 MW azimuthing propulsion units

A notable addition to the list is the Austrian shallow-draught river icebreaker built for the Danube River: *Röthelstein*, delivered in 1995. She has a minimum operating draught of only 1.57 m and an icebreaking capability of 0.7 m. The vessel has two 0.56 MW azimuthing propulsion units.

Aker Arctic has conducted full-scale ice trials with all of its shallow water vessel designs, and has been able to compare the resulting data against the model test data from the ice laboratory.
"In this way we have been able to further develop the efficiency of icebreaking in shallow waters," says Uuskallio. ■

Kapitan Chechkin class

Kapitan Evdokimov class

Antarcticaborg class

Mangystau class

Röthelstein