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Heat Exchanger Innovations – Design and Application

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Contents

- Innovation Drivers
- Micro-Tube: Development Practices and Benefits
- Active Maintenance
- Research Areas

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- Innovation Drivers in heat exchangers for heating and cooling can be summarised as:

  - Legislation Changes: Such as F-Gas or ErP

  - Competitive Landscape: Improving competitive position through innovation

  - Social Changes: Increasing population density

  - Materials Sustainability: Availability of raw material

  - Environmental Sustainability: Use of energy in production and in application

  - Application Demands: Challenging applications often lead to innovations which may then be applied more widely

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‘Micro-Tube’ / 5mm Configuration

- The development of a new configuration using 5mm tube
- This provides opportunities for:

  - Reducing refrigerant charges
  - Radically improving capacity density
  - Less materials to achieve the same capacity
  - Less air volume / power input / noise to achieve the same capacity
  - Ideally suited for the construction of natural refrigerants, such as CO2

- Reflecting the most common innovation drivers, it facilitates an R&D project and potential manufacturing investments

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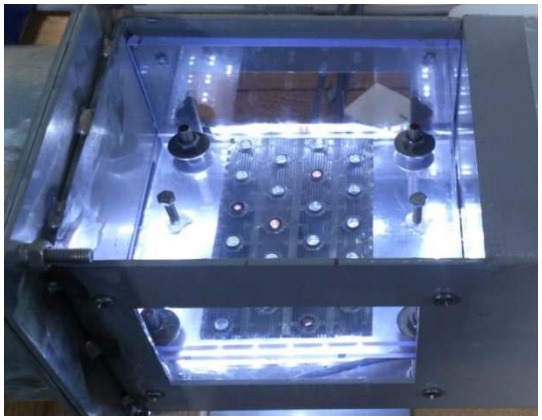
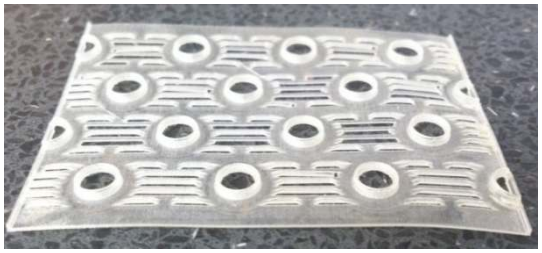
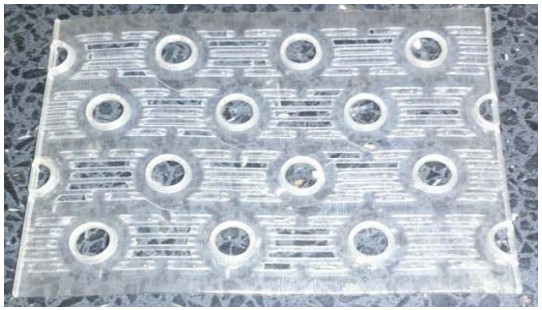
- Rapid prototyping used for the first time in the optimisation of a tube configuration
- LSBU assisted in expertise and production of prototyped fin samples
- Greater flexibility to optimise configurations than previously possible
- Previous CFD analysis completed in conjunction with Brunel University had established the dead areas that can exist behind tubes







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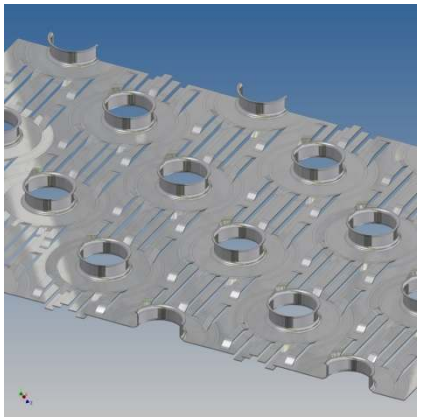
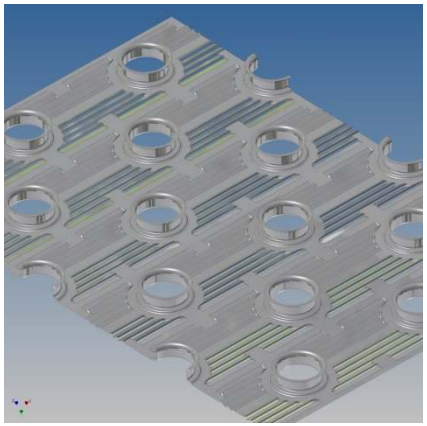
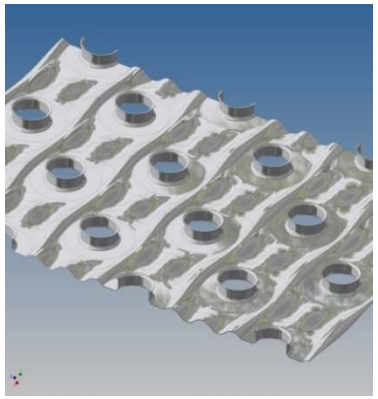
- Airflow testing helped to validate early stage CFD for flow paths

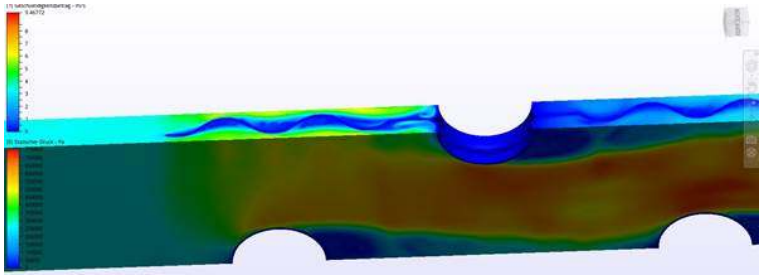


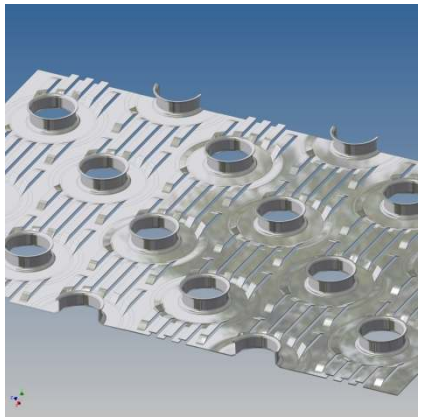
- Combined with commercial review, a tube pattern of 20mm x 12mm was fixed upon, in order to focus on enhancement developments



- Fin enhancement optimisation considered a number of variations







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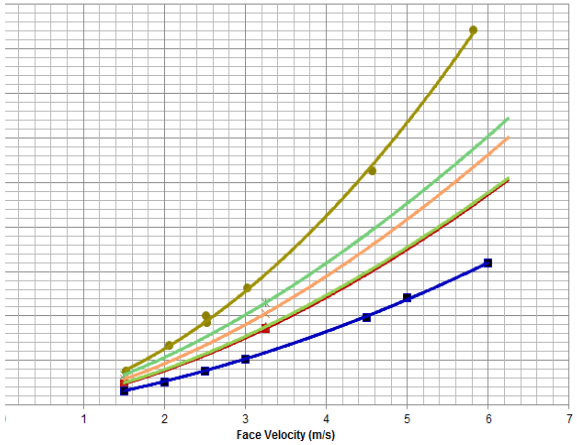
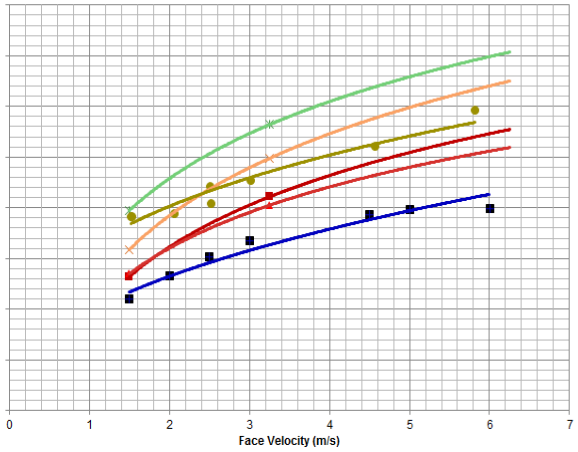
CFD RESULTS – PRESSURE DROP



CFD RESULTS - HEAT TRANSFER



- Validating against known results for existing patterns helped to refine the model to improve accuracy
- Critical balance between heat transfer coefficients and airside pressure loss
- The most effective option then needs to be balanced against what is possible for manufacture

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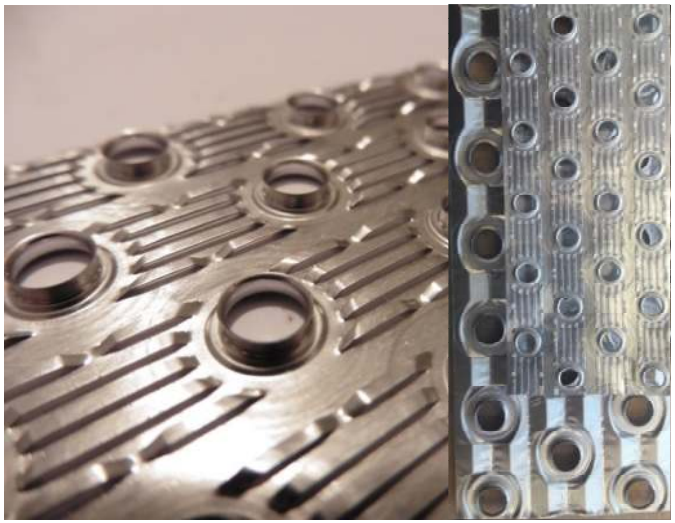
- Fin press purchased after development project
- Complex press die to produce fin enhancements
- Example of improvements in capacity for specified surface area



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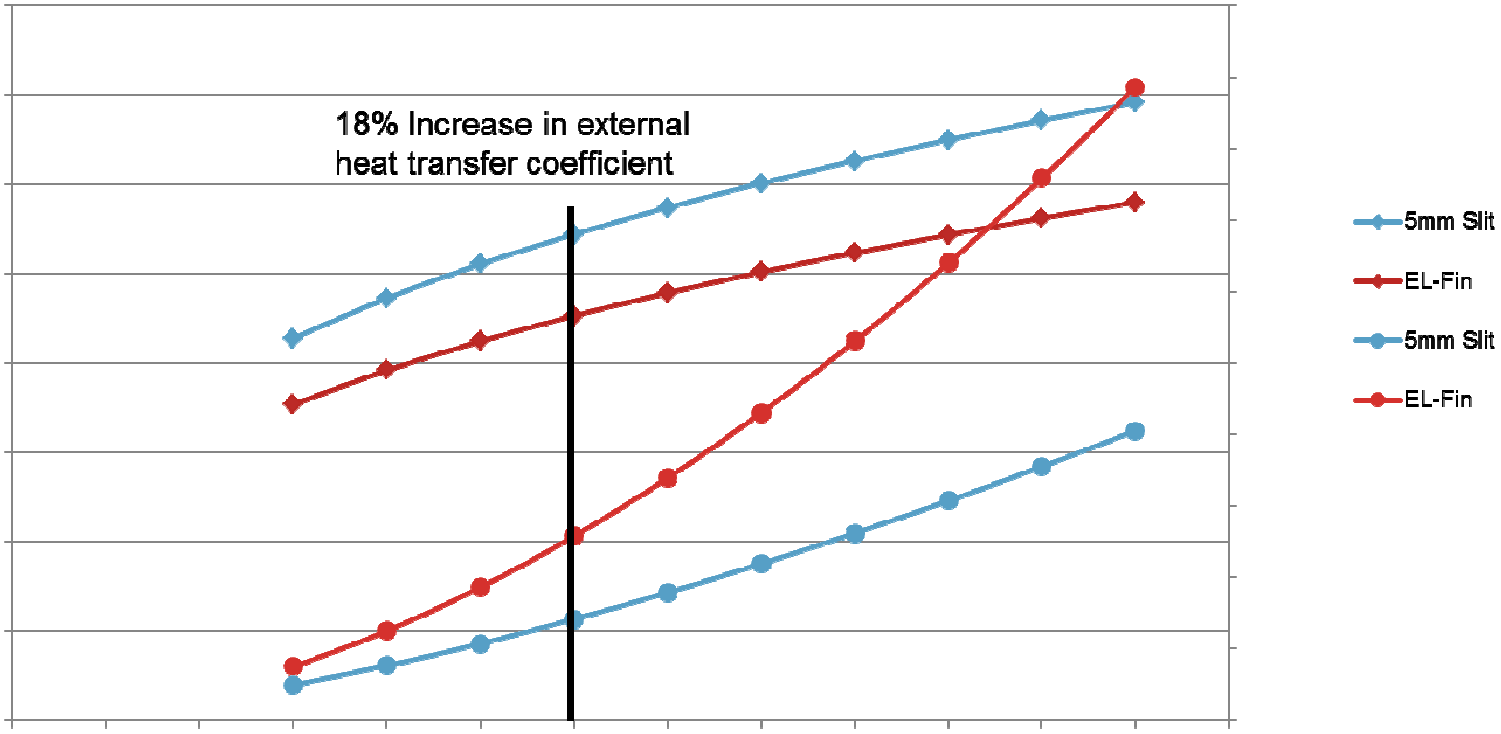
- Test results for final coil
  - 2.12mm Fin Spacing
  - Slit Enhancements
  - 4 Rows Deep



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- Selection examples showing potential for:
  - Reduced material consumption
  - Application benefits, i.e. smaller footprint and lower sound level
  - Reduction in energy use

Tube Pattern	Duty (kW)	Area (m^2)	Noise Level (dBA)	Power Input (kW)	Cu Qty (kg)	Al Qty (kg)	Cu % Diff	Al % Diff	Area % Diff	Sound Diff (dBA)	Power Reduction
G-Fin (8mm)	98.8	3.9	31	0.38	87	195	-47%	-45%	0%	0	0%
F-Fin (5MM)	95.8	3.9	31	0.38	46	108					
G-Fin (8mm)	293.9	12.5	30	1.03	304	678	-21%	-18%	0%	-4	-34%
F-Fin (5MM)	295.3	12.5	26	0.68	238	553					
G-Fin (8mm)	293.9	12.5	30	1.03	304	678	-37%	-35%	-22%	1	6%
F-Fin (5MM)	292.3	9.7	31	1.09	191	443					

- Manufacturing innovations and investments also required to realise full commercial potential

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Active Maintenance

- Combination of increased air pollution and changes in fan operation logic leading to varying levels of heat exchanger fouling
- Traditional scheduled / preventative cleaning cycles not reflecting requirements across estates
- Incorporation of IoT offers opportunity to monitor and visualise operational characteristics
- Building relationships between power consumption and fouling allows for algorithm development for possibility of alarm output for cleaning cycles

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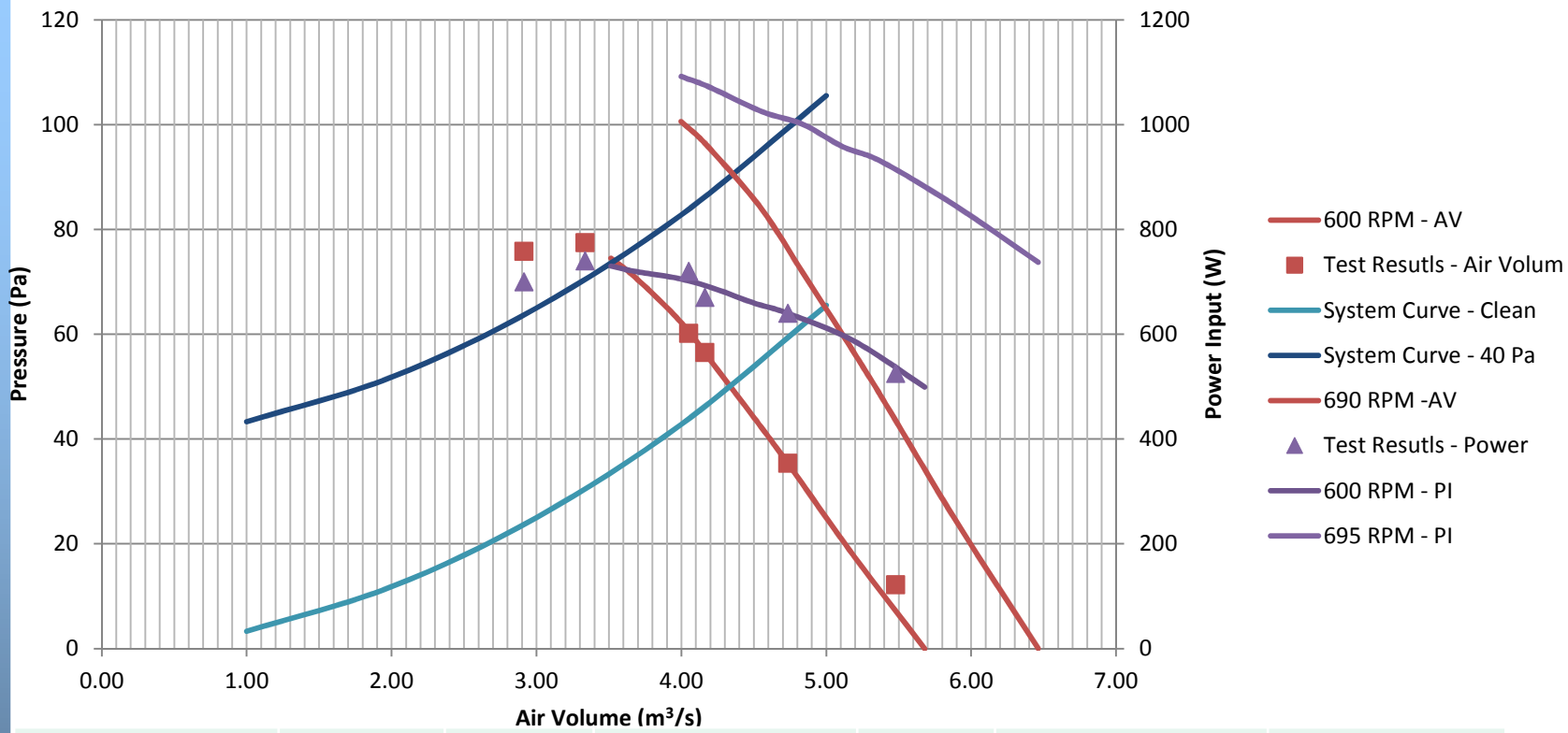

8 Fan Condenser	RPM	Air Volume	Power Input	Capacity	Power Input Change	Capacity Change
Clean Coil	600	34.56	5400	386	---	---
20 Pa Fouling	600	32	5640	370	4.44%	-4.02%
40 Pa Fouling	600	28.24	5840	345	8.15%	-10.51%
40 Pa Fouling, design capacity	690	34.56	8400	386	55.56%	---

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- Operating cost reductions possible

Clean Coil				Fouled Coil (40 Pa)		Comparisons – 6 months operation				
Duty	Air Vol	Power Input	Fan Speed	Power Input	Fan Speed	Direct Power Saving (kW)	Annual Power Saving (20 hr)	Annual Cost Saving (20 hr)	Annual Power Saving (14 hr)	Annual Cost Saving (14 hr)
386.0	34.56	5.4	600	8.4	690	3	10920	1092	7644	764.4

- Costs of pre-mature failure even more significant

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Continued Areas of Research

- Continued application simulation and optimisation
- Active equipment, with auto defrosting and auto cleaning
- Reduction in use of conventional materials, with target of alternative materials
- Reduction in operating costs, through optimised control strategies and high efficiency coils / air movement
- Accurate selection and application of heat exchangers to reduce operating energy / costs

Capacity	Air On	Fluid In	Fluid Out	Condensing Temp	Pressure	Fluid Pressure Drop	Fan Speed	Air Volume	Power Input	Sound Power
kW	°C	°C	°C	°C	Bar A	kPA	RPM	m3/s	kW	dB(A)
230	32	115	35	N/A	92.0	120	680	28.2	3.71	82
60	12	60	15	16	52.1	11	680	28.2	3.71	82
75	12	60	15	16	52.1	14	950	38.4	9.60	91
230	12	65	20	21	58.6	94	950	38.4	9.50	91
230	12	70	21.2	22.2	60.3	94	680	28.2	3.71	82

Example of application modelling to ensure appropriate selection / operation