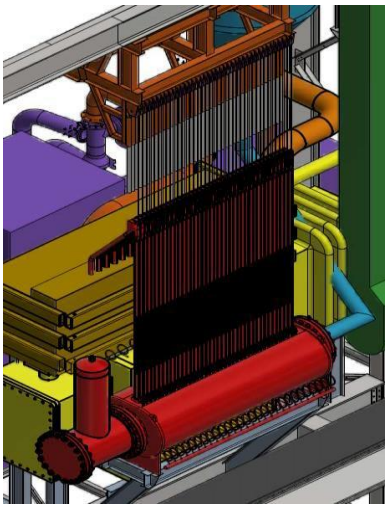
H2020 NEXT CSP DESCRIPTION FOR SolarPACES2020 PAPER ON WORK PERFORMED BY WHITTAKER ENGINEERING

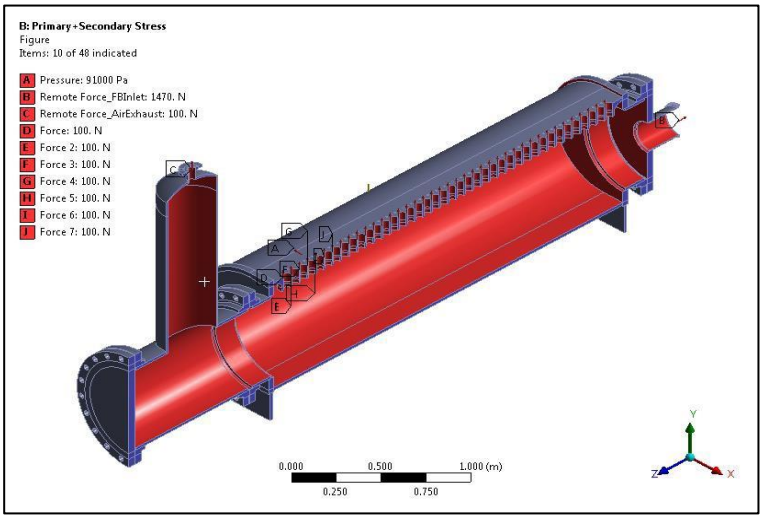
Whittaker Engineering is a design and manufacturing company based in the North East of Scotland mainly supporting the North Sea Oil & Gas industry.
We were asked to join the consortium of the H2020 Next CSP High Temperature Thermal Solar Power Plant because of our experience with design analysis and manufacturing to high standards of workmanship.

The difficulty in working with materials at very high temperatures when their strength reduces dramatically and the material strength allowables are outwith the ASME stress and strain curves published data.
The financial constraints of the project and potential future scale up of this type of solar power plant make the use of exotic materials such as Inconel 601 prohibitively expensive. The selected high temperature materials used were 304H, 310H and 310S stainless steels.

The solar receiver tubes were designed to maximise the heat flux between the external surface of the solar collector tubes and the heat transfer medium inside the tubes, we developed a practicable method of welding internal fins into the bore of a 2" tube. There were 6 fins in total with tapered ends which protruded radially into the tube bore.

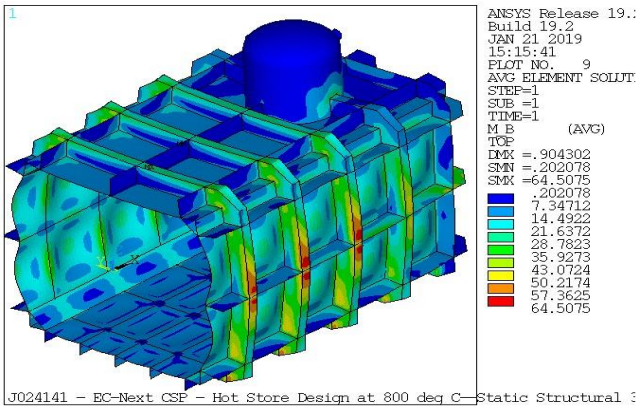
The Solar Collector Tubes cannot be rigidly mounted as they will bend away from the sun when heated, the heat flux and heat distribution on the 40 tubes are also not evenly distributed. Therefore, each tube is fixed at the bottom of the dispenser with bolted low stress connections, the tubes are suspended individually from a framework above the top of the tubes, this suspension is via 40 individual counterweights. A mechanical design analysis was carried on the receiver tubes stress distribution and creep starts at 40% of melting point in Kelvin during the 300 hour design life.



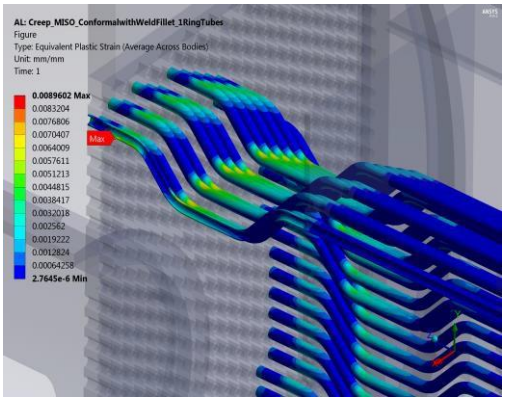


The Dispenser is the vessel which supports the 40 finned solar collector tubes, it is 4.3m long x 1.1m wide x 760mm high and weighs 3.5Te. This vessel receives the cold transfer medium from the cold store which is mounted high in the tower.
At the top of the solar window aperture the tubes protrude beyond the top opening and turn down 45 degrees and spill the high temperature Cristobalite into the hot store

The Hot Store dimensions are 4.4m x 1.6m x 2m and weighs 4.2Te empty with a design temperature of 800C and was designed by using FE analysis to ensure that is would be strong enough to support its own weight but also well enough insulated so that it could store this heat for at least one hour. An L valve is fitted in the bottom of the hot store to discharge the fluidised Cristobalite into the air pre-heater heat exchanger mounted directly below it.



The Air Pre-Heater heat exchanger is designed to transfer heat from the hot Cristobalite into a shell and tube type exchanger, hot air from the tubes is delivered to a Bryton Cycle gas turbine which produces the 3MW power. The exhausted hot air is then returned back to the air pre-heater tubes in a continuous process as the hot Cristobalite continually heats up the tubes externally and then heats the hot air inside the tubes to feed the turbine. The air pre-heater empty weight is 14t. The dimensions are 6m x 1.9m x 2m, the shell side design temperature is 800C.
There are 1300 tubes in this heat exchanger with a 65mm thermal growth from end to end of the tubes. After a lot of analyses the only way we could reduce the loads in the tube end welds to an acceptable level was to form an offset or joggle in each tube which would creep preferentially compared to the tube welds.



The fluidised Cristobalite passes over the 1300 tubes through baffles and spills over the outlet weir where is it collected by the **Elevator** which transfers the now warm Cristobalite into the cold store.

The Cold Store dimensions are 1.5m diameter x 3.4m long, weighs 900kg and design temperature is 380C. A control valves meters the Cristobalite where it drops down from the cold store to the Dispenser where it is fluidised and then feeds the solar collector tubes which are heated by the sun, and so the process repeats itself.
Installation complete in Themis Tower.

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