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ABSTRACT

EXPERIMENTAL COMPARISON OF DIFFERENT MINICHANNEL GEOMETRIES FOR USE IN EVAPORATORS

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This thesis investigates the refrigerant (R-134a) flow in three minichannels having different geometries experimentally. During the last 40 years heat transfer in small scales has been a very attractive research area. Improvements in heat transfer in the refrigeration applications by means of usage of micro/minichannels provide significant developments in this area. Also it is known that experimental studies are very important to constitute a database which is beneficial for new developments and research. During the two-phase flow experiments conducted in the minichannels, low mass flow rates and constant wall temperature approach, which are the conditions in the evaporators of the refrigerator applications were applied because one of the purposes of this study is to determine the most ideal minichannel among the tested minichannels for usage in the evaporator section of the refrigerators. Two-phase flow experiments were made with refrigerant R134a in the three minichannels having hydraulic diameters of 1.69, 3.85 and 1.69 mm respectively. As distinct from the others, the third minichannel has a rough inner surface. Comparison of the experimental results of the three minichannels was made in terms of forced convection heat transfer coefficients and pressure drop at constant quality and mass flux values. As a result of the experiments, the most ideal minichannel among the tested minichannels was determined for the evaporator applications in the refrigerators.

Keywords: Minichannels, forced convection heat transfer, pressure drop, refrigerant, R134a, two-phase flow, experimental study.

ÖZ

EVAPORATÖRLERDE KULLANILMAK ÜZERE FARKLI MİNİKANAL GEOMETRİLERİNİN DENEYSEL KARŞILAŞTIRILMASI

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Bu tez farklı geometrilere sahip üç minikanaldaki R134a soğutkan akışını deneysel olarak incelemektedir. Son 40 yıldır küçük boyutlardaki ısı transferi çok ilgi çeken bir araştırma alanıdır. Mikro/minikanal kullanımı sayesinde gerçekleşen soğutma uygulamalarındaki ısı transferi artışı bu alanda önemli gelişmeler sağlamaktadır. Ayrıca deneysel çalışmaların, bu alandaki yeni gelişmeler ve araştırmalar için faydalı olan veritabanı oluşturmak için çok önemli olduğu bilinmektedir. Minikanallarda yürütülen iki fazlı akış deneyleri boyunca buzdolabı evaporatör koşulları olan düşük kütle debileri ve sabit duvar sıcaklığı yaklaşımı uygulanmıştır, çünkü bu çalışmanın amaçlarından biri test edilen minikanallar arasından buzdolabı evaporatör kısmında kullanıma en uygun olan minikanalı belirlemektir. R134a soğutkanıyla yürütülen iki fazlı akış deneyleri sırasıyla 1.69, 3.85 and 1.69 mm hidrolik çaplara sahip olan minikanallarda yapılmıştır. Diğerlerinden farklı olarak üçüncü minikanal pürüzlü iç yüzeye sahiptir. Üç minikanalın deneysel sonuçların karşılaştırılması sabit kütle akıları ve kuruluk derecelerinde zorlanmış konveksiyon ısı transfer katsayısı ve basınç düşümüne göre yapılmıştır. Deneylerin sonucunda test edilen minikanallar arasından buzdolaplarındaki evaporatör uygulamaları için en uygun minikanal tespit edilmiştir.

Anahtar kelimeler: Minikanallar, zorlanmış konveksiyonla ısı transferi, basınç düşmesi, soğutkan, R134a, iki fazlı akış, deneysel çalışma.

To My Parents

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LIST OF SYMBOLS

| | |
|----------------------|---|
| A..... | surface area of the minichannels, m ² |
| Al..... | Aluminum |
| C..... | specific heat, kJ/kgK |
| d..... | diameter, m |
| D _h | hydraulic diameter, m |
| DP..... | differential pressure, bar |
| G..... | mass flux, kg/m ² s |
| \bar{h} | average convective heat transfer coefficient of R134a, W/m ² K |
| h..... | enthalpy, kJ/kg |
| H..... | height, m |
| I..... | current, mA |
| j_g^* | non-dimensional mass flux |
| k..... | thermal conductivity, W/mK |
| L..... | length of the test section, m |
| \dot{m} | mass flow rate, kg/s |
| P..... | pressure, Pa |
| P_h | heated perimeter, m |
| \dot{Q} | heat transfer rate, W |
| Re..... | Reynolds Number |
| T..... | temperature, K |
| t..... | thickness, m |
| u..... | velocity, m/s |
| U..... | overall heat transfer coefficient, W/m ² K |
| \dot{V} | volumetric flow rate, m ³ /s |
| v | specific volume, kg/m ³ |
| V..... | voltage input, Volt |
| w..... | width, m |
| X_{tt} | Lockhart-Martinelli parameter |
| x..... | quality |

Greek letters

| | | |
|----------|-------|-------------------|
| Δ | ..... | difference |
| μ | ..... | dynamic viscosity |
| ρ | ..... | density |

Subscripts

| | | |
|--------|-------|-------------------------------------|
| Al | ..... | aluminum |
| c | ..... | cross sectional |
| ch | ..... | channel |
| ent | ..... | entered |
| he | ..... | pre-heater exit |
| hi | ..... | pre-heater inlet |
| i | ..... | channel inner |
| ins | ..... | insulation |
| inp | ..... | insulation pipe |
| l | ..... | liquid |
| LM | ..... | logarithmic mean |
| m | ..... | mean |
| R | ..... | refrigerant |
| re | ..... | refrigerant test exit |
| ri | ..... | refrigerant test inlet |
| RI | ..... | input to refrigerant |
| si | ..... | shell inner |
| so | ..... | shell outer |
| TP | ..... | two-phase |
| v | ..... | vapor |
| V | ..... | viscous heating |
| w | ..... | test section wall |
| W | ..... | water |
| W,loss | ..... | water side loss to the surroundings |
| w,mean | ..... | water mean |
| we | ..... | water test exit |
| wi | ..... | water test inlet |