WHITE PAPER

TESTING CREEP FOR POLYETHYLENE WATER TANKS

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Find out how to design tanks with greater precision and less waste by using data generated by a world first process
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A polyethylene (poly) tank full of water supports a significant physical load on a continuous basis and must be well designed to provide a lifetime of service. Many materials including polyethylene can stretch over time when put under stress in a process known as creep. By employing finite element analysis and using a measure known as the creep modulus engineers can develop tank designs that will ensure creep stays within acceptable level. In a world first development, creep data generated from rotational moulded items is now available at temperatures that better reflect the service conditions encountered in Australia, giving engineers much greater precision in FEA modelling and leading to improved product quality and lower waste.

A POLYETHYLENE (POLY) TANK FULL OF WATER SUPPORTS A SIGNIFICANT PHYSICAL LOAD ON A CONTINUOUS BASIS. ONE OF THE MOST IMPORTANT CHARACTERISTICS TO CONSIDER IN THE DESIGN OF A POLY WATER TANKS IS CREEP. CREEP REFERS TO THE PROCESS IN WHICH A MATERIAL SUCH AS POLYETHYLENE STRETCHES OVER TIME WHEN IT IS PUT UNDER STRESS.

The rotational moulding of polyethylene is an extremely versatile process, capable of manufacturing items as diverse as kayaks, traffic barriers, furniture and tanks. The importance of designing for creep varies by application and is especially pertinent for poly water tanks due to the presence of long term loads. As the tank fills with water it exerts pressure on the inner walls of the tank. When applied over an extended time, this load can cause the tank to stretch and bulge.

If the tank has not been designed and manufactured properly, this constant pressure can eventually lead to a failure of the tank and loss of containment of the tank contents. By following the correct design and manufacturing processes the likelihood of tank failure can be substantially reduced.

OPTIMISING FOR CREEP RESISTANCE: THE PROCESS INVOLVED

In order to protect tanks against the effect of creep, engineers need to determine the thickness of the tank wall that will prevent a deformation beyond a predetermined amount under a range of conditions over the life of the tank. While some bulging is inevitable, it is crucial to keep this within a certain range.

To calculate optimal thickness, engineers first generate what is known as a creep modulus. This is determined from data generated by applying a stress (force) to the material (polyethylene) and measuring the degree of strain (stretching) over time.

The data derived from this testing can be extrapolated to allow engineers to predict strain rates over much longer periods of time. This extrapolated strain, at say 10 years, is divided by the stress to provide a 10 year creep modulus.

THE NEXT STEP: FINITE ELEMENT ANALYSIS (FEA)

Once generated, the creep modulus is applied to a process known as Finite Element Analysis (FEA), the most crucial step in designing a tank with optimal creep resistance. FEA is widely used in a number of industrial and engineering design applications and can help determine the required thickness of rotationally moulded polyethylene water tanks.

> EXTREME TEMPERATURES CAN AFFECT THE RATE OF CREEP, WHICH IS WHY FEA USING CREEP DATA OBTAINED UNDER REAL OPERATING CONDITIONS IS SO IMPORTANT.

The tank design and creep modulus value are entered into a computer program and a simulation is run over a range of hypothetical wall thicknesses. The program then simulates how the tank is likely to bulge and stretch under the pressure of water over time, in relation to the thickness of the polyethylene.

Such is the specificity of the modulus produced that designers can assess how thick they need to make the polyethylene across different areas around the tank. For example, water generates downward pressure in any vessel due to the natural force of gravity, meaning there is more pressure on the wall at the bottom than at the top of a tank. Tank manufacturers should therefore make the walls at the bottom of the tank thicker than at the top.

While the FEA process is of enormous value in polyethylene tank production, it is only effective if performed under the right conditions. One of the most important factors to consider is the operating temperature of the tank. This is particularly relevant in Australia with its extremes of climate.

MAXIMISING POLYETHYLENE PRODUCTION EFFICIENCY

The temperature in parts of Australia regularly reaches 40°C during the hottest parts of the year. Extreme temperatures can affect the rate of creep, which is why FEA using creep data obtained under real operating conditions is so important.

By replicating the temperature and conditions that will be faced, engineers can make more accurate calculations regarding the required wall thickness. The alternative to the calculations is a process of guesswork or trial-and-error which can quickly waste time and money and consume significantly more polyethylene than necessary over the long term.

A mould that contains more polyethylene than is needed takes extra time (and money) to heat up in the manufacturing process. This also drives longer cooling periods which further reduce productivity. The result is a continuous flow of surplus expenses that can be avoided by good design using data produced under the right temperature conditions.

THE IMPORTANCE OF TESTING TO AUSTRALIAN CONDITIONS

Creep data for use in Finite Element Analysis is typically generated at 23°C. Whilst this is convenient for laboratory testing it is not representative of what occurs in the field. In recognition of this, Qenos also tests the creep properties of polyethylene at 40°C reflecting real life operating conditions. Having data at 40°C allows designers to more accurately specify the thickness required at any point around the tank in an elevated temperature situation.

Major changes occur in the structural integrity of a polyethylene tank when going from 23°C to 40°C. Poly tanks lose around 40% of their rigidity through this increase in temperature with the higher temperature making the material more flexible and prone to creep.

HOW IS THE DATA PRODUCED?

Qenos utilises a completely new method of generating creep data, optimised for results that are not only more accurate but also more relevant to the Australian industry and for the specific application of rotational moulding.

Qenos' methodology involves producing creep data from the circumferential expansion of rotationally moulded pressurised pipes. The pipes are pressurised with air to generate specific levels of stress and submerged in a water bath held at the required test temperature.

The circumferential expansion of the pipes is then recorded over a time period of 10,000 hours. The process generates highly repeatable data and is easily controlled and measured in the Qenos test facility. The data is then made available to engineers who may use it to generate long term creep modulus values.

It's a world-first approach to creep measurement, giving engineers much greater precision in FEA modelling and leading to improved product quality and lower waste.

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