Abstract

For the past 30 years injecting aerosols into the stratosphere has been suggested as a method for cooling the Earth and mitigating the impact of global warming. Several injection methods have been considered: this thesis assumes the use of a balloon at a height of 20 km, supporting a combined tether and pipe through which the aerosol particles can be pumped. The pipe would resist both internal pressures and tensile forces from its own self weight, wind loading and supertension. The thesis investigates the possibility of using PBO (Zylon) and the form of construction for such a pipe.

Hydraulic pipes are normally designed to resist pressure forces alone using thick-walled theory; however PBO is not isotropic and therefore classical thick walled theory does not apply. This work extends thick walled theory to materials whose axial and transverse properties differ and considers different construction methods for a pipe to resist pressure and external tension.

The long-term design strength of high modulus polymers is controlled by creep-rupture. The creep-rupture behaviour of aramids have been extensively studied but PBO, which is a newer material with a higher break stress, has only been studied at high loads with times to failure less than one week.

This thesis uses the stepped isothermal method (SIM): a single specimen is held under a constant load as the temperature increases over a series of steps, chosen so that the tests are completed in less than 24 hours, compared to decades required for conventional testing. The creep curve over all the temperature steps is then adjusted to a single master creep curve at a single reference temperature.

The master curves from SIM testing are verified by comparison with creep curves (not taken to failure) obtained from conventional testing under ambient conditions. In addition a rheological model for the short term loading, creep and creep-rupture of the material is considered to increase confidence in the predicted long-term behaviour.

This research provides assurance that stratospheric particle injection is feasible and gives data for the long-term properties of PBO, a possible material.

Key words: geoengineering, thick walled pipes, creep, creep rupture, viscoelasticity, stepped isothermal method, continuous chain model, PBO, Zylon