determined by experts in the field. Furthermore, valve fluid without oil contents, such as dry gas or water without oil, are found to enhance the problem in general, resulting in increased friction over time. Eventually, highly polished surfaces seem to increase the problem with respect to the unexpected size effect and the unexpected fluid type effect.

When the friction problem occurs, it will in general increase with time or operation cycles in a real full scale gate valve. The problem is still not quantified in great detail and the mechanisms resulting in the problems are not yet understood in great detail. But in addition to what is mentioned above the problems have been found to in general increase with increasing level of friction, increasing sliding distance, increasing contact pressure, increasing temperature, and particularly, the problems increase with time or operation cycles. The prevailing mode of friction is probably a dry or mixed type of friction. The problem is found to be very relevant for gate valves, particularly subsea gate valves, presumably due to large sealing surfaces, high pressures and long sliding distance.

The objective of the present invention is to reduce or eliminate the friction problem discussed above.

These objectives are obtained by a gate valve according to claim 1, a method of commissioning or operating a gate valve according to claim 5, and use of a diamond like carbon (DLC) top layer according to claim 8. Additional preferred embodiments are claimed in the dependent claims.

Summary of the invention

To this end, one aspect of the invention provides a gate valve for control of petroleum production or water injection, distinctive in that at least one surface subject to sliding in operation of the valve comprises a top layer coating of diamond like carbon (DLC). The DLC-coating comprises sp3 bonds or a combination of sp2 and sp3 bonds, characterised in that the DLC-coating comprises hydrogen.

The solution of the invention solves or mitigates the above mentioned problems. This is very surprising since persons of ordinary skill in the art would have no

Full scale testing has revealed that the type of DLC coating is critical. The valve is tested to simulate real life conditions. This includes operation of the valve at both elevated temperatures and with both gas and fluid as pressure medium in the valve. Typical differential pressure in the valve during operating is 69 MPa, but could be as high as 138 MPa. A typical gas used for testing is nitrogen.

In nitrogen or other dry inert gasses the inventors found out that DLC containing hydrogen has a clear benefit over DLC coatings without any hydrogen, especially a-C:H DLC with a hydrogen content of 17 atom-% or more.

In a preferred embodiment the DLC-coating is applied on top of a carbide-coating or a chrome nitride coating. Preferably the DLC-coating has been applied by PVD (physical vapour deposition) , PACVD (plasma assisted chemical vapour deposition) or CVD (chemical vapour deposition); alternatively other application methods known in the art for DLC coating application, directly on metal objects or on sub coatings, can be used. There are several suppliers that can apply DLC coating, such as Oerlikon Balzer of Lichtenstein and DIARC of Finland.

According to one aspect of the invention, a method of commissioning or operating a gate valve according to any of above embodiments is provided. During commissioning or assembly, the at least one surface with a DLC top layer coating subject to sliding in operation of the valve is operated or treated to a point beyond a top of high initial friction according to a curve of friction coefficient against sliding distance or close-open cycles in operation.

According to another aspect of the invention, use of a diamond like carbon (DLC) top layer coating comprising hydrogen is provided. Preferably more than 16 atom-% hydrogen and most preferred more than 17 atom-% hydrogen, on at least one surface subject to sliding in operation of a gate valve for control of petroleum production or water injection is provided.

The invention provides use of a diamond like carbon (DLC) top layer coating on at least one surface subject to sliding in operation of a gate valve for control of petroleum production or water injection. Preferably, the use is for a subsea petroleum production or water injection Xmas tree gate valve, for coating at least one of all interfacing sliding and sealing surfaces.

Figures

The invention will be further explained in the following detailed description with reference to the drawings, of which:

Figure 1 illustrates an embodiment of a gate valve according to the invention, with surfaces coated by DLC;

Figure 2 illustrates the underlying problem of the invention;