Refrigerant Reclamation Processing

BSc (Hons) Engineering Design & Manufacture

LIGHTFOOT DEFENCE
MILITARY REFRIGERATION SOLUTIONS SINCE 1885

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Located In
Southampton, UK

PROJECT TIMELINE

8 Months

SOLENT UNIVERSITY SOUTHAMPTON

Project Scope

With anthropogenic induced climate change under the microscope, the refrigeration industry is set to act by way of HFC refrigerant phase out. Currently, the multi-role fighter jet, Eurofighter Typhoon, utilises Pentafluoropropane (R245fa) within its Defence Aid Sub-system (DASS).
After a number of customer enquiries, an opportunity existed to upgrade LDL's existing R245fa reclamation machine, 'PECR-RU'. A design review highlighted two significant improvement areas:

- Distillation methodology
- Moisture removal process

Project Results

Project achievements are outlined below:

1. Enhancment of the distillation & moisture removal processes.

2. Reduction in operator 'input' through automation.

3. Increased volumetric capacity resulting in higher output.

4. Transient thermal CAD analysis to verify inefficiencies in material conductioin rate.

5. Conduct experimentation where possible to further validate proposals.

Future Work

August 2020
Further Experimentation
Horizontal vessel testing, validation of moisture removal

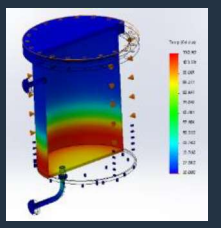
January 2021
Pre & Post CFD Analysis
Conduct CFD analysis on the original design and new proposals

May 2021
Liquid Agitation
Explore alternative methods of agitating the liquid

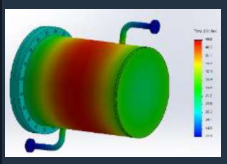
Transient Thermal Analysis

Transient thermal analysis revealed:

- Inefficiencies in thermal conduction rate
- Varying temperatures across the vessel body resulted in further condensing leading to cycle repetition
- Occurrence of nucleate boiling & liquid entrainment with increased vapour flow
- Only 40% of the vessel was penetrated by the heater in comparison to over 80% in the aluminium proposal



Distillation Vessel Proposal



Options analysis & CES material investigations made Concept 3 favorable both technically and commercially.

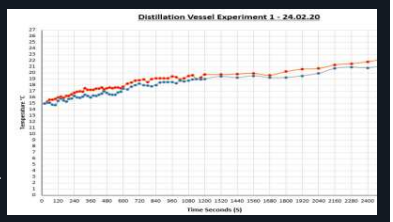
- Rotate through 90° - giving a 7.4% increase in volumetric capacity
- Aluminium construction - 174W/m2
- Lower surface roughness resulting in fewer nucleation sites & reducing entrainment
- Minimal disruption to existing equipment

Experimentation & Testing

Experimental results did not align with CAD modelling or hypothesis possibly due to the extreme variation in setup conditions and limited project budget which restricted the ability to replicate the exact vessel heating system.

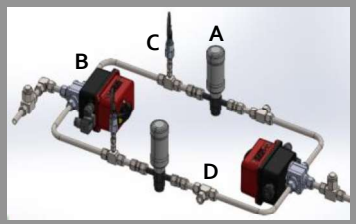
Experiment 1: Probes produced a linear response, central probe constantly 1°C higher than outer until 500 seconds, differential never higher than 0.8°C

Experiment 2: Probe responses were as predicted until 700 seconds, central probe climbed significantly. Liquid took 1320 seconds to reach 18°C whereas in experiment 1 it took just 630 seconds.



Experiment 3: Boiling stones added to vessel. Smooth gradual climb in temperature observed. The probes took 330 seconds to stabilize at 18°C. Nearly half the time it took during experiment 1 and 4 times quicker than experiment 2.

Moisture Removal



Analysis of water content data and investigation revealed the drier cores (A) were continually exceeding their maximum adsorption capacity and blockages were a regular occurrence. Implementation of automated valves (B), pressure transducers (C) and vacuum pump connections (D) allowed for the driers to maintain efficiency and avoid machine downtime without warning.

Proposal Integration

To make the proposals commercially viable they were required to be seamlessly implemented into the existing PECR-RU chassis.
Additional design work was conducted to demonstrate how the upgrades would be incorporated, including:

- Distillation Vessel Cradle (Right) manufactured at MD Technical Services
- Filter drier pipework redesign (Above)