150 – Research, Design, Construction & Testing of Carbon Heated Piping Systems for Various Industrial Applications

Shayne Crawshaw

Aims – To design and construct this project, the focus was to create an environmentally ethical, cost-efficient and consumer friendly substance heating and circulation system for different industrial applications, using Carbon Paint as the only source of heating. This also was driven by the desire to improve on the current industry solutions by creating a cost-effective alternative.

The aim when constructing the proof of concept model was to learn as much about the properties and operating characteristics of carbon paint and circulation piping, whilst creating a visually attractive and relevant proof of the idea for demonstrations.

The Processes & Limitations – The design, construction & testing of this model had its challenges, which included;

1. Development of the piping, reservoir sizing and layout
2. Electrical insulation problems
3. Different electrical setups used in testing

A problem which I encountered was trying to locate a pump which could withstand the heat of the substance e.g. water whilst also being powerful enough to circulate 25 litres of water through 4m of piping at 30L per minute. Dad helped solve this, by suggesting an inline circulation pump, which could withstand the 90°C and couple to the piping with universal fittings welded on by Teralba.

For the piping & reservoir, stainless steel piping was my general idea, and after consulting a local heat exchanger manufacturer, Teralba Industries Pty Ltd, they confirmed that stainless steel is the best material for the application. Stainless steel has sound thermal conduction abilities, and is also corrosion resistant, which helps greatly in an application where water is constantly in contact with the metal. They agreed to construct the actual piping layout, which was a benefit because they have over thirty years of experience in stainless steel fabrication for heat exchangers. A plan which I drew was submitted to them with the piping diameter and length specifications (D: 65mm L: 4m) and they made it to these specs, with all the resources they have. The actual layout of the piping was an idea I took from existing heat exchangers, which use a snake layout and this is important because you can fit significantly more piping into a smaller area.

When the piping was constructed an insulating coat of two pack epoxy was applied. As I now know, it was not thick enough and I did not prepare the piping for painting properly, because I had many problems down the line with the coat peeling up. This affected the overall effectiveness of the carbon paint, because electricity was leaking into the piping.

The next step was to apply the copper strips, which run the length of the piping and conduct D.C. electricity from the transformer into the paint. Unfortunately the masking tape which I used as a spacing guide, when it was removed, lifted the insulation layer and allowed the electricity to conduct into the stainless steel, and caused severe problems until it was re insulated. This involved lifting the copper tape and painting underneath it with a quick dry single pack epoxy.

Applying the carbon paint was also difficult as there was limited space between the piping lengths, this was solved by using a very small roller.

The initial test of the project failed spectacularly due to two main factors:

- There was a short in the piping, caused by the insulation paint failure
- The wiring which I was using to connect the power supply to the copper strips, was not capable of handling the current that was being used

These two problems were overcome by:

- Finding areas of the piping which were shorting, by using a multimeter and testing the copper nodes inch by inch to detect any drops in current caused by a short, then finding the exact spot and coating it with the epoxy.

This was suggested by my Physics Teacher, Mr Austing. This was a better option than stripping it all back and starting again, saving time and money.

Once the model was operational, it was just a matter of running all the systems together as many times as possible to record its temperature gain and electricity consumption. This data helped me to make slight changes to solve efficiency problems. This included a better way to insulate the reservoir, as it was losing a lot of heat energy through this area as it wasn't insulated. The solution was simple, towels were wrapped around the reservoir to keep the heat from dissipating, and kitchen foil on the rim of the reservoir to condense any evaporating water. This prevents water loss and time spent refilling.

The testing achieved some amazing results, with a maximum recorded water temperature of 85°C. Once the substance was at target temperature it required extremely low current to maintain it. The results would be even better if the model didn't have the reservoir. It is only necessary for demonstrational purposes, because it enables easy transport and viewing. In reality the reservoir would not be needed, and therefore not have the same heat dissipation problems because all the water would be contained.

Acknowledgements

Doug Austing – For his advice on locating the electrical short.

Joe Chesterfield (Chemist @ A&I Coatings) – For his constant oral support and problem solving with the paint coats, electrical calculations, material selection and his help with formulating specific ratios in the carbon paint for my project.

Peter Gillies (CEO – A&I Coatings) – For his financial support providing the carbon paint and the other paint coats, provision of equipment (lab & spray booth), time, and expertise on surface coatings technology within his business.

Jim Crawshaw – For financial support with the transformer, pump, wiring & insulation. Constant motivation and problem solving with every little detail.

Murray Baker – For help with the designing and financing of the piping, then the fabrication of all its parts.

Rochelle Horan – For her oral support with the constant constructive criticism of my portfolio and scientific investigation. Also her supervision in the school laboratory during model testing.