Tank tests’ test plan

Twardowsky 2 propulsion

Bartosz Hyży, Pavel Chernenko

1. **Introduction**

Due to its role in the propulsion system, tank is critical component when it comes to pressure and leakage proof testing procedures. Its durability is determined by the weakest spot in its structure, which is the weld that joints the tank body with its ends. Tank has been welded using simple TIG method, which was chosen for it accessibility and based on previous experiences in Twardowsky project, where welding technology was particularly problematic. Tank leakage test is included in test plan, due to possibility of leakages on weld itself, in case when it was manufactured without cleaning precautions. The test is important because there may be holes in the weld of such small dimensions that pressure tests utilizing water will not detect the leak due to the low compressibility of the medium. For this reason, the fact that the leak test is carried out using air, a compressible gas, is crucial. In the case of target engine operation or when performing cold flow and hot fire tests, the medium that will fill the tank will be partly in the gas phase, which can lead to uncontrolled leakage at the weld.

1. **Preparations**

All components overgoing the testing need to be cleaned with isopropanol in a possible way. Beside that the test is recommended to be conducted in nitrile gloves.

1. **Pressure Prove Test**

The test should take place with a gaseous medium, the pressure of which can be easily controlled once the tank is full and can reach maximum pressures in the region of 1 MPa. Carrying out leak tests with higher pressure gases is not recommended for reasons of test safety. A compressible gas, unlike an incompressible liquid (e.g. water), stores much more kinetic energy during compression, which, if the tank is destroyed, can lead to a risk to the life or health of the test participants. At the time of writing, it is assumed as standard, to use a compressor with a maximum operating pressure of 8 bar for this purpose. A compressor with such parameters has been used on numerous occasions during the tests of the Twardowsky 1 engine.

1. **Strength Testing**

Then, when the tank is found to have passed the test, it should proceed to the pressure test stage. As required, pressure testing of any tank that is part of the rocket must pass the pressure test given a nominal design safety factor of 1.5. The tank's destruction safety factor is 2, but at the time of writing, no tank destruction test is assumed. The nominal tank pressure is 58 bar, so a pressure test must be carried out bringing the tank to a pressure of 87 bar with an accuracy equal to that of the available pressure indicator. For pressure testing the compressed medium is water, preferably demineralized water should be used here to reduce the risk of mineral deposition inside the tank. Water, as a liquid, is an incompressible medium which is preferred for pressure tests. Because of this fact, if a tank is damaged during the test, the kinetic energy that will be imparted to the debris will be much lower than if a gas-filled tank is destroyed. Tank need to be filled to the top with demineralized water, for it to be possible to achieve required pressure of 87 bars as was mentioned above. Nevertheless, special safety measures and personal protective equipment, such as safety goggles or protective headphones, must be observed here. It is also recommended to be at the safe distance and having as little people as possible to minimize possible damages. According to the requirements set, the predefined pressure must be maintained for one and a half times the maximum time allowed for the tank filling process, so the time during which the pressure must be maintained is 90 minutes. During this time, the pressure reading must be checked every 20-30 minutes or so and changes recorded. After this time has elapsed, or if a partial failure of the tank is detected, or if leaks are detected, the set pressure should be released completely before the test participants approach the tank. During the test, the tank should be immobilized and the bottoms protected against damage in case of weld rupture. The tank need to be covered with a piece of cloth, preferably bright color for easier determination of leakage source. In case the leakage detected the tests need to be stopped immediately to prevent further damages to the tank and to full fill safety requirements.