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Thermophysical Properties of Aged Nitrate Salts

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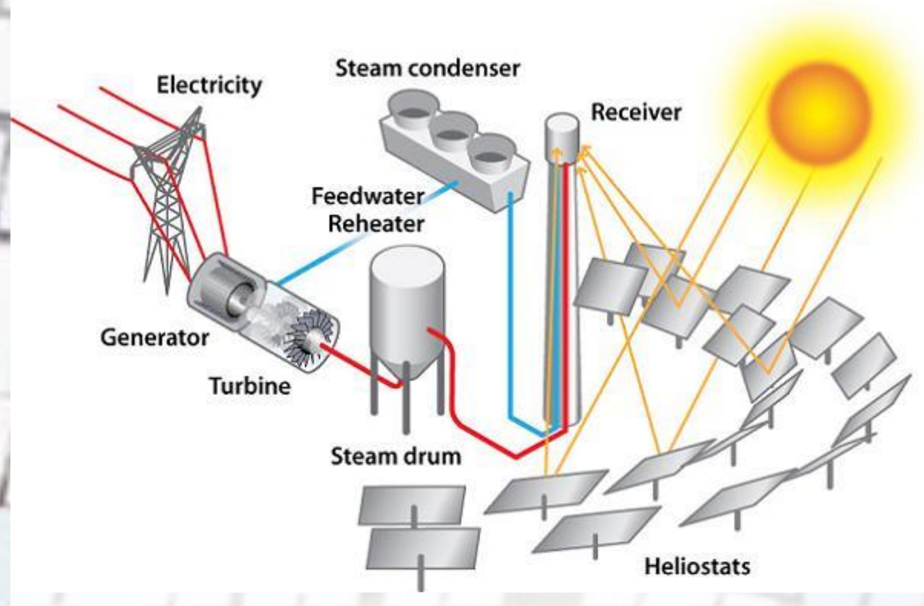
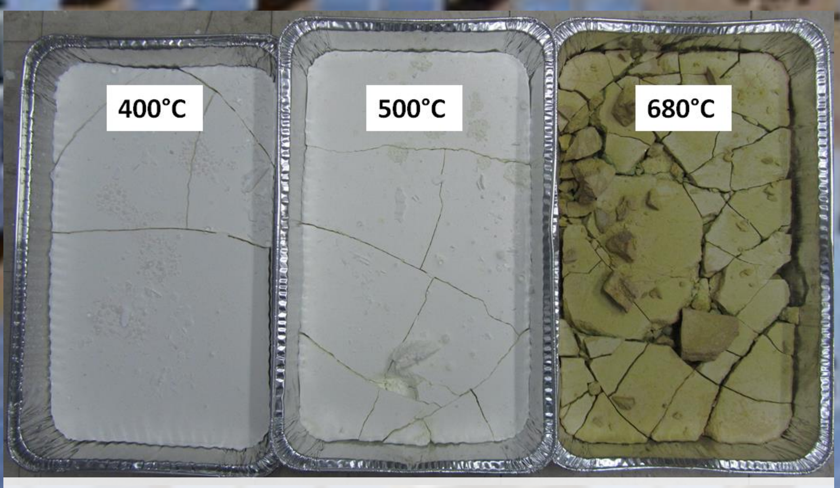


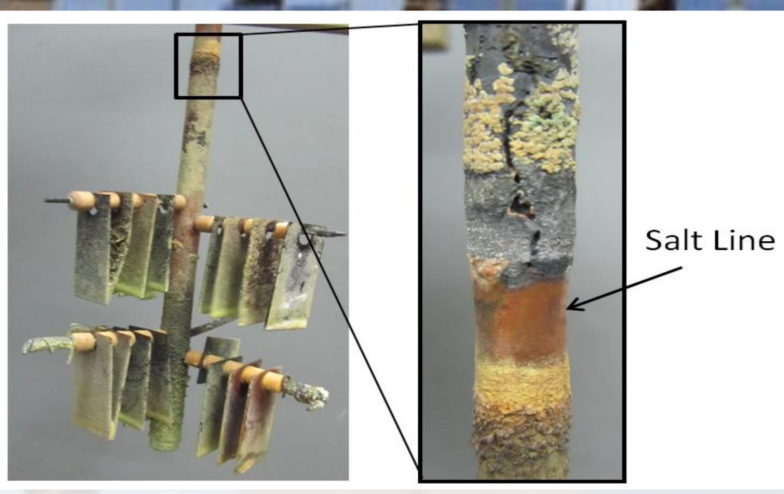
The basics of concentrated solar power

Background

- The mixture of $NaNO_3$ and KNO_3 (solar salt) has become popular for use in concentrated solar power plants as a heat transfer fluid.
- Previous work was done to test how this liquid salt mixture corrodes the metal of the collector section of the tower.
- This work examines how the thermal properties of the solar salt change due to these impurities including melting point, heat of fusion, and specific heat.



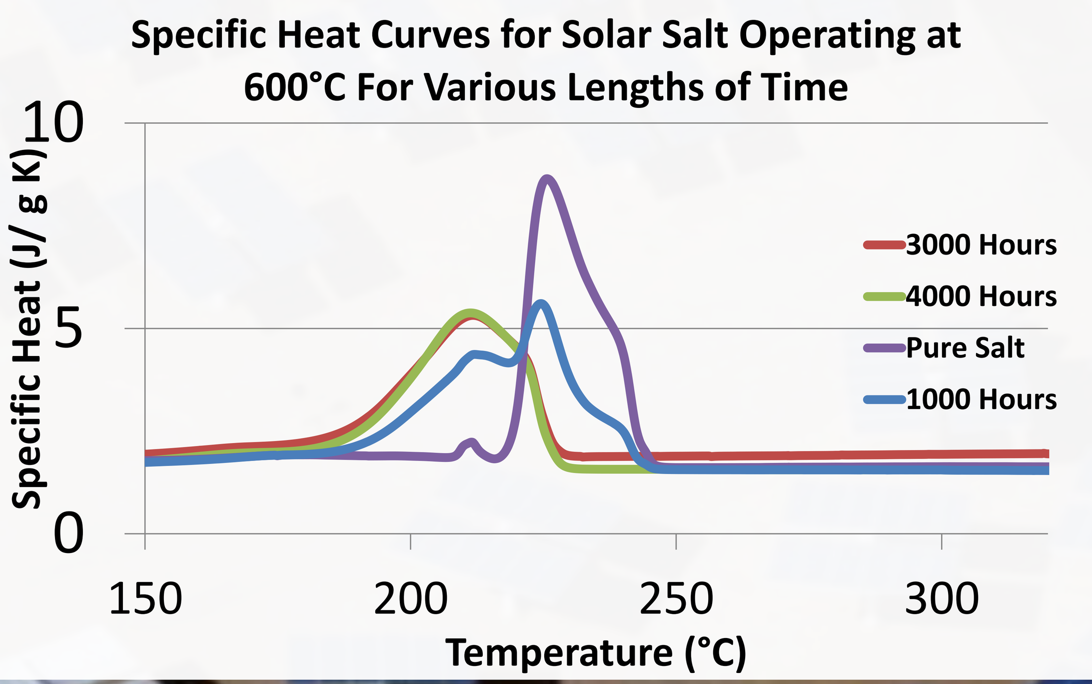
A photo of previously tested solar salt

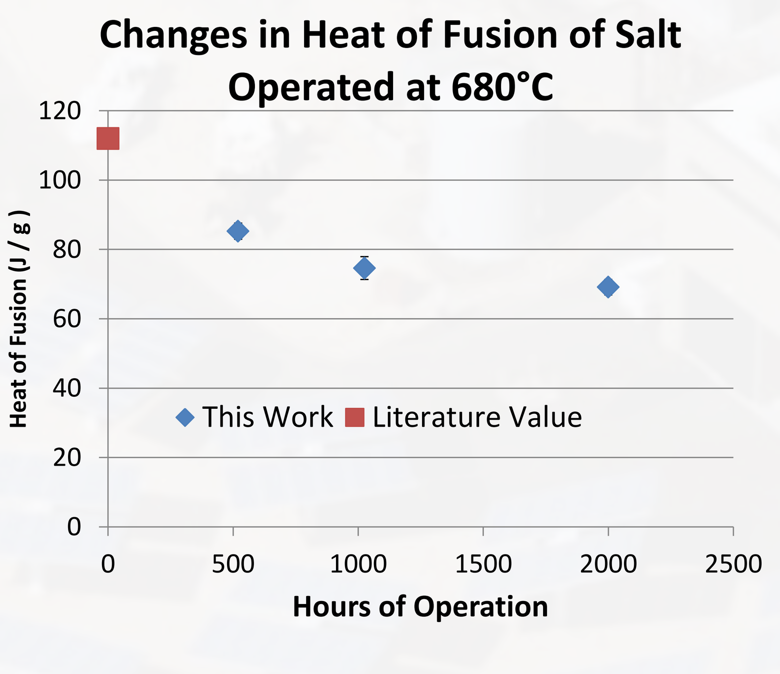


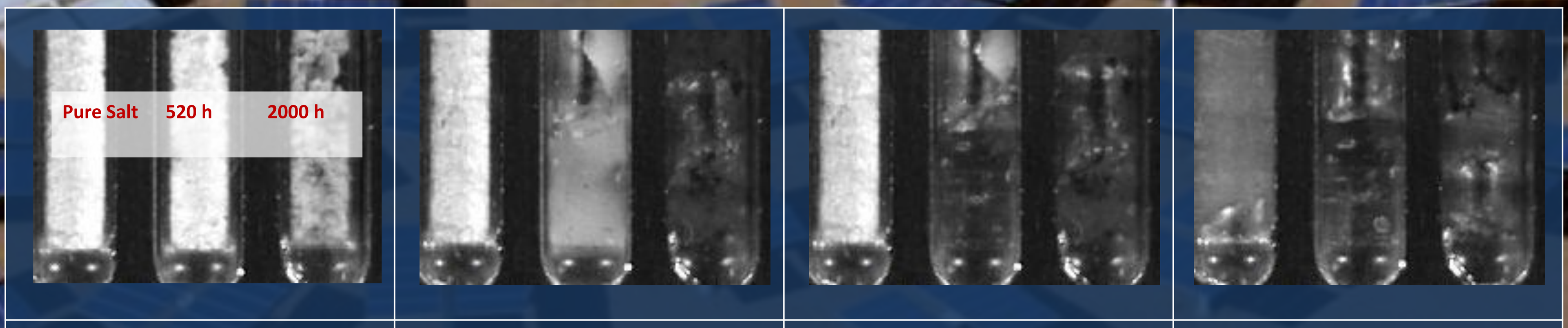
a photo of previous corrosion experiment

Results

The measurement of specific heat, heat capacity and melting point was conducted using Differential Scanning Calorimetry. In addition, an optical measurement system was used to confirm the melting range of the salts. For each thermodynamic quantity general conclusions can be made. In general, the heat capacity and heat of fusion change very little- if at all- as impurities are introduced. It can also be seen that the melting point shows significant decreases (up to 50°C) as more impurities are added. Overall, the repeatability of the data is best for pure solar salt and worsens as the impurity content increases. Most values have a standard deviation less than 10%.



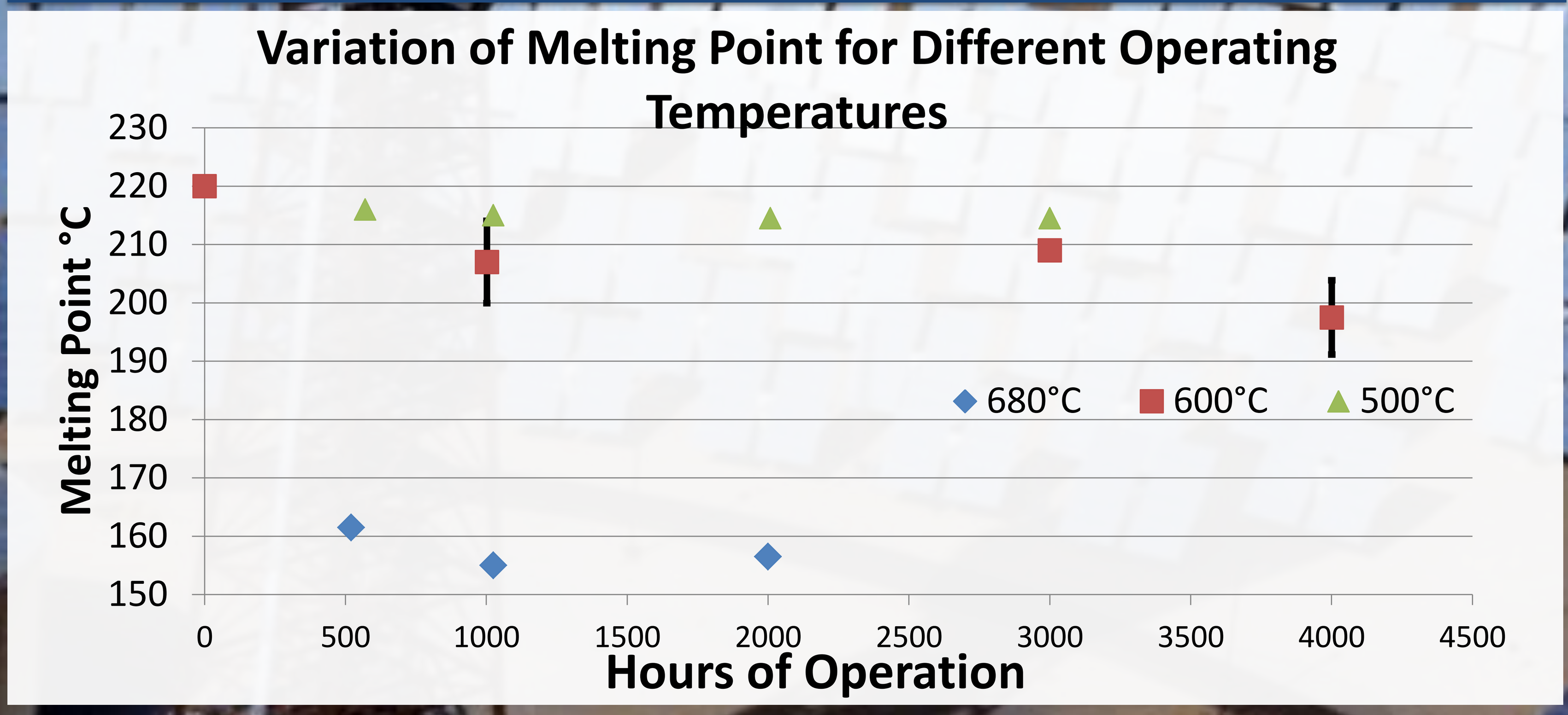




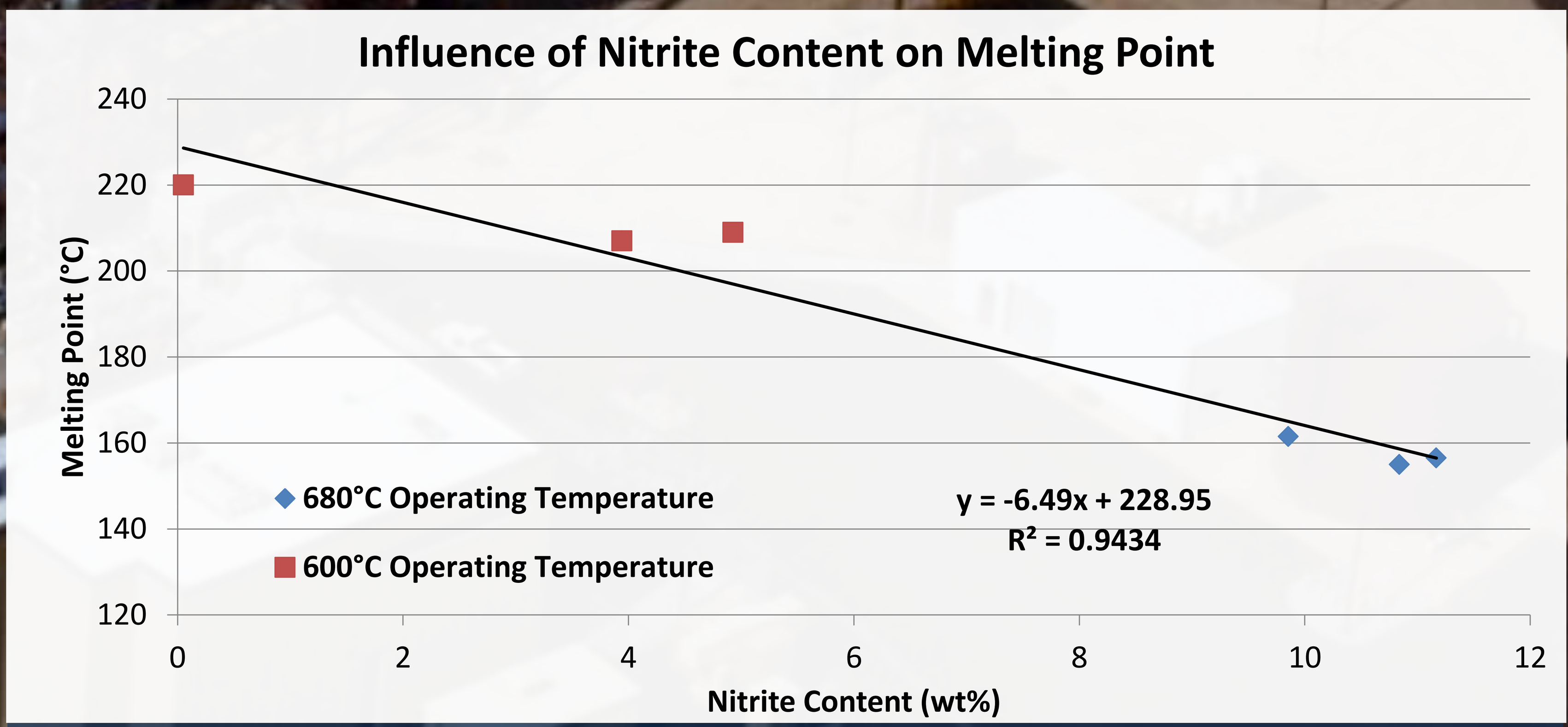
100°C	199°C	207°C	247°C

Optical images showing the melting process of nitrate salts. From left to right- Pure Solar Salt, 520 hours, and 2000 hours of use at 680°C. Each photo starting at 199°C demonstrates the liquidus point (end of melting range) of one of the salts.

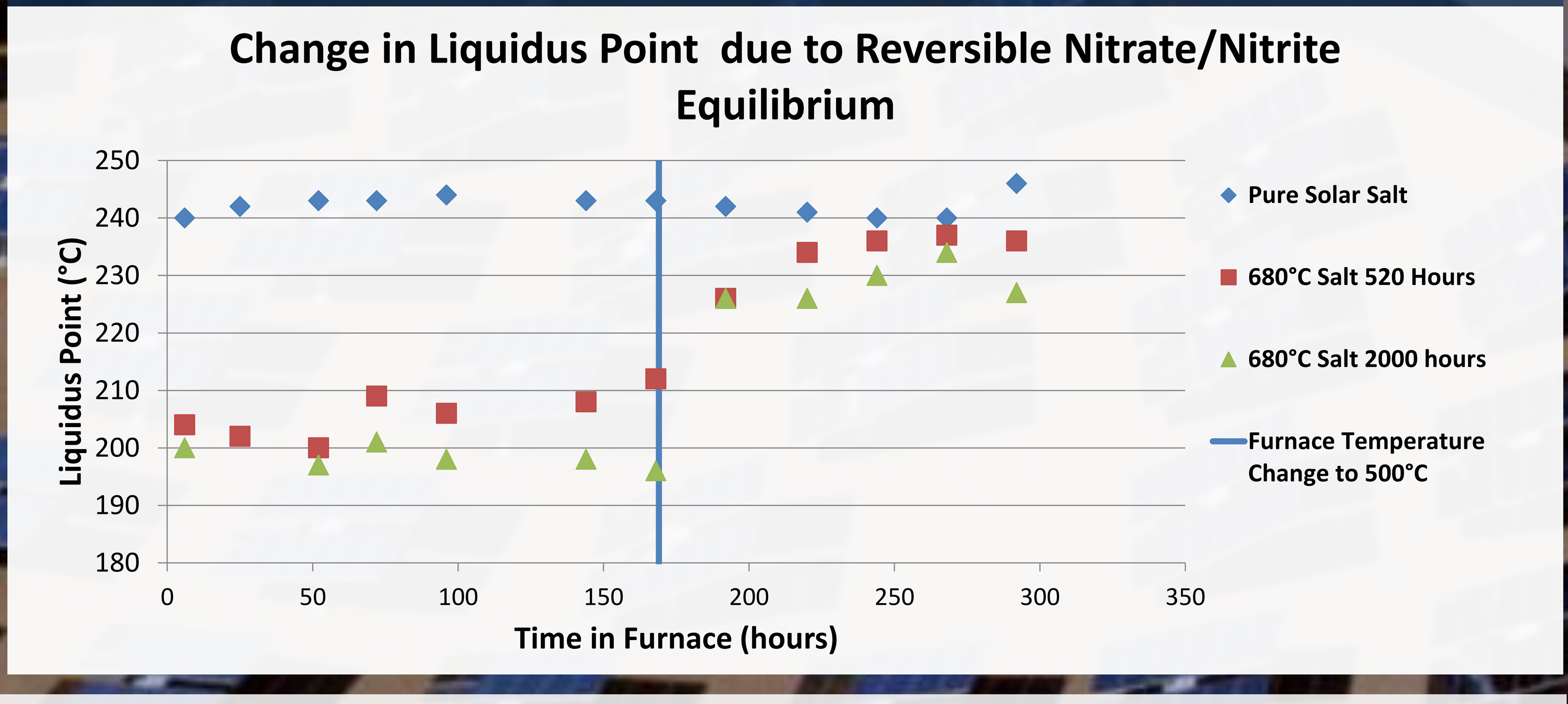
Results– Cont.



This graph shows how melting points change when molten salt is held at high temperatures for difference lengths of time. Note the significant change of the 680° operating temperature.



In attempt to explain the change in melting point, a correlation was drawn between nitrite content and melting point. Then, samples were placed in an oven to shift the concentration of nitrite in the salt.



Conclusion

This work has shown that that nitrate salts undergo some changes in thermophysical properties after exposure to high temperature corrosion tests. It is clear that even if substantial corrosion occurs, the heat transfer fluid will only show a small change in both the specific heat and heat of fusion. However, large decreases in melting point will occur after operation at high temperatures. This decrease in melting point is due to an increase in nitrite compounds in the salt when exposed to temperatures over 600˚C for many hours. It has also been shown that the melting point changes are reversible due to the temperature dependence of the nitrate/nitrite equilibrium. Because lower melting points will allow the system to function as designed, these results provide positive data on the longevity of nitrate salts as a heat transfer fluid, even in extreme corrosion. This work helps to show the potential for concentrated solar power as a low cost source of electric power.

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Background image and solar power diagram credit: U.S. Department of Energy