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A Bibliometric Review on Explanation in Micro Channel Heat Exchanger

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Abstract: The world is going towards decrease as nearly each technological industry advances. In order to provide constant performance & extended life for very small systems like high-performance computer chips, laser diodes, & nuclear fusing & fission reactors, significant heat flux must be removed. Micro-Channel Heat Exchangers (MCHX) have the ability to lighten the weight of the instruments & increase its compactness. Considering the progressively number of papers in this subject over the last 10 years, research in this area has attracted a lot of interest. The Scopus database was utilized to pull together a thorough assessment of all pertinent papers for this paper's bibliographical research. Any study that calls for data to be acquired from published sources is referred to as the research. The describing data provided by this bibliographical study on a piece of writing includes the author, title, publishing date, etc. The study also enables the mapping of the discipline's breadth and organizational structures as well as the identification of existing international cooperation trends. Additionally, this study reveals the present research areas of interests & possible future research initiatives.

Keywords: Micro channel heat exchanger, Micro channel, Heat transfer coefficient, Thermal engineering, and Refrigerant.

1. Introduction:

The issue of copper substitutions has gained considerable attention in recent years because to the rise in demands for lightweight products & the price of copper. The Micro-Channel Heat Exchanger (MCHX) may decrease equipment's weight & enhance the device's compactness in order to satisfy the heat exchanging requirement[1][2]. MCHX has a straightforward cross-section, which is commonly rectangular, triangular, round, or trapezoidal. They have a limited volume, making it possible to utilize them immediately as micron-sized heat sources. They also have great heat-exchange efficiency, & the majority of its fluids state is laminar flow [3]. The fluids flows in lateral detentions having a hydraulic diameter of smaller than 1mm in this sort of heat exchangers. Heating, ventilation, & air conditioning (HVAC) equipment like water coils, heat pumps, air conditioning, & others mostly employ MCHXs[4]. Additionally, the market for MCHXs is very competitive because to the increase in renewable energy laws [5]. The objective of MCHX is to enhance total heat transfers, that may result in a reduction in the temperatures differential among air & a refrigeration. The heat exchangers also reduce airside pressure

loss, that leads to increased energy savings from fan energy use. MCHX is often utilized as a platform technologies for high-performance, size-critical applications [6]. Through improved heat & mass transference for pathways on the order of 100 microns & a large surface area-to-volume ratios a very high (>95%) heat & mass transfer efficiency could be attained [7]. Figure 1 depicts the MCHX's geometric parameters.

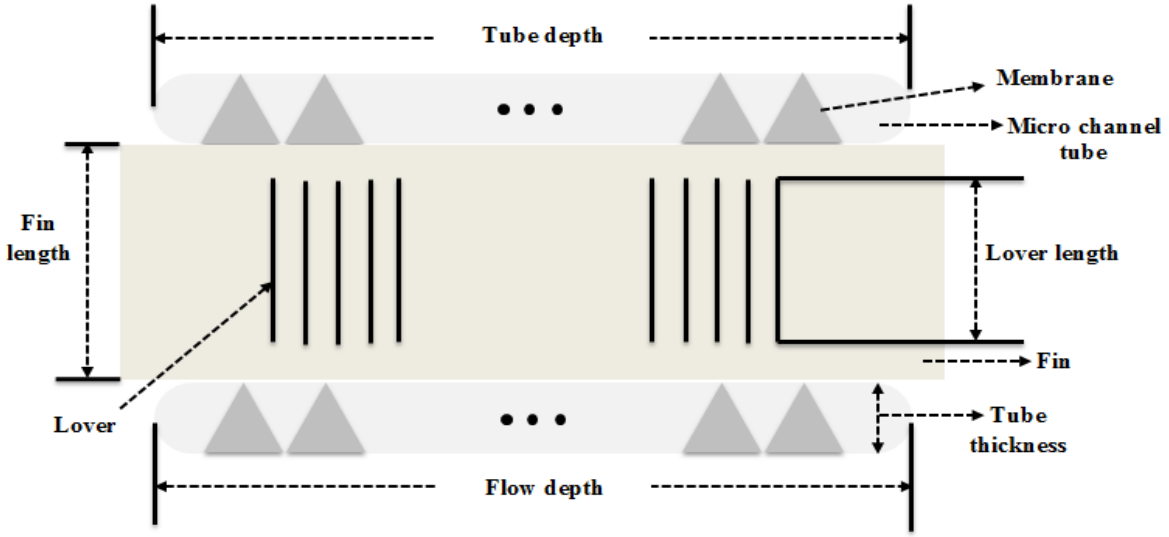

Figure 1: Geometric parameters for the MCHX

MCHX has been extensively researched and applied in the cooling of electronic equipment[8]. Micro-channel technologies is increasingly being incorporated into refrigeration, home air conditioning, & vehicle air conditioning equipment in tandem using the advancement of technology for processes [9]. There are some advantages for the MCHX. They are [10][11].

- **High heat transfer ratios:** There are several contributing elements responsible for MCHX's high heat transfer coefficients.
- **Low Airside Pressure Drops:** Lower airside resistance is an additional advantageous characteristic of MCHXs over conventional HVAC coil designs.
- **Close Approach Temperatures:** Close approach temperatures among the air & refrigerant are made feasible by identical factors which provide the MCHX its excellent performance.
- **Low Refrigerant Charge:** The core of an MCHX is much more durable than that of conventional finned tube heat exchangers.
- **Robust Construction:** In contrast to traditional finned tube heat exchangers, the core of an MCHX is extremely robust.

Due to structural & others peculiarities, MCHX differs greatly from the typical heat exchangers in terms of flow & heat transfer properties [12][13]. Scale effects may be used to explain certain events & novel principles in the formation of microchannel [14] Reducing scale increases the impact of fluids compressibility [15].

The bibliographic survey paper is explained as follows: section 2 summarizes the survey on MCHX with its methodology and data analysis; section 3 indicates the bibliographic analysis, and the paper is concluded in section 4.

2. Deep Conventional Explainability On Methodology Ofmchx:

Increased volumetric heat flux, compactness for space-critical programs, excellent flow distribution, & sturdy designing are further benefits that MCHX offers [16]. MCHX is being utilized more & more in single-phase (liquid or gas) & two-phase (condensation - evaporative) heat exchanges[17] The lower scale & costs acquired in the case of enhanced serial manufacturing depending on nanotechnology series productivity improvements offset the drawback of the increased pumping power [18]. From the investigative approach of Bo Xu, et al. [19], It had been demonstrated which one kind was a standard MCHX, which were often utilized in mobile & commercial air conditioning systems & had horizontally flat tubes & louver fins. The alternative kind, which had louver fins & vertical flat tubes, was anticipated to have higher draining capabilities. Similarly, Ehsan et al. [20] The strategy was to conduct experimental studies of the impact of surface coatings & water retaining on MCHX's ability to prevent icing in heat pump systems. According to the results, the hydrophilic coated surface (coil 2) increased capacity in wet coils circumstances by up to 15% while maintaining a similar icing duration to the uncoated coil (coil 1). Figure 2 displays a diagrammatically depiction of MCHX.

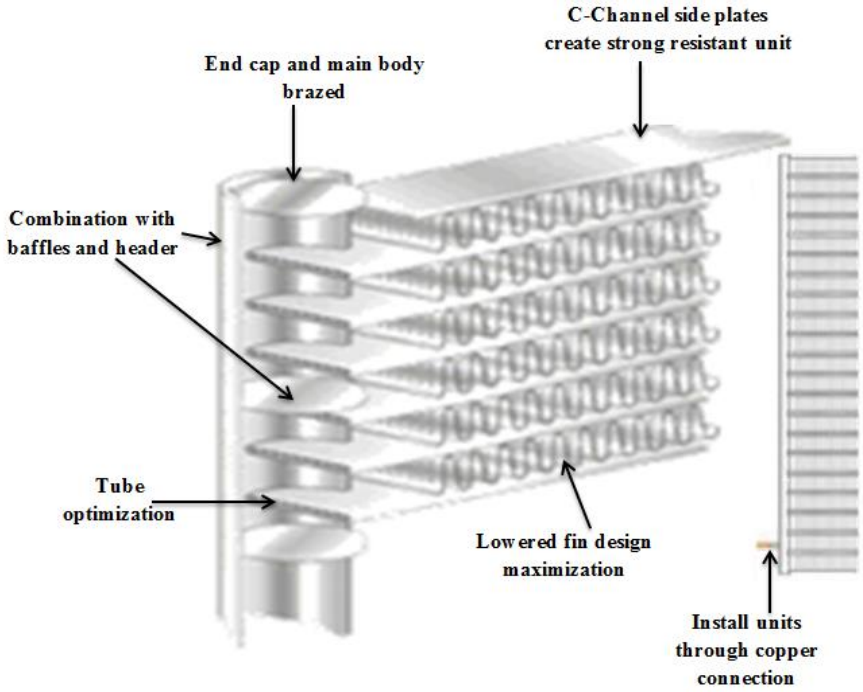

Figure 2: Diagrammatic representation of the MCHX

The channel flooring that divide the hot & cold streams are a technologies in MCHX, & they are around 600 microns thick [21].There are 3 reasons why the axial gaps in channel ribs are displayed. The primary goal was to enable channels pressures equivalence. Due to the fact which the axial pressure drop is roughly inversely proportional to the cube of the channel height, even minor manufacturing differences may significantly alter the flow distribution across channels [22]. Gaps therefore migrate to enhance flow distribution. The gaps were moved for a second reason: to reduce possibly harmful longitudinally wall conductivity. The end goal was which once the flow entered the micro-channel parts, the rib gaps must produce local entry length boundary-layer behaviors. It was dispersed to improve regional heat transfer efficiency [23]. N.T.Dhokane, et al. [24] have done an experimental investigation of the MCHX. Following an analysis of the experiment's findings, it was discovered which the Heat Transfer Rate (Q) and the coefficient of Performance (COP) both demonstrated the greatest heat transfer rate

performances. The whole manufacturing processes for MCHX includes the phases listed below. They are:

- **Fabricate the heat exchanger core**

A core with many tubes might be placed for assembling as part of the assembling technique. Putting the pressurized core into a housing's inner area may also be part of the procedure [25]. A core builder precisely fabricates & installs heat exchangers elements including manifolds, flat tubes, including fins at a specific location.

- **Thermal degreasing**

Thermal degreasing is a combined process involving pyrolysis and oxidation. As an industrial application, it was used to remove organic substances, such as polymers, plastics, and coating from parts[26]. Impurities and lubricants will be removed from the surface by applying them at a specific temperature[27].

- **Fluxing**

Essentially, fluxing is the quantity of heat energy that passes across a specific surface. A heat flux sensor may directly contribute to improving the thermal comfort of a garments by providing information on the heat exchanges among the body & the environmental. When flux is given to the coils as an aqueous solution, surplus flux slurry would be removed using air blow-off and it will be distributed evenly throughout the coil [28][29]. It will be heavily used in the components of the heat exchangers like manifolds and flat tubes.

- **Drying**

The thermal procedure of drying involves the simultaneous transport of heat & moisture. The temperatures of the solids including any moisture present is raised via convection, which transfers heat from warm air to the product. Coil surface temperatures among 200 & 250 °C are used for drying [30].

- **Brazing**

By allowing molten metal to flow into the connection, the technique of brazing unites 2 or many metal surfaces. To prevent the work components from melting, the filler metal has a lesser melting point than the parts that need to be linked. Brazing is the most important process in the MCHX. When welding or brazing the microchannel, the most important one is to use it at low temperatures. The flames are essential to moving constantly to prevent the channels from melting. The brazing furnace's nitrogen environment is essentially where the procedure takes place. Temperature rises as the coils moves through a tunnel-style furnace, & flux begins to melt at a temperature of approximately 565°C, followed by the melting of the brazing alloy at a temperature of about 580°C.

- **Cooling**

In essence, the cooling systems fulfills 3 crucial tasks. It begins by removing extra heat from the engines, continues by keeping the engine running temperatures where it operates more effectively, & concludes by swiftly bringing the engines up to the proper operating temperatures. When the metal solidifies during the cooling step of the heat exchangers production, a metallurgical link is created among every component[31] [32].

- **Testing**

The coils is now prepared for additionally production steps like coating after passing a variety of tests, includes leakage testing, pressure tests, geometric checks, & brazing quality controls[33].

3. Bibliometric Analysis:

This section explains the analysis of keywords on the research of MCHX, analysis of the journals with their metrics, and publication of journals on the research of MCHX ranging between the years 2012 to 2022.

3.1. Data collection:

For the purpose to have the overall part of the literature on the MCHX research, the data were related to the number of published articles indexed in the web of science database. The bibliometric data were gathered between the years 2012 to 2022 from 3 research databases of Web of Science (WOS), Scopus, and Science Citation Index Expanded (SCIE). Most people agree that the Web of Science database is the gold standard & the most reliable source for scientific data. Furthermore, Scopus is regarded as the biggest abstracts & citations database of books, journals, & conference proceedings that have undergone peer review. The information was gathered via searches for "title, abstract, keywords" in the WOS, Scopus database, & SCIE.

3.2. Data Analysis:

Initially, a detailed analysis was conducted. A Sequence of graphs was generated for detecting the path related to the published articles on MCHX. Further, the bibliographic methodology was used. This research uses citations to recognize the worthiest papers, researchers, and journals enclosed by certain domains. The number of times a scientific paper had been cited by another article in the index was recognized by utilizing the citation analysis. The MCHX research was quantitatively and qualitatively analyzed through normal data analysis. For normal data analysis, bibliographic measures like journals, countries, authors, scientific papers, and publishers were utilized.

3.3. Keyword analysis:

Keywords are significant in any type of research. The keywords have an important role in the findings of the research. The common keywords, “Thermal Engineering”, “Micro-Channel Heat Exchanger”, “Thermal analysis”, “Heat exchanger”, and “Flat and Curved Face Micro-Channel Heat Exchanger” were used to search the documents to effectively identify the documents that best match the theme of this work. From the analysis of the entire journals belonging to the main keywords, 25 reputed journals were filtered, which were most suitable for this study, as well as for bibliometric research.

3.4. Analysis of journals with their metrics:

There will be a number of journals for the research of MCHX. In this analysis, there were 25 journals taken with mentioning their metrics, such as impact factor (IF), Scimago Journal Rank (SJR), Source Normalized Impact per Paper (SNIP), Citation score (CS), Country, publication frequency, and publisher. Therefore, table 1 represents the analysis of journals with their metrics for the research of MCHX.

Table 1: Analysis of journals with their metrics for the research of MCHX:

Journal Name	IF	SJR	CS	SNIP	Publisher	Country	Publishing frequency
Renewable and Sustainable Energy Reviews	16.8	3.678	28.5	4.53	Elsevier Ltd.	UK	12 issues per year
Energy Conversion and Management	11.1	2.829	18	2.37	Elsevier Ltd.	UK	biweekly
Energy	8.51	2.041	13.4	2.04	Elsevier Ltd.	UK	Bi-Monthly
International Communications in Heat and Mass Transfer	6.78	1.112	6.8	1.65	Elsevier Ltd.	UK	Bimonthly
Case Studies in Thermal Engineering	6.51	0.898	5.2	1.83	Elsevier BV	UK	Quarterly

Applied Thermal Engineering	6.32	1.584	10.7	1.89	Elsevier Ltd.	UK	18/year
International Journal of Heat and Mass Transfer	5.46	1.461	10.5	1.83	Elsevier Ltd.	UK	Six issues per year
Journal of Thermal Analysis and Calorimetry	5.12	0.639	7.4	1.21	Springer Netherlands	Netherlands	Twenty four issues every year.
International Journal of Thermal Sciences	4.63	1.132	7.3	1.71	Elsevier Masson s.r.l	France	Monthly
Experimental Heat Transfer	4.01	0.779	5.3	1.35	Taylor and Francis Ltd.	UK	Quarterly
Experimental Thermal and Fluid Science	3.57	1.105	7.8	1.67	Elsevier Inc.	US	Quarterly
Thermal Science and Engineering Progress	3.54	0.653	7.1	1.53	Multidisciplinary Digital Publishing Institute (MDPI)	Switzerland	Bi-Monthly
Arabian Journal for Science and Engineering	3.08	0.469	4.4	1.03	Springer Berlin	Germany	Quarterly
Energy Efficiency	3.05	0.837	5.3	1.04	Springer Netherlands	Netherlands	Bimonthly
International Journal of Heat and Fluid Flow	2.77	0.928	5.5	1.48	Elsevier	Netherlands	Bimonthly
Energy Procedia	2.63	0.533	2	0.78	Elsevier BV	UK	Irregular
Heat Transfer Engineering	2.61	0.632	3.8	1.25	Taylor and Francis Ltd.	UK	22 issues per year,
Journal of the Brazilian Society of Mechanical Sciences and Engineering	2.44	0.445	3.6	0.89	Springer Verlag	Germany	Quarterly
Heat and Mass Transfer	2.37	0.506	4.6	0.92	Springer Verlag	Germany	Six volumes annually.
Journal of Thermal Science	2.28	0.505	3.2	0.9	Science Press	China	Five issues per year.
Heat Transfer	2.26	0.361	4.6	0.99	Begell House Inc.	US	22 issues per year
Thermal Science	1.94	0.377	2.7	0.66	Vinca Inst Nuclear Sci	Serbia	Six times a year.
Advances in Mechanical Engineering	1.7	0.378	3.1	0.8	SAGE Publications Inc.	US	Semi-annual.
Australian Journal of Mechanical Engineering	1.34	0.286	2.3	0.54	Taylor and Francis Ltd.	UK	Quarterly
Thermal Engineering	0.84	0.382	1.5	0.84	Pleiades Publishing	US	Monthly

From table 1, it had been found that each journal is from a different country like the United Kingdom (UK), United States (US), Switzerland, Netherlands, France, Germany, and Serbia. The journals were

arranged based on the ranking priority of impact factor from high to low. Out of all the other mentioned journals,Renewable and Sustainable Energy Reviews and Energy Conversion and Management indicate the highest IF of 16.8 with its SJR and SNIP of 3.678 and 4.53,respectively. There were many publishers for the journals like Elsevier Ltd, Pleiades Publishing, Taylor and Francis Ltd, SAGE Publications Inc, Science Press, Springer Verlag,etc. Energy Conversion and Management attained the 2nd position with an impact factor of 11.1; SJR rating and SNIP of 2.829and 2.37. The IF metric was lower in the Thermal Engineeringjournal at 0.84.

3.5. Analysis of journal published on MCHX research:

There are numerous types of research for MCHX by most of the effective authors from different countries. Table 2 describes the number of authors found from each country for MCHX research between the years 2012 to 2022.

Table 2: Number of authors found from each country for MCHX research between the years 2012 to 2022

Journal name	2012 to 2015	2016 to 2018	2019 to 2022
Energy	10	11	10
Thermal Science and Engineering Progress	0	7	16
Thermal Science	3	9	12
Australian Journal of Mechanical Engineering	2	2	2
Advances in Mechanical Engineering	4	1	1
International Journal of Thermal Sciences	11	7	10
Energy Conversion and Management	7	9	8
Journal of Thermal Analysis and Calorimetry	0	3	5
Journal of the Brazilian Society of Mechanical Sciences and Engineering	0	1	3
International Journal of Heat and Mass Transfer	18	18	16
Energy Procedia	4	2	1
Renewable and Sustainable Energy Reviews	24	16	11
Experimental Thermal and Fluid Science	12	8	8
International Journal of Heat and Fluid Flow	5	5	3
International Communications in Heat and Mass Transfer	14	9	3
Experimental Heat Transfer	10	4	5

Heat Transfer	9	6	8
Arabian Journal for Science and Engineering	7	8	3
Case Studies in Thermal Engineering	3	2	10
Heat and Mass Transfer	6	8	8
Applied Thermal Engineering	19	16	17
Energy Efficiency	3	3	6
Journal of Thermal Science	10	5	3
Heat Transfer Engineering	12	16	16
Thermal Engineering	11	10	4

The above table 2 displayed the published journal based on the research of MCHX between the years 2012 to 2022. When compared with all the other journals, "Applied Thermal Engineering" and "International Journal of Heat and Mass Transfer" published the highest number of articles in the year 2012 to 2022; with the same total count of the published article based on MCHXwas 52. "Renewable and Sustainable Energy Reviews" obtained the second-highest number of published articles during the year 2012 to 2022. Furthermore, the journal "Applied Thermal Engineering" obtained the highest position in publishing articles between 2019 and2022; it published the highest number of articles than the previous years, the published article is 17. Further, the journal "Journal of the Brazilian Society of Mechanical Sciences and Engineering" attained the lowest position, and the total of published articles based on MCHX research in this journal was 4.

Most of the authors are from different locations, so further the percentage of the country where the number of authors having higher citations is being analyzed in the pie chart of figure 3.

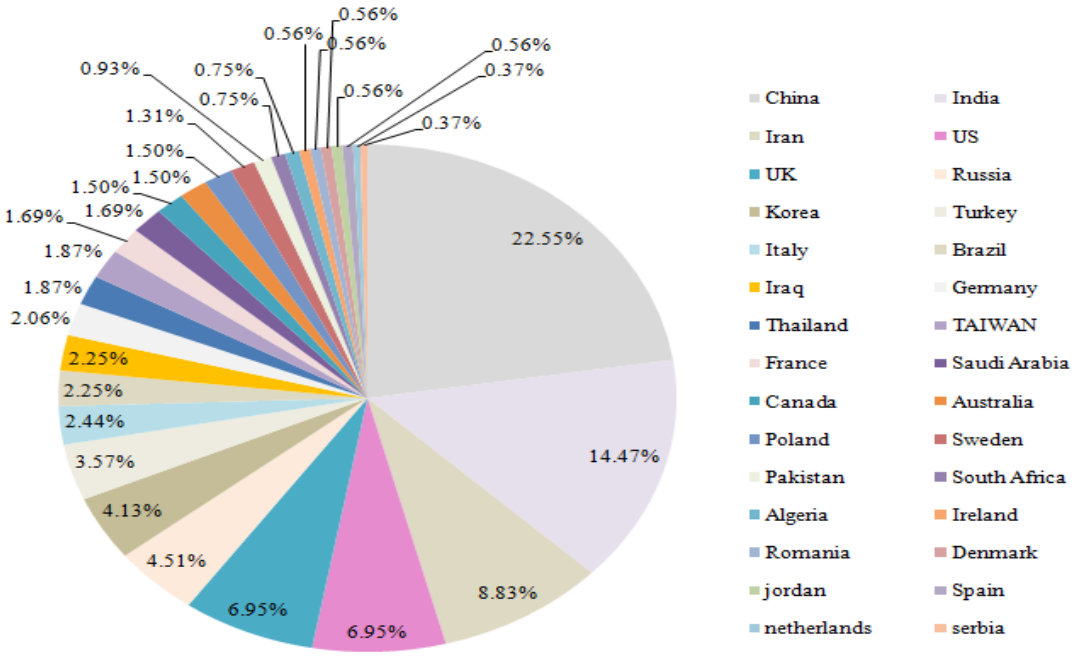

Figure 3: Percentage of countries where the number of authors having higher citations

From figure 3, it is clear that authors of country China had more percentage (22.55%) of higher citations when compared with the other countries. 2nd position was achieved by the authors from the country India with a percentage of 14.47%. Country Iran authors achieved the 3rd position with 8.83%. Surprisingly, it was found that US and UK authors attained the 4th position with the same percentage level of 6.95%.

Further, the language of the last 10 years from standard publications had been analyzed in figure 4. A organized system of communications is language. A language's grammar is its framework, while its vocabulary is its free-form elements. Humans primarily communicate via languages, which may be expressed orally, visually, or in writing.

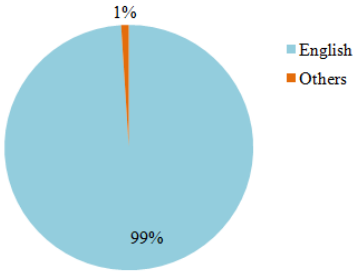

Figure 4: Pie chart of Language of the last 10 years from standard publications

It is understandable from figure 3 that the English language completely dominates in the standard publications of the last 10 years between the years 2012 to 2022 for the research of MCHX. In other languages, the standard publication was only 1%.

Further, the geographical distribution of the authors country-wise for the research of MCHX between the years 2012 to 2022 had been analyzed. Geographical distribution is the usage of colored areas on a map chart to depict how data is spread throughout various regions. A darker region represents a higher concentration of values. Figure 5 explains the geographical distribution of the list of authors' countries based on the research on MCHX.

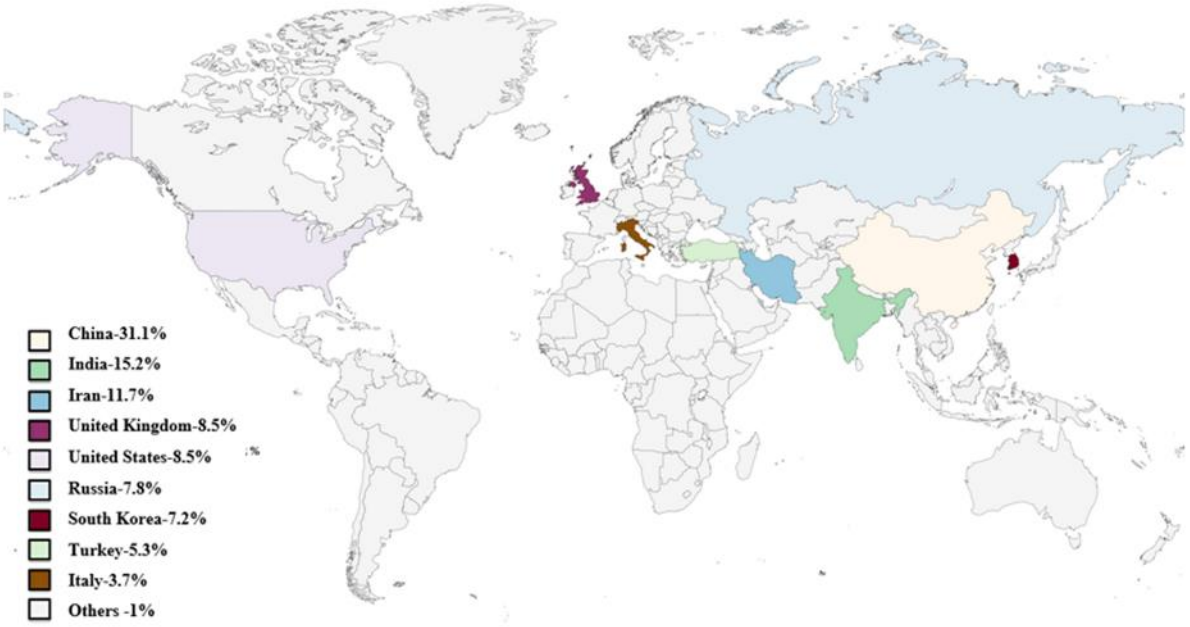

Figure 5: Geographical distribution of the list of author's country based on the research of MCHX

The author's countries include China, India, South Korea, Turkey, Iran, Russia, Italy, the US, the UK, and others. From figure 4, it is noted that more authors have taken part and done the research. From the country china, 31.1 % of the authors had done research on MCHX and it is having a higher percentage when compared with the other mentioned countries. India attained the 2nd -highest percentage (15.2%) of authors for research between the years 2012 and 2022. The author from the country Iran achieved the 3rd position with a percentage of 11.7 %. Other than the mentioned countries, there are 1% of the authors from other countries have done the research.

Further, like the author's country, the geographical distribution of the list of journal countries based on the research of MCHX had been analyzed in figure 6. The journal countries include US, UK, Germany, Netherlands, Switzerland, France, China, Serbia, and others.

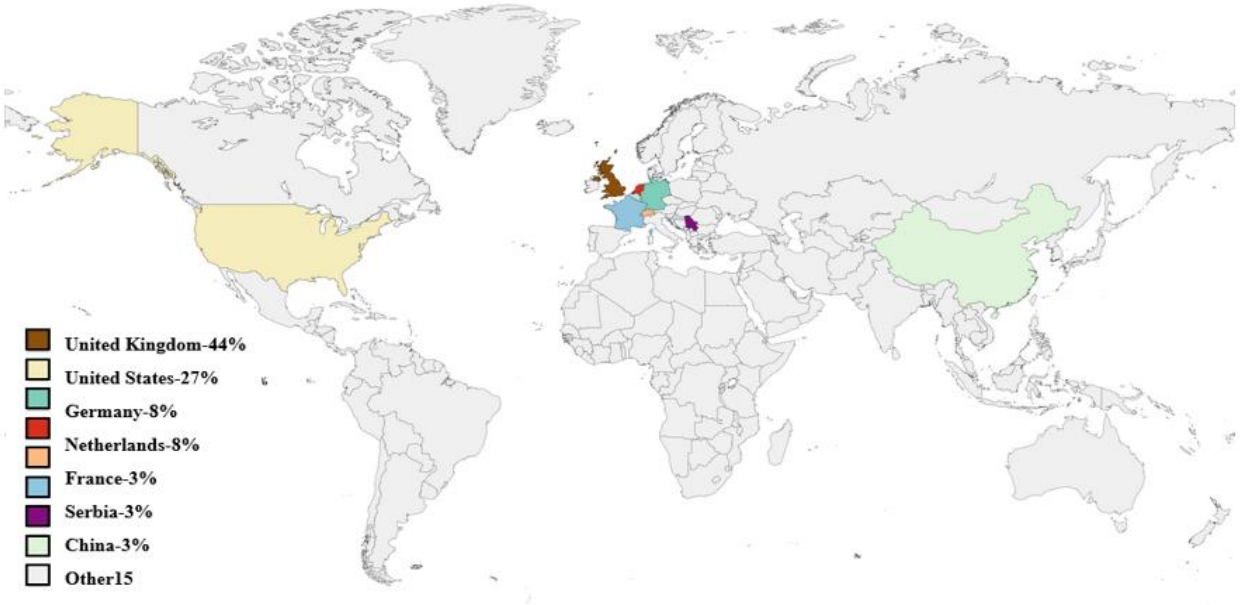

Figure 6: Geographical distribution of the list of journal countries based on the research of MCHX

From figure 6, it is noted that from more countries, journal publications have been done for the research. UK holds the highest percentage of 44 for having the journal based on the research of MCHX. 2nd place was attained by the country US with 27%. The Netherlands and Germany achieved the 3rd position with 8%. Switzerland, France, China, and Serbia hold the same percentage of 3. Unfortunately, for the research of MCHX, the journal from country India is not there between the years 2012 to 2022.

3.6. Effective authors and citations:

Author credentials are the education, abilities, and/or biographical information that qualifies someone to write about/speak about a given issue. Table 3 explains the top 25 authors and the citations.

Table 3: Top 25 authors and the citations:

AUTHOR NAME	TITLE	YEAR	MAJOR FINDINGS	AUTHOR CITATIONS	JOURNAL NAME
Gabriela, et al. [34]	It utilized by temperature exchangers:	2012	Results indicated that uniformly distributed and stable nanostructures increased the base fluid's driven heat exchange efficiency.	508	Renewable and Sustainable Energy Reviews
S. Liu, et al. [35]	Improvements in passively transmission of heat with piping mixers	2013	The MCHX's integrated rib's the Nusselt quantity and the friction factor measurements proved to be far stronger when compared to those of the rib/DW singly.	485	Renewable and Sustainable Energy Reviews
Mónica, et al. [36]	Microencapsulated phase-shifting element lumps as well as part alteration element emulsions	2012	Due to its poor thermal properties as well as its the viscosity the MCHX slurry with a cubic percentage of 50% appears to be unsuitable.	409	Renewable and Sustainable Energy Reviews
Dong, et al. [37]	Enhancement of boiling heat transfer using microsurfaces	2015	The findings showed that the dual-height modified the ground performed around three times better than a plain surface.	320	Experimental Thermal and Fluid Science
Hakan, et al. [38]	For energy systems, entropy formation in both naturally occurring and convection-based movements of heat	2012	Analysis revealed that because the temperature source mountains were in the bottom horizontal wall, the Nusselt coefficient reached its highest value and the formation of dissipation was at its lowest.	287	Renewable and Sustainable Energy Reviews
Zoubida, et al. [39]	Nanofluids' spontaneous laminar transfer of warmth	2012	Analysis revealed that the standard numerical value for both small particles in MCHX rose as the solidification volume percentage increased.	285	Renewable and Sustainable Energy Reviews
Tisha, et al. [40]	Evaluation of single-phase hydraulic thermal exchangers and sinks for micro- and mini-channels	2015	The exchanger with the lowest hydrodynamic diameter exhibited the maximum rate of heat transfer, according to experimental findings using deionized water. This was done as the test fluid.	275	Renewable and Sustainable Energy Reviews

M. Mohanraj, et al. [41]	Artificial artificial intelligence (ANN) applications for heat transfer devices thermal analysis	2015	The ANN projected a thermal process management approach for heat exchangers that would save a large amount of energy, according to the reported findings.	267	International Journal of Thermal Sciences
Oronzio, et al. [42]	Nanofluid forced to condense in grooved channels: A statistical investigation	2012	According to investigation, the amount of heat transported in MCHX rises with particle volumetric concentration, but this is coincided with an increase in the amount of pumping energy needed..	263	Applied Thermal Engineering
Jahar, et al. [43]	using hypercritical carbon dioxide as a cool to enhance the cooling capacity of micro-channel mechanical heat sinks	2019	Results indicated that for an identified number of fluid intake temperatures, supercritical CO2 produces better outcomes than water. The highest decrease in heat resistance by employing CO2 was estimated to be 30% among the examined ranges.	234	Thermal science
Sung, et al. [44]	Predictive techniques and libraries for heat transport in boiling as well evaporating mini/micro-channel flows	2014	It was demonstrated that, despite the effectiveness of earlier forecast approaches for certain substances and limited datasets, these systems could not provide precise forecasts.	227	International Journal of Heat and Mass Transfer
M. Hatam, et al. [45]	Review of several radiator designs for improving the waste recuperation of heat from emissions from diesel engines	2014	Due to the reduced pressure reduction and higher radiation rate, utilizing fins was demonstrated to be more suitable and acceptable than produces an and permeable substances.	216	Renewable and Sustainable Energy Reviews
W. Srimuang, et al. [46]	Review the techniques that heat pipe exchange mechanism uses for reheating	2012	The heating exchanger specifications for the two-stage closed thermosyphon (TPCT), oscillations warmth pipe (OHP), and traditional heat conduit (CHP) were successfully prevented	209	Renewable and Sustainable Energy Reviews

Trilok, et al. [47]	Indian earth-air heat transfer (EAHE) systems observational and qualitative investigations	2013	Analysis revealed that both the blower and also temperature exchanger losses were mostly to blame behind the loss of electricity. COP and energy consumption were 10.51 along with 89.25%, respectively.	190	Renewable and Sustainable Energy Reviews
Mazen, et al. [48]	Modern plates exchanger (Hex) advancements	2012	According to the findings, the alloy's experiment surface enhancement was accomplished without utilizing heat without by treating the surface to increase durability against corrosion.	175	Renewable and Sustainable Energy Reviews
Sung, et al. [49]	Microchannels are with sequential congestion	2012	Based on the combination of the current FC-72 data and an extensive collection of data for mini/micro-channel inflows gathered from eight earlier people, the correlation study demonstrated good prediction potential.	146	International Journal of Heat and Mass Transfer
Ziqiang, et al. [50]	An electronic device heating and cooling and uniform temperatures improvement using tiny heat islands	2020	Results indicated that at a wasted rate of 72 W, the highest temperature ever in the modified one might've decreased by 26.7%.	146	Energy
M.E. Suryatriyastuti, et al. [51]	Studying the physical properties of electrical power foundations of piles caused by temperature	2012	Results demonstrated a substantial relationship connecting the state of their contact and the temperature-induced mechanical characteristics within the pile as well as soil.	145	Renewable and Sustainable Energy Reviews
Omid, et al. [52]	Impact of ribs on flow characteristics and laminar heat transmission of water-aluminum oxide nanofluid technology in a three-dimensional circular microchannel with various nanoparticle volume percentages	2015	It was discovered in MCHX that that there was a rise in the volume fraction of nanoparticles, which results in superior heat transfer overall friction qualities for nanofluids than for the fluid that is used for cooling because of an increase in viscosity.	135	Advances in mechanical engineering

Sharjeel, et al. [53]	Laminar tiny liquids motion and heat transport in a ring-shaped channel are being studied numerically.	2012	According to the findings, the energy transmission coefficient increases linearly with both Reynolds quantity and container percentage, while it decreases nonlinearly and parabolicly as the size of the particle increases.	130	Applied Thermal Engineering
R. Manikanda , et al. [54]	Studies of heading design, inlet/outlet combinations, and flowing injustice in parallel tiny cavities using computational and empirical techniques	2013	According to estimates, mal transmission is worse with header height and that there is an ideal header depth (7 mm) where the flow dispersion, volume fall, and ill-distribution variables are all better.	128	Applied Thermal Engineering
JUAN, et al. [55]	The History, possibilities and Risks of Polyurethane Heat Exchangers	2014	The findings of the investigation have shown that a decreased thermal conductivity significantly lowered the loss of warmth, which in consequence improved operational temperatures and inflammability limits.	119	Heat Transfer Engineering
Yuechao, et al. [56]	The effectiveness for the innovative flat plate collector for sunshine with micro-channel radiator network (MHPA-FPC) was experimentally investigated.	2013	Comparisons showed that the MHPA-FPC had greater insulation from temperature capabilities and a higher maximum flash efficiencies than the standard deviation of those chosen samples by more than 25%.	119	Applied Thermal Engineering
Mohamed, et al. [57]	correlation of heat exchange for flow melting in tiny with microtubes	2013	After investigation, it was discovered that an additional relation had an average total error that was 14.3% which projected 92% of the results to fall within the 30% error ranges.	107	International Journal of Heat and Mass Transfer
Maziar, et al. [58]	Evaluation and understanding of the embedded fluid media's local thermodynamic irregular (LTNE) state in pipe heat transfer systems	2014	The results demonstrated that the LTNE intensity (DNE) relies on the medium's porosity, and conduction ratio, plus Darcy quantity and correlates to the combination of the normalization velocity as well as temperature without dimensions during LTE conditions.	106	Energy Conversion and Management

These were the top 25 authors with higher citations and from the journals like Renewable and Sustainable Energy Reviews, Energy Conversion and Management, International Journal of Heat and Mass Transfer, Applied Thermal Engineering, Heat Transfer Engineering, Advances in mechanical engineering, etc. From table 3, it is shown that author Gabriela had the highest number of citations (508) from the year 2012 and belongs to the journal of Renewable and Sustainable Energy Reviews. 2nd position was attained by S. Liu with a number of citations of 485 and it belongs to the same journal of Renewable and Sustainable Energy Reviews. 3rd position was achieved by the author Mónica with a number of citations of 409. Surprisingly, the top 3 authors' work belongs to the same journal (Renewable and Sustainable Energy Reviews). Among these top 25 authors, the least cited (106) author was Maziar.

4. Conclusion:

Numerous research topics based on MCHX have been published, as have several literature reviews on relevant themes. In this article, a Scopus database bibliographic research on the subject of MCHX was done. Despite the availability of various alternative databases in the public domain, the Scopus database is clearly the greatest commonly utilized & popular resource for exploring, comparing, & tracking multiple citations. Initially, visualizing all the journals of MCHX research, 50 journals were filtered and it was considered for the research. Metrics of journals, such as SJR, SNIP, publishing frequency, publisher, and impact factor are analyzed from the database. The countries of the author and their published work under different journal countries for the research also had been analyzed. Analysis has the potential to further bridge disciplines and contribute additional streams from other related disciplines. In this paper, it was easier to identify their development and trends through the analysis of bibliometric. This bibliographic review focusing on each domain of the process would be a promising avenue for future work.

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