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RENEWABLE ENERGY

НЕТРАДИЦИОННЫЕ ИСТОЧНИКИ ВОЗОБНОВЛЯЕМОЙ ЭНЕРГИИ
UNCONVENTIONAL SOURCES OF RENEWED ENERGY

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COMPUTATIONAL EVALUATION OF THERMOPHYSICAL PROPERTIES OF MIXED REFRIGERANT AND EFFECT OF PRESSURE R-290 AND R-600A AT DIFFERENT COMPOSITIONS FOR VCRS

[1] Seepana PraveenKumar, [1, 2] Naseer T. Alwan, [3] V.I. Velkin, [4] Raja Sekhar Dondapati

[1]Ural Federal University, Ekaterinburg, Russia
seepanapraveenkumar5@gmail.com,
[2] Kirkuk Technical College, Northern Technical University, Kirkuk, Iraq
nassir.towfeek79@gmail.com,
[3]Ural Federal University, Ekaterinburg, Russia
v.i.velkin@urfu.ru,
[4]Lovely Professional University, Punjab, India
Rajasekhar9@gmail.com

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The concept of mixed refrigerant fluids has emerged during the past few decades from 20th century due to its superior thermophysical properties as compared to base fluids. It is primarily used as coolants in heat transfer equipment such as heat exchangers and thermoelectric cooling systems. In the current study, an analysis of the physical-thermodynamic properties and the different parameters was performed by considering 10gms of mixed refrigerant of propane and ISO-butane at different compositions ratio. All results presented for simulations carried out at range temperature about 300-350K and a pressure range of 3MPa to 7MPa. They concluded from the result that as the temperature increases specific heat of mixed refrigerant decreases. Similarly, thermal conductivity increases with an increase in temperature for a mixed refrigerant at different compositions. Further, as the pressure is varied from 3MPa to 7MPa while keeping the temperature constant at 350K, the specific heat decreases by 5.2% as well as thermal conductivity follows the opposite trend and is increased by 6.9%.

Ключевые слова: refrigerants, thermo-physical, base fluids, heat transfer, coolants, heat exchangers.

ВЫЧИСЛИТЕЛЬНАЯ ОЦЕНКА ТЕРМОФИЗИЧЕСКИХ СВОЙСТВ СМЕШАННОГО ХЛАДАГЕНТА И ВЛИЯНИЯ ДАВЛЕНИЯ R-290 И R-600A НА РАЗЛИЧНЫЕ КОМПОЗИЦИИ ДЛЯ ВКМ

[1]Сипана Правинкумар, [2]Насир Т. Алван, [3]Велькин В. И., [4]Раджа Сехар Дондапати

1 Уральский федеральный университет, Екатеринбург, Россия
seepanapraveenkumar5@gmail.com
2 Киркукский технический колледж, Северный технический университет, Киркук, Ирак
nassir.towfeek79@gmail.com
3 Уральский федеральный университет, Екатеринбург, Россия v.i.velkin@urfu.ru
4 Высший профессиональный университет, Пенджаб, Индия
Rajasekhar9@gmail.com

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Концепция смешанных хладагентов появилась в течение последних нескольких десятилетий, начиная с середины 20-го века, благодаря своим превосходным теплофизическим свойствам по сравнению с базовыми жидкостями. Он в основном используется в качестве теплоносителя в теплообменном оборудовании, таком как теплообменники и термоэлектрические системы охлаждения. В настоящем исследовании был проведен анализ физико-термодинамических свойств и различных параметров с учетом 10 г смешанного хладагента пропана и изобутана при различном соотношении составов. Все результаты представлены для моделирования, выполненного при температуре около 300-350 К и диапазоне давлений от 3 МПа до 7 МПа. В результате они пришли к выводу, что с повышением температуры удельная теплоемкость смешанного хладагента уменьшается. Аналогично, теплопроводность увеличивается с увеличением температуры для смешанного хладагента при разных составах. Кроме того, поскольку давление изменяется от 3 МПа до 7 МПа при сохранении постоянной температуры на уровне 350 К, удельная теплоемкость уменьшается на 5,2%, а теплопроводность следует противоположной тенденции и увеличивается на 6,9%.

Keywords: тепловой насос, теплофизические характеристики, теплообмен, хладагенты, теплообменники.

Seepana PraveenKumar
Сипана Правинкумар

Information about the author: postgraduate, Ural Federal University, Department of Nuclear Power Plants and Renewable Energy Sources, Russia. MR Seepana Praveenkumar.

Place of work: Ural Federal University named after the First President of Russia B.N. Yeltsin, Department of Nuclear Power Plants and Renewable Energy Sources.

Education: Seepana PraveenKumar was born in India (1995). He earned his Bachelor's and Master's degree in Mechanical engineering one of the prestigious institutes in the world.

Awards and scientific awards: Awarded first prize presentation in Urfu in University exhibition.

Research interests: renewable energy sources, wind and solar energy conversion systems, wind turbines, refrigeration and air conditioning, cryogenic engineering.

Publications: 7.

Сведения об авторе: аспирант, Уральский федеральный университет, кафедра атомных станций и возобновляемых источников энергии, Россия. MR Seepana Praveenkumar.

Место работы: Уральский федеральный университет имени первого Президента России Б.Н. Ельцина», кафедра «Атомные станции и возобновляемые источники энергии».

Образование: Сипана Правинкумар родился в Индии (1995). Получил степень бакалавра и магистра в области машиностроения в одном из престижных мировых институтов.

Награды и научные премии: Вручение первой премии в УрФУ на университетской выставке.

Область научных интересов: возобновляемые источники энергии, системы преобразования энергии ветра и солнца, тепловые насосы, охлаждение и кондиционирование воздуха, криогенная техника.

Публикации: 7.

Naseer T Alwan
Насир Т. Алван

Information about the author: postgraduate, Ural Federal University, Department of Nuclear Power Plants and Renewable Energy Sources, Russia. MR Naseer T Alwan.

Place of work: Ural Federal University named after the First President of Russia B.N. Yeltsin, Department of Nuclear Power Plants and Renewable Energy Sources.

Education: he earned his Bachelor's and Master's degree in Mechanical engineering one of the prestigious institutes in the world from Iraq. Currently, he is Pursuing PhD in UrFu.

Research area: renewable energy sources, wind and solar energy conversion systems, wind turbines, refrigeration and air conditioning.

Publications: More than 12.

Сведения об авторе: аспирант, Уральский федеральный университет, кафедра атомных станций и возобновляемых источников энергии, Россия. MR Naseer T Alwan.

Место работы: Уральский федеральный университет имени первого Президента России Б.Н. Ельцина», кафедра «Атомные станции и возобновляемые источники энергии».

Образование: получил степень бакалавра и магистра в области машиностроения в Государственный университет Ирака.

Область научных интересов: системы преобразования энергии ветра и солнца, тепловые насосы, охлаждение и кондиционирование воздуха.

Публикации: более 12.

Vladimir Ivanovich Velkin
Владимир Иванович Велькин

Information about the author: Professor of the Department of Nuclear Power Plants and Renewable Energy Sources of the Ural Federal University, Russia.

Education: graduated from the Kirov UPI in 1982.

He defended his PhD thesis in 1996;
in 2018, he defended his doctoral thesis at Peter the Great St. Petersburg University.

Research interests: nuclear power, renewable energy.

Publications: more than 150, four monographs, 15 patents, 1 textbook.

Сведения об авторе: Профессор кафедры атомных электростанций и возобновляемых источников энергии Уральского федерального университета, Россия.

Образование: закончил УПИ им.С.М.Кирова в 1982 г., защитил кандидатскую диссертацию в 1996 г.; в 2018 г. защитил докторскую диссертацию в Санкт-Петербургском университете Петра Великого.

Область научных интересов: атомная энергетика, возобновляемая энергетика.

Публикации: более 150, четыре монографии, 15 патентов, 1 учебник.

Rajas Sekhar Dondapati
Раджас Секхар Дондапати

Information about the author: Prof Rajas Sekhar Dondapati works in school of Mechanical Engineering, Lovely Professional University.

Education: he received his PhD from the Indian Institute of Technology, Kharagpur in the year 2015.

Research area: thermal energy, cryogenic and superconductivity, refrigeration and air conditioning.

Publications: more than 40.

Сведения об авторе: профессор Раджас Секхар Дондапати работает в школе машиностроения при Профессиональном университете Лавли.

Образование: Он получил докторскую степень в Индийском технологическом институте, Харагпур, в 2015 году.

Область научных интересов: тепловая энергия, криогенная и сверхпроводимость, охлаждение и кондиционирование воздуха.

Публикации: более 40.

Introduction

In present scenario studies on mixed refrigerants has become versatile all over the universe, so for these reasons vapor compression refrigeration systems (VCRS) are used for cooling purposes. In general, Figure 1 represents VCRS cycle consists of four major parts such as compressor, condenser, expansion valve and evaporator. The compressor is the process where the low temperature and low-pressure gaseous refrigerant is compressed isentropic ally to obtain high-pressure super-heated vapor region this process is also predominately known as 'Win' process. From process 1-2 Figure 1, Figure 2, represents the work given by the compressor [1] – [3]. From the process 2-3 condenser process takes place in condenser the high pressure and high temperature superheated vapor is converted to high pressure and high temperature liquid refrigerant this process takes at constant pressure (P=C) and within the dome there will be occurrence of constant temperature process (T=C). In this process heat rejection will take place 'Q_{out}' in Figure 1,Figure 2 represents process 2-3 [4]–[6]. Expansion valve is the process takes place at takes place from 3-4 in this neither heat input nor rejection of heat occur or neither supply of work or nor rejection of work takes it is the process enthalpy is the process where narrow cut junction will occur to supply the liquid from high pressure and temperature liquid to low pressure and temperature liquid and vapor region Figure 1, Figure 2 represents process 3-4. Evaporator is the process where the object is cooled this process generally takes place from 3-4 is the process represents in Figure 1, Figure 2 where low pressure and low temperature liquid and vapor refrigerant is converted to Vapor refrigerant. This process is also widely known as heat supply process (Q_{in}) [5], [6], [8]. In the current study, 10gms of zoetrope with the combination of hydrocarbons are chosen for the analysis such as propane (R290) and ISO-butane (R600a) are considered as refrigerants. The number of moles calculates the compositions of each refrigerant. For this analysis, a mixed refrigerant of R290 and R600a operates at a pressure of 3MPa to 7MPa and temperature of 300-350 K properties of the refrigerant are available from Table 1. The molecular weight of refrigerant mixture is taken as 10gms and refrigerant mixture is in the mass ratio of 10%-90%, 20-80%, 30-70%, 40-60% is considered density and viscosity varying with respect to temperature as plotted. Thermophysical properties based on the refrigerants such as specific heat and thermal conductivity are evaluated for the refrigerant mixture and the effect of pressure on different compositions are evaluated at pressure of 3 MPa to 7 Mpa.

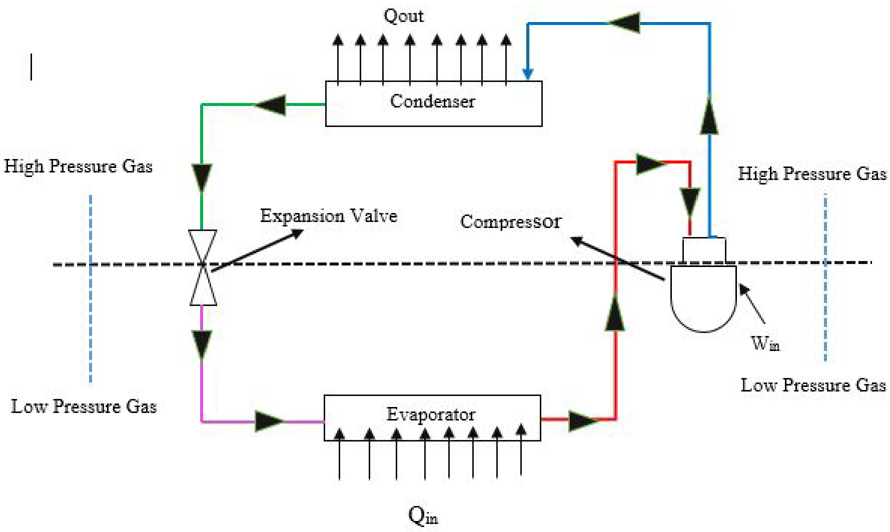


Fig.1. Schematic representation of VCRS Cycle.
Рис. 1. Схематическое изображение цикла VCRS.

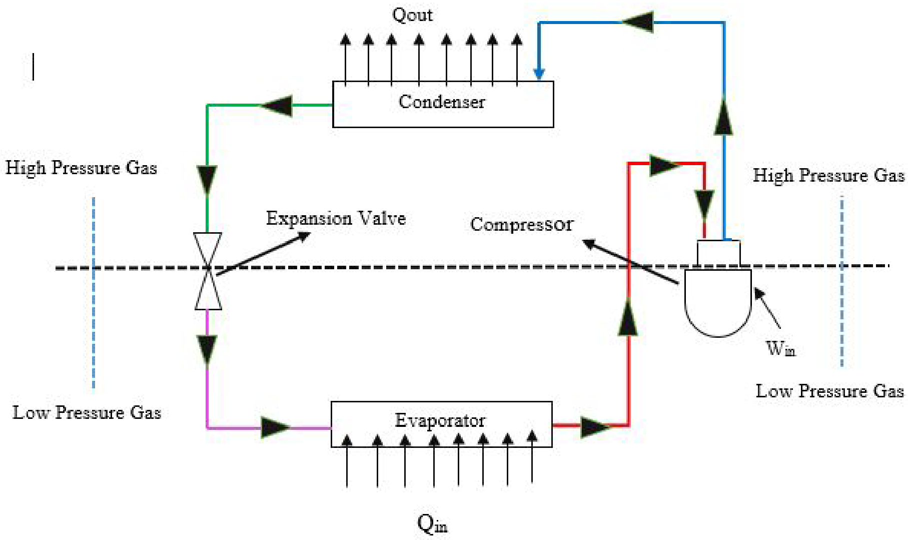


Fig. 2. P-h representation of VCRS.
Рис. 2. P-h представление VCRS.

Gow [8] Investigated with the elementary materials of cryogenics and 39 pure refrigerants are used to design the vapor pressure vs temperature relationship by using different type's hydrocarbon refrigerants and the cryogenic compounds the equation has developed. Richardson et al [9] conducted experimentally without passage of air the performance of refrigerants and concluded that propane and ISO-butane gives the better performance of Coefficient of performance (COP). Lorentzen [10].Considered thermodynamic and heat transfer properties as an important factor. Natural substances such as propane, ammonia and carbon dioxide are used as halocarbons. Scalabarin et al in this work, pure fluids and mixtures are predicted fluid families such as alkanes and halogenated alkanes with high accuracy of dedicated equations of state (DEOS) have been proposed thermodynamically. Latra Boumaraf et al [11] have been proposed simulation results for the performance and characteristics of the operating cycle of refrigeration system. This simulation results includes co-relation of the ejector entertainment the conservation of 1-D model. Dalkilic et al [12] in this study experimental results of pressure drop condensation was determined by choosing two refrigerants such as R600a 1m long horizontal and smooth with inner diameter 4mm ad outer diameter 6mm and R134 in a vertical 0.5mm smooth copper tube with inner diameter 8.1mm and outer and 9.52mm. Mohanraj et al [13] performed an experimental work, with single evaporator domestic refrigerator using hydrocarbons mixture, which mean a mixed refrigerant of propane (R290), and ISO-butane (R600a) it presents that hydrocarbons have lower consumption of energy. However, it leads to higher value of coefficient of performance (COP). Ardhapukar et al [14]. In the present investigation to calculate the overall heat transfer coefficients along with the length of heat exchangers for various mixtures has been determined for these experimental data and empirical co-relations have been determined. Yan et al [15]. Investigated with zeotropic refrigerant mixture such as R290 and R600a for domestic freezer in an Internal Auto Cascade Refrigeration Cycle (IARC) performance of these IARC a mathematical model is used to develop the performance. The results are discussed about the pressure ratio of compressor, COP performance volumetric compressor. Yan et al [16]. Study reports using zoetrope mixture such as R290 and R600a for the modified ejector expansion cycle in this conventional ejector expansion cycle and throttling cycle is carried out, results are presented that refrigerant effect of COP, volumetric efficiency etc. Chen [17]. To enhance the overall system performance an internal subcooler with additional bypass is used. In this study, Modified Vapor Compression Refrigeration Cycle (MVRC) using zeotropic mixtures with addition of hydrocarbons of refrigerants such as propane (R290) and ISO-butane (R600a) is used.

List of symbols	
Abbreviations	
VCRS- Vapor compression refrigeration system	COP- Coefficient of Performance
R290- Propane	MVRC -Modified Vapor Compression Refrigeration Cycle
R600a- Isobutane	Q_{in}, Q_{out} -heat in and out from the system
IARC- Internal Auto Cascade Refrigeration Cycle	W_{in}, W_{out}- work in and out from the system
Latin alphabet letters	
(^{0}C), K, T- Temperature	C_p,C_v- Specific heat at constant Pressure and volume
P- Pressure	ODP- Ozone Depletion Point

1. Methodology of study

1.1. Selection of refrigerant mixture

Selection of refrigerant mixture such as propane and IS0-butane are generally based on different properties such as boiling point (^{0}C), Melting Point (^{0}C) and specific heat (kJ/kg.^{0}C) of the refrigerant.

Table 1

Represents Properties of Refrigerant Mixture

Таблица 1

Представлены свойства смеси хладагентов

Properties	*R290*	*R600a*
IUPAC	Propane	ISO-butane
Chemical Formula	C_3H_8	C_4H_{10}
Density	2.0098 kg/m^3	2.51 kg/m^3
Melting Point	-187.7	-159.42
Boiling Point	-42.25	-11.7
Vapour Pressure	853.16	204.8
Specific Heat Capacity	73.6	96.65
Saturated Hydrocarbon	Alkane	Alkane
ODP	0	0
GWP	3.3	3
C_p/C_v	1.136	1.006
Critical Temperature	96.7	134.7
Critical Pressure	4248	3640

1.2. Selection of Composition

In current study, 10gms of refrigerant are chosen for the analysis at different composition for the refrigerants such as Propane and the number of moles defines ISO-butane. Number of moles is defined by the ratio of given mass of the composition (%) to the mass of a single refrigerant R290 and R600a that are tabulated in Table 2.

Table 2

Composition of Refrigerant Mixture

Таблица 2

Состав смеси хладагентов

Refrigerant Mixture (gms)	*Propane (C_3H_8)*	*ISO-butane (C_4H_{10})*
10	1gm (0.022)	9gm (0.155)
10	2gm (0.045)	8 gm (0.137)
10	3gm (0.068181)	7 gm (0.12068)
10	4gm (0.090909)	6 gm (0.10344)

1.3. Thermophysical Properties

For the present work, effect of pressure on different refrigerant compositions are evaluated for Propane and ISO-butane (R290 and R600a) and temperature range varies from 300-350K selected thermo physical properties such as specific heat and density are discussed in the succeeding chapter.

2. Results and Discussions

2.1. The effect on specific heat in relation to the temperature of the refrigerant mixture at different compositions

To evaluate the thermophysical properties refrigerant mixture such as specific and thermal conductivity are evaluated for the propane and ISO-butane (R290 and R600a) are considered. Refrigerant mixture operates at a pressure of 3MPa to 7MPa and temperature of 300-350K. Specific heat and thermal conductivity of the refrigerant mixture are evaluated.

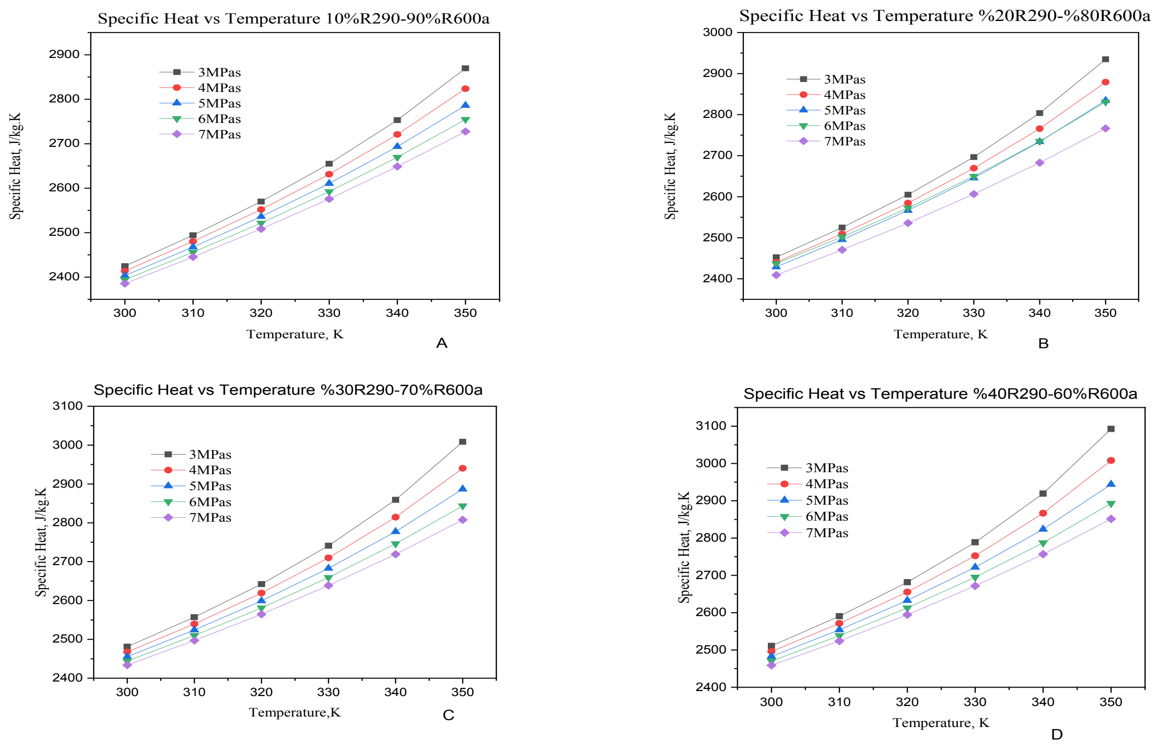
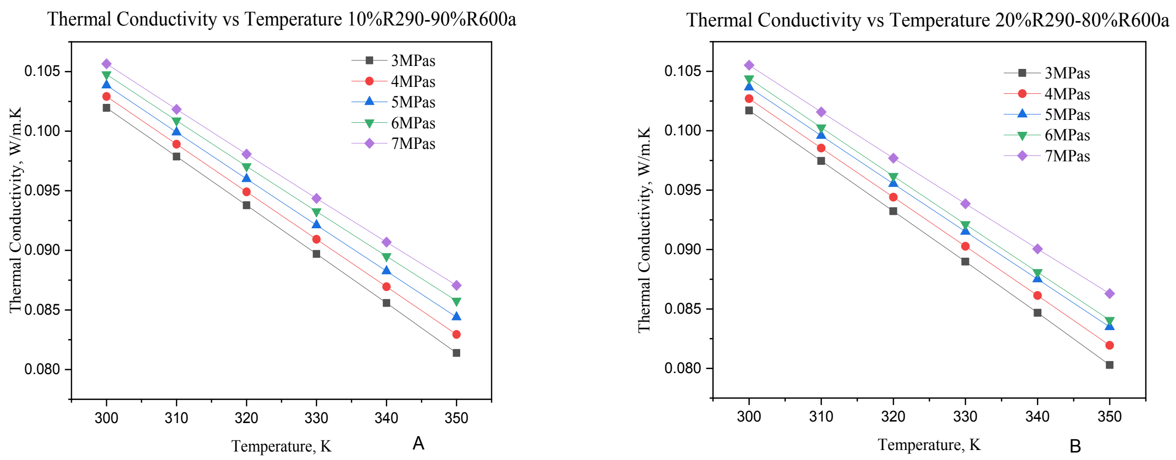
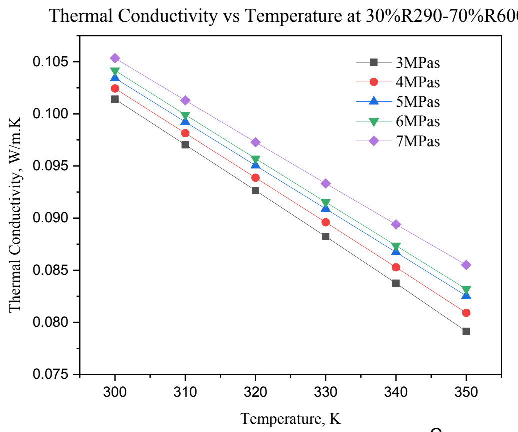


Fig. 3. Specific heat vs temperature at different compositions of mixed refrigeration.
Рис.3. Удельная теплоемкость в зависимости от температуры при различных составах смешанного хладагента.

2.2. The effect on thermal conductivity in relation to the temperature of the refrigerant mixture at different compositions





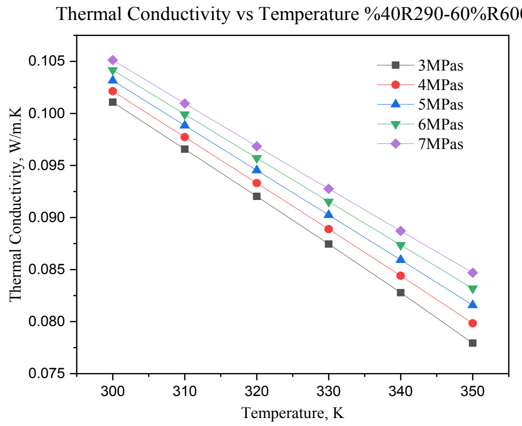


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Fig.4. Thermal conductivity vs temperature at different compositions.
Рис.4. Зависимость теплопроводности от температуры при различных составах хладагента.

Figure 4 shows the variation of thermal conductivity with respect to temperature at a composition of a mixed refrigerant R290 and R600a. However, it shows that as the increase in temperature and pressure thermal conductivity of a mixed refrigerant is increases.

Conclusions

In current study, investigation on pressure effect of mixed refrigerants such as propane and ISO-butane are evaluated at different composition. It was concluded that as that as the increase in thermal conductivity by 6.9% at constant temperature 350K. Meanwhile, opposite trend was followed by the specific heat decrease from temperature range of 300-350K and it reduces by 5.2% reduction at constant temperature 350K in the liquid region.

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Транслитерация по BSI

“НОВАТЭК” увлекся водородом

Российский производитель сжиженного газа “НОВАТЭК” намерен всерьез заняться развитием водородных технологий. Компания в начале года подписала сразу два знаковых для нее соглашения, предполагающих работ в этом направлении.

В частности, крупнейший в стране независимый производитель газа договорился с германской Uniper о сотрудничестве при производстве и поставок водорода. Две компании планируют вместе развивать производство, транспорт и поставки водорода, в том числе на электростанциях Uniper в России и Западной Европе, сообщил “НОВАТЭК”. “*Рассматриваются поставки „голубого“ водорода, произведенного из природного газа с дальнейшим улавливанием и хранением CO_2, а также „зеленого“ водорода, полученного с использованием возобновляемых источников энергии*», — говорится в сообщении компании.

Глава «НОВАТЭКа» Леонид Михельсон назвал водородную энергетику перспективным направлением долгосрочной стратегии развития компании. “*Развитие коммерчески эффективного производства „низкоуглеродного водорода“ находится в начальной стадии, и наше совместное сотрудничество в этой области с Uniper, одной из ведущих международных энергетических компаний, позволит заложить надежную основу для дальнейшего выстраивания долгосрочных отношений*», — рассчитывает он.

Кроме того, “НОВАТЭК” подписал с итальянской Nuovo Pignone, входящей в состав Baker Hughes, соглашение о стратегическом сотрудничестве в области сокращения выбросов CO_2. Две компании будут работать в области электрических и газотурбинных решений по добыче и сжижению газа, а также сокращения выбросов CO_2. “НОВАТЭК” и Nuovo Pignone уже договорились и о конкретных проектах. В частности, они планируют начать совместный перевод турбин на работу на водородсодержащих смесях топливного газа.

Baker Hughes является одним из поставщиков основного оборудования для проектов “НОВАТЭКА” по сжижению газа «Ямал СПГ» и «Арктик СПГ 2».

Прошлой осенью финансовый директор “НОВАТЭКа” Марк Джетвей заявлял, что компания изучает возможность производства водорода, исследуя перспективы его выработки из метана с технической и экономической точек зрения. Речь идет как о производстве водорода для нужд самой компании, так и для поставки конечным потребителям.

Ресурсная база компании позволяет производить как СПГ, так и водород, отмечал он.

Энергостратегия России предполагает экспорт 200 тыс. т водорода к 2024 г., а к 2035 г. — 2 млн. т.

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