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MINISTRY OF EDUCATION, YOUTH AND SPORTS

PRESSURE DROP STUDY OF POLYMERIC HOLLOW FIBER HEAT EXCHANGERS

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Heat Transfer and Fluid Flow Laboratory is a part of Faculty of Mechanical Engineering, Brno University of Technology.

Heatlab Interest:

- Secondary Cooling in Continuous Casting
- Roll Cooling
- Descaling
- Product Cooling (Heat Treatment)
- Testing of Automotive Headlamps
- **Hollow fibers**

Polymeric Hollow Fiber Heat Exchangers

- Firstly published in 2004 – shell‘n‘tube type
- Heat transfer surface consists of hundreds of capillaries
- Small diameters, $d_o = 0.4\text{-}1.6\ mm$
- Big heat transfer surface in small volume
- Need of separation → chaotic bundles
  - Straight 214 W, chaotic 585 W – with same heat transfer area, temperature and flow conditions (Raudensky et al. 2017)
- Application: desalination, heat recuperation

Raudenský, M., Astrouski, I. a Dohnal, M. Intensification of heat transfer of polymeric hollow fiber heat exchangers by chaotisation. *Applied Thermal Engineering*. 2017, roč. 113. S. 632–638. ISSN 13594311.

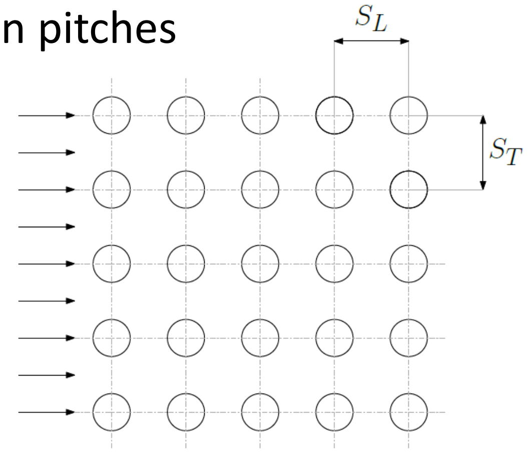
PHFHE – gas-liquid type

- Presented in 2016
- Rectangular shape
- Separation due to the textile interveawing
- Comparison with automotive radiator (Krasny et al.)
  - Heat transfer rate up to 10 kW (10 m/s, $\Delta T = 40°C$), $U_O = 335\ W/(m^2\ K)$
  - OHTC similar to the aluminum raditator
  - Higher pressure drop

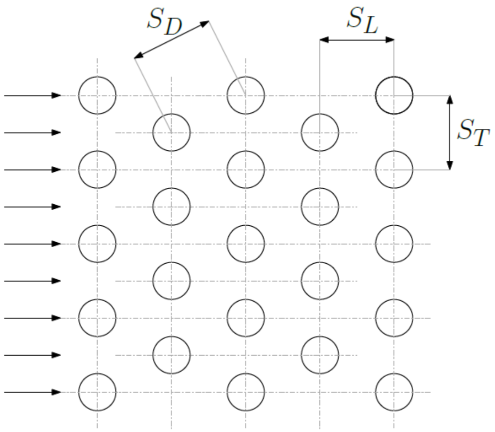
Krásný, I., Astrouski, I. a Raudenský, M. Polymeric hollow fiber heat exchanger as an automotive radiator. *Applied Thermal Engineering*. 2016, roc. 108. S. 798–803. ISSN 13594311.

Air-side pressure drop

- Common geometry - bank of tubes
- Pressure drop is dependent on the geometry and working fluid
- Emirical models – Grimison, Jakob, Kays and London, Zhukauskas
- Two basic alignment – inline and staggered
- Most of models only for common pitches



In-line



Staggered

Pressure drop of PHFHE

Can we use the models to compute pressure drop of polymeric hollow fiber heat exchangers?

- **There is at least one – published in (VDI-Heat Atlas) based on Gnielinski**
- **Pressure drop given by the equation:**

$$\Delta p = \xi n_{mr} \frac{\rho v_{max}^2}{2}$$

- **where pressure drop coefficient is function of Reynolds number, pitches and tube diameter**

$$\xi = f(\mathrm{Re}, a, b, c)$$

[1] *VDI Heat Atlas*. 2. vyd. Berlin, Heidelberg: Springer Berlin Heidelberg, 2010. ISBN 978-3-540-77876-9.

The experimental details

Experimental data from (Krasny et al. 2016) compared to the VDI-HA model

The experimantal details

- Two PHFHE with different diameters
- Inside fibers 50/50% water-glzcol coolant solution, temperature 60°C
- Cooling medium: Air, 20°C

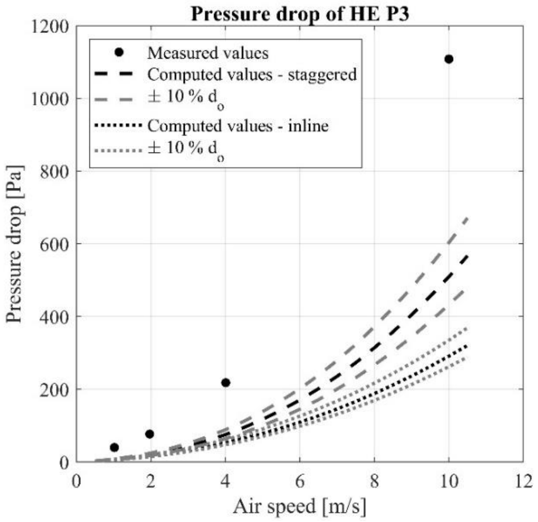
Due to the extruding technology the diameter of fiber varies ±10 %

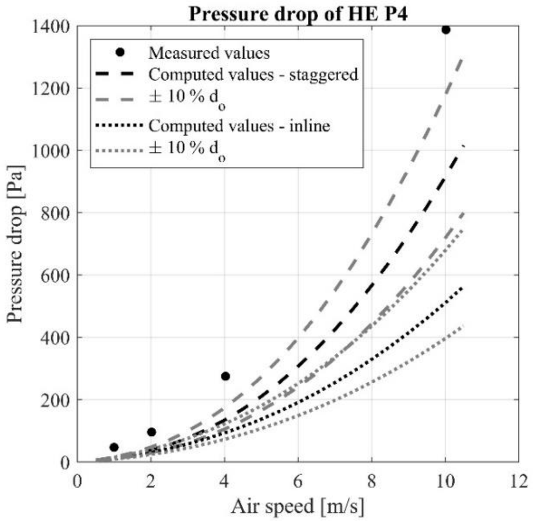
PHFHE	l [mm]	d_o [mm]	d_i [mm]	S_T [mm]	S_L [mm]	n [-]
P3	250	0,6	0,48	1,8	2	14
P4	220	0,8	0,64	1,8	2	14

Tested PHFHEs details

Results

- Computed values underestimated
- Relative error up to 458 % for P3
  and 280 % for P4
- Significant difference due to the diameter variation (up to 32 %)
- Why?
  - Flexibility of fibers – the pitches are changing during operation of heat exchanger
  - Flow-induced vibrations





Conclusion

- PHFHE are alternative to convetional heat exchanger which is chemically resistant.
- They have big heat tranfer surface to volume ratio.
- There is not much research about gas-side pressure drop.
- This study shows that discrepancy between the model and experiment is huge.
- There is need to resive/set new corelations for flexible tubes.

THANK YOU FOR YOUR ATTENTION

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FACULTY OF MECHANICAL ENGINEERING
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