MEMO

Version Control:

Nr	Subject	Date	Name
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Introduction

This research is conducted in order to examine the influence of ice between a magnet and a steel surface. In the next following chapters, the theory of ice expansion during freezing was discussed. Subsequently, some relevant tests were conducted, and the results of these tests were examined and analyzed. Eventually, a conclusion based on the findings was drawn.

Theory

Ice expands 0.4% volumetrically when it cooled down from 0°C to -20°C ["Handbook of Chemistry and Physics"].

The assumption was based on the existence of an air gap of 0.5 mm and is filled entirely with water. Upon cooling to -20°C, the water freezes and starts to expand.

Even if the ice can only expand in one direction, the air gap enlargement causes a full volume increase. The expansion of the ice corresponds to 0.4% of 500µm, which is equal to 2µm. The percentage of 0.4% is insignificant regarding the increase in the air gap and, consequently, the magnetic force's decrease.

The strength of a magnet is temperature-dependent. For Neodymium, it is -0.5%/K. Therefore, with decreasing temperature, the magnetic force increases.

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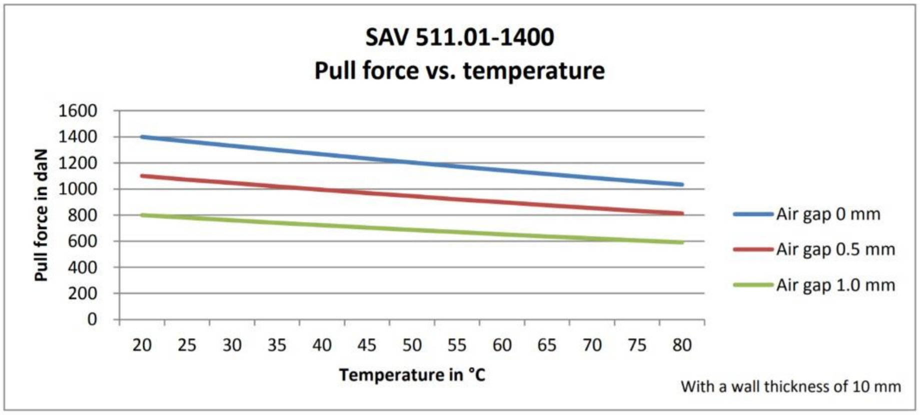

Figure 1: perpendicular force (standard force) vs. temperature, scaffolding anchor on 10mm steel plate

With a temperature decrease of 38K (+18°C- > -20°C), a magnetic force increases of 19% is expected.

Practice

The measurement process was carried out at SAV in Bladel, in which the magnet was placed at the correct distance from the plate with two 0.5mm strips of copper foil. A border of putty containing water is applied around the magnet to be tested. The complete structure was placed in a freezer and cooled down to -20°C.

The substrate's plate thickness was 7mm; the air gap was 0.5mm (Cu-oil),

and the temperature in the test room; T-test room = 18°C.

After placing the container, which includes the structure, in the freezer for 24 hours, a breaking force of 480kgf was measured. "*The measured values were with a NEO500 magnet.*"

Figure 2: magnet in freezer

The next step after the freezing phase was exposing the container to the room temperature for 24 hours; a break-away force of 40kgf was measured.

According to the theory, the magnetic force should increase from +18°C to -20°C by 19%, equal to 77kgf. The expected release force at -20° is equal to 482kgf, and the measured force of 480kgf deviates by 0.4%. "The given numbers were based on the margin of repetitive measurements."

Measuring the sheer force with the proposed method is not applicable because the air gap is created with intermediate materials. Therefore, the coefficient of friction deviates from practice.

Figure 3: test set-up for the determination of the break-away force

Conclusion

Conclusively, freezing to -20°C, in which the magnet was in a layer of water/ice, influences the magnetic strength; as may be expected, according to the theory, it increases. The impact of ice is insignificant in the break-away force, neither in a positive nor in a negative sense.