Friction coefficients for steel to steel contact surfaces in air and seawater

R.J.M. Pijpers, H.M. Slot

Addresses of authors: TNO, Stieltjesweg 1, 2628 CK Delft
Author contact email: richard.pijpers@tno.nl

TNO innovation for life

INTRODUCTION

In various types of offshore structures, friction based joints are used of which the friction coefficient of steel to steel surfaces in air and/or seawater is uncertain. The friction coefficient is known to be dependent on the surface condition, contact pressure and environmental condition.
This paper gives the results of the dedicated laboratory friction tests for the derivation of the coefficients of friction for a variety of steel surface conditions and loading conditions, in air and in artificial seawater environment.

OBJECTIVES

The objective of the friction measurements is to quantify the coefficient of friction for offshore applications regarding various steel surface conditions. This enables quantification of friction properties for steel – steel contact (static and dynamic coefficients of friction) based on sub-sized contact surfaces of about 100 mm × 40 mm.

METHODOLOGY

Through a series of laboratory friction tests on small scale specimens, an understanding of the physical behaviour is gained. The laboratory tests have been executed by TNO in the Structural Dynamics lab. The test set-up composed of two hydraulic actuators working in perpendicular directions. A horizontal jack has been used to gain the normal force on the steel plates to obtain contact pressures varying between 2 MPa and 40 MPa; a servo-hydraulic actuator was used to generate a displacement controlled cyclic movement of one of the plates. In this way, the static friction force is measured at the start of the test and the dynamic friction force during a short time of continued slip between the plates. All friction specimens are made of steel plate S355ML, 25 mm thick.

The friction test assembly was composed of a double working inner plate and two single working outer plates, see Figure 1 and Figure 2. In this way, the measured friction force during the test was not polluted by the (not always constant) friction of another sliding system in the test setup. In fact, because both sides had exactly the same treatment and quality, an effective contact area twice the mentioned nominal contact area was used. For creating a realistic corrosive environment, artificial seawater has been used.

For creating a realistic corrosive environment, artificial seawater has been used. Figure 3 shows a plexiglas container for the friction tests in artificial seawater.

RESULTS

The test program of the friction tests contained 25 test specimen variants (in total 75 tests), with a combination of dry air and seawater environment, varying contact pressures and (combination of) various surface conditions: clean steel, mill scale, pre-corroded and calcareous layer as a result of cathodic protection. The contact surfaces of all pre-corroded specimens obtained a rust grade which complies with rust grades according to ISO 8501-1: Grade B: Steel surface which has begun to rust and from which mill scale has begun to flake; Grade D: Surface on which the mill scale has rusted away and on which general pitting is visible under normal vision. Figure 4 presents selected results of the dynamic coefficients of friction of friction air (a) and in seawater (b).

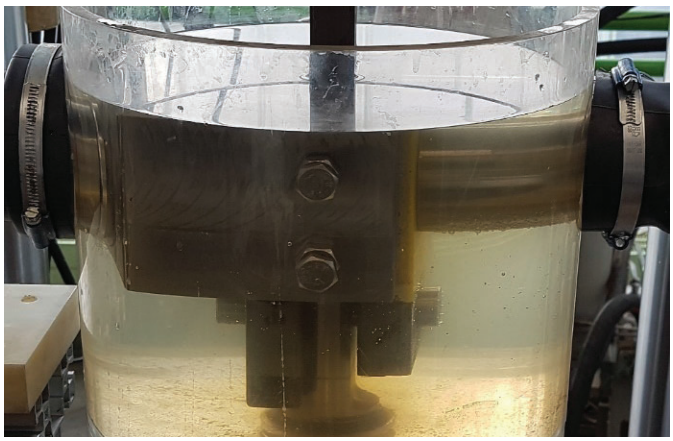

Figure 3. *Container for the friction tests in artificial seawater.*

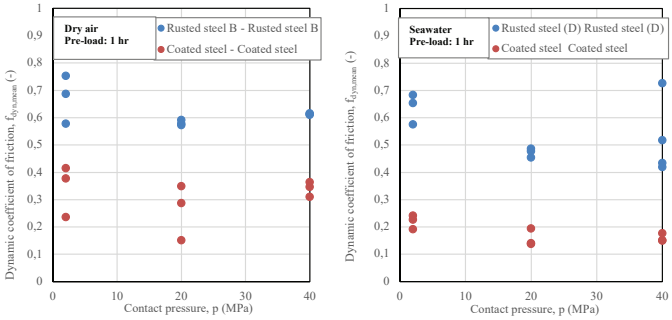

Figure 4. *The dynamic coefficients of friction air (a) and in seawater (b).*

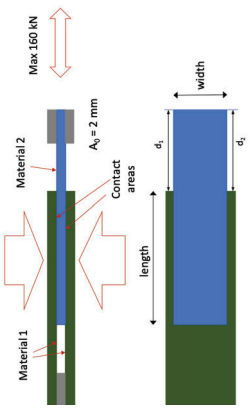

Figure 1. *Schematic of the Friction test assembly.*

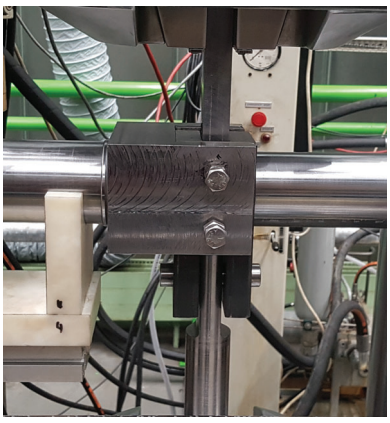

Figure 2. *Friction test set-up with specimens tested in air.*

CONCLUSION

The mean values of the dynamic coefficients of friction of the combinations in air are: "Rusted steel (B) / Rusted steel (B)" between 0.57 and 0.75; "Coated steel / Coated steel" between 0.14 and 0.42 with an influence of the amount of contact pressure.

The mean values of the dynamic coefficients of friction of the combinations in seawater are: "Rusted steel (D) / Rusted steel (D)" between 0.42 and 0.73; "Coated steel / Coated steel" between 0.14 and 0.24 with an influence of the amount of contact pressure.