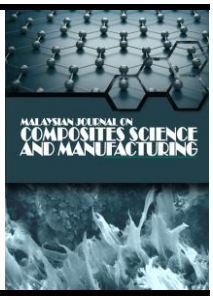
Penerbit Akademia Baru

Malaysian Journal on Composites Science and Manufacturing

Journal homepage:
https://www.akademiabaru.com/submit/index.php/mjcsm/
ISSN: 2716-6945



Production of Porous Copper via Uniaxial Compaction Assisted by Potassium Chloride as a Space Holder

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Shaiful Anwar Ismail[1,*], Azrina Arshad[2], Muhammad Hussain Ismail[3], Russell Goodall[4]

[1] Industrial Technology Department, Faculty of Industrial and Manufacturing Technology and Engineering, Unversiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka
[2] Quality Engineering Section, Universiti Kuala Lumpur, Malaysian Institute of Industrial Technology, Persiaran Sinaran Ilmu, Bandar Seri Alam, 81750, Johor
[3] Pengajian Kejuruteraan Mekanikal, Fakulti Kejuruteraan Mekanikal, Kompleks Kejuruteraan Tuanku Abdul Halim Mu'adzam Shah, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia
[4] School of Chemical, Materials and Biological Engineering, Sir Robert Hadfield Building, The University of Sheffield, Mappin Street, Sheffield, S1 3JD, United Kingdom

ARTICLE INFO

Article history:
Received 15 February 2025
Received in revised form 27 March 2025
Accepted 27 March 2025
Available online 30 March 2025

Keywords:
Porous Copper, Powder Metallurgy, Potassium Chloride (KCl), Porosity Control, Uniaxial Compaction

ABSTRACT

Porous metal fabrication has garnered considerable attention for its cost-effectiveness, lightweight properties, and desirable characteristics such as mechanical strength, thermal management, acoustic insulation, and fluid permeability, making it valuable across industries like automotive, biomedical, aerospace, and electronics. Among these, porous copper stands out for applications like heat sinks in portable electronic devices due to its high specific surface area and excellent permeability. However, the challenge lies in achieving precise control over porosity and mechanical properties. This study explores the fabrication of porous copper using powder metallurgy, employing uniaxial compaction and potassium chloride (KCl) as a space holder. KCl was chosen for its chemical inertness and efficient dissolution properties. Copper-KCl mixtures with KCl content ranging from 10% to 30% were compacted at pressures between 9.81 MPa and 19.61 MPa, sintered at 700°C under an argon atmosphere, and subjected to a dissolution process at 50°C for 5 hours. Porosity was determined using a gravimetric method based on Archimedes' principle, while X-ray Fluorescence (XRF) analysis assessed the efficiency of KCl removal. Uniaxial compression testing revealed the influence of porosity and compaction pressure on the mechanical strength of the samples. The findings highlight the potential of tailored porous copper for lightweight, high-performance applications requiring controlled thermal and mechanical properties.

* *Corresponding author.*
E-mail address: shaiful.anwar@utem.edu.my (*Shaiful Anwar Ismail)*
E-mail of co-authors: azrinaa@unikl.edu.my, hussain305@uitm.edu.my, r.goodall@sheffield.ac.uk

https://doi.org/10.37934/mjcsm.16.1.125139

1. Introduction

Porous metals represent a unique class of materials characterized by a significantly reduced metallic content compared to their fully dense counterparts, exhibiting a structure permeated by voids and pores. This inherent architecture results in lightweight materials with relatively low density. While this characteristic might render porous metals unsuitable for certain structural applications demanding high integrity and resistance to defects, such as load-bearing joints and building constructions, prior investigations [1-2] have highlighted their promising potential across a wide spectrum of applications [3]. This versatility stems from their exceptional combination of low density with other advantageous properties, including tailored mechanical strength, specific physical and thermal characteristics, acoustic damping, low density [1] and energy absorption capabilities [3-4].

Owing to these distinctive attributes, porous metals have found increasing utility in diverse fields such as filtration systems, biomedical [5], automotive and structural application [6]. Porous copper, in particular, offers a compelling suite of properties, including high stiffness, excellent thermal conductivity, and low density. Consequently, it holds significant potential for functional applications such as electrodes, catalysts, heat sinks, thermal management in electronic packaging, heat exchangers, and catalyst supports [4]. Various fabrication techniques have been developed to produce porous copper [7], including powder metallurgy [8-9], gasar [10-11] , de-alloying [12], metal injection moulding [13-14]. Each of these methods presents its own set of advantages and potential limitations. Powder metallurgy is a successful approach for fabricating porous copper with good overall performance. Within the powder metallurgy family, the sintering and dissolution process (SDP) is a notable technique, pioneered by Zhao and Sun [15]. They used these techniques to produce aluminum foam using NaCl as a space holder to create the porous structure. Subsequently, they refined this process by employing potassium carbonate as a pore-forming agent, termed Lost Carbonate Sintering (LCS) [9] using a lost carbonate (K_2CO_3) sintering method, with porosity up to 85% with different cell sizes. Then, the fabrication of porous copper also employed different types of space holders, such as Carbamide [16], Acrawax [17] and Sodium Chloride (NaCl) [18-19].

Fundamentally, this fabrication route involves mixing metal powder with temporary space holder materials, followed by compaction and sintering. The desired porous network is then generated by selectively removing the space holder material through dissolution in a suitable solvent, such as water. This method has attracted considerable research interest due to the direct control it offers over crucial porosity parameters, including pore size, pore shape, and overall porosity [20]The physical characteristics of the space holder largely dictate the resulting pore morphology, while the space holder's volume fraction in the initial mixture determines the final porosity level.

According to Wang *et al.* [21], there is a relative scarcity of detailed studies on porous copper fabricated using the SDP method, which is combined the traditional uniaxial compaction method and space holder technique. This method shows successful results, as demonstrated in the previous studies [22-23]. Therefore, this study aims to investigate the production of porous copper utilizing the SDP technique, employing potassium chloride (KCl) as the space holder material. KCl was chosen due to its higher solubility than the conventionally used NaCl, facilitating more efficient removal. Furthermore, KCl exhibits no adverse chemical interaction with copper powder and possesses a relatively low melting point of 770°C. Recognizing the common trade-off between high porosity and compromised mechanical properties, this research focuses on fabricating low- to medium-porosity copper as previous studies [24-26], which may offer a favorable balance of porosity and acceptable mechanical and thermal performance. As highlighted by previous research [24, 26], there remains a relative lack of comprehensive investigation into the processing and behavior of low- to medium-porosity metals, particularly concerning the relationship between their mechanical properties and

porosity characteristics. This study will, therefore, explore the production of low- to medium-porosity copper and subsequently analyze its porous characteristics. Specifically, it will investigate the significant influence of space holder volume fraction and compaction pressure on the resulting porosity.

2. Methodology

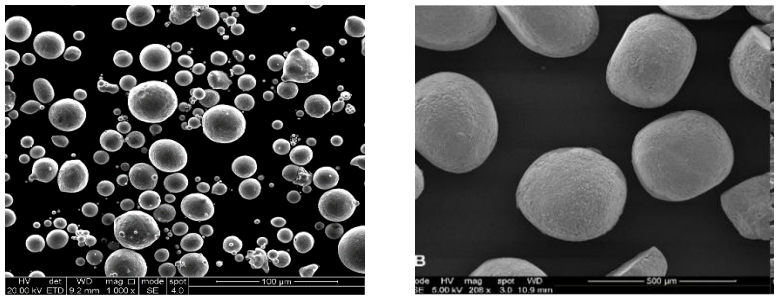
2.1 Starting Materials

The primary metallic constituent in this investigation was copper powder, procured from Goodfellow (Cambridge, UK), characterized by a spherical morphology, an average particle size of 50 µm, and a stated purity of 99%. Potassium chloride (KCl) powder, sourced from Sigma-Aldrich (Steinheim, Germany), served as the space holder material. Particle size analysis using a Malvern Mastersizer 3000, employing a dry dispersion method, revealed an average particle size of approximately 300 µm for the KCl powder, exhibiting a cubic crystalline structure.

KCl was selected as a leachable space holder due to its relatively high solubility in water (253 g/L at 20°C) and a melting temperature of 770°C. This space holder material was intended to precisely control the development of key porosity characteristics within the porous copper structure, including the overall porosity percentage, pore size, and pore shape. The bulk densities of copper and KCl powders were determined using an AccuPyc II 1340 Pycnometer (Micromeritics, USA) under a helium gas purge, with the measured values summarized in Table 1. The initial particle morphologies of the as-received copper and KCl powders from their respective suppliers were characterized using Scanning Electron Microscopy (SEM), as illustrated in Figure 1.

Table 1
Characteristics of starting materials

Material	Size (µm)	Shape	Density (g/cm^3)
Copper	Average 50	Spherical	8.96
Potassium Chloride (KCl)	Average 300 (Dx 50)	Spherical	1.98



(a) (b)

Fig. 1. Morphology of the starting materials, (a) copper powder, and (b) potassium chloride (KCl)

2.2 Porous Copper Processing

The entire fabrication process for the porous copper samples is schematically illustrated in Figure 2. Copper powder and potassium chloride (KCl) powder were meticulously blended, with the weight percentage of KCl ranging from 10 to 30 % wt. Given the disparity in the densities of the two constituent materials, a small volume percentage of acetone was introduced into the mixture to facilitate the attainment of a homogenous blend. This mixing process was performed using a

SpeedMixer 800 FZ (Hauschild, distributed by Synergy Devices Ltd., UK). The absence of an integrated temperature control unit in this particular mixing apparatus necessitated reliance on precisely controlled speed and duration parameters. Consequently, a specific mixing protocol was developed for this study to ensure the creation of a uniform dispersion of copper and KCl particles. The primary advantage of this high-speed mixer is its capacity to achieve thorough mixing within a significantly reduced timeframe, operating at speeds of up to 2100 rpm.

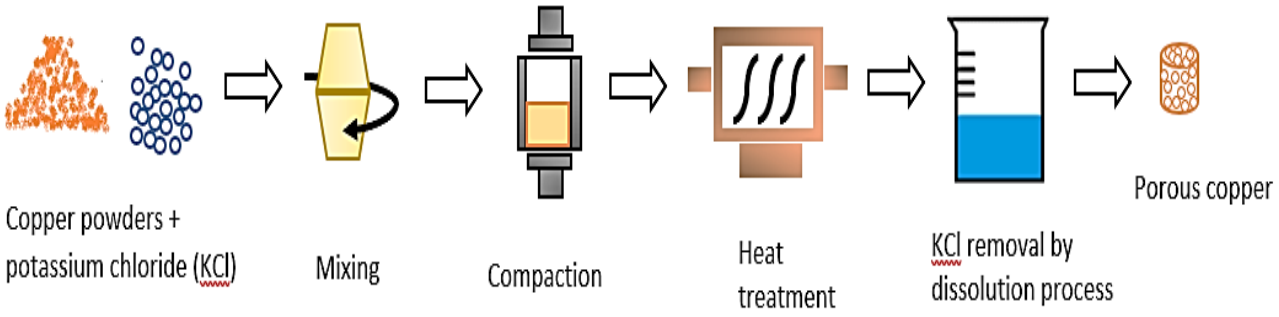


Fig. 2. The fabrication process of porous copper by compaction and dissolution process

The compaction process occurs at low compaction pressure, ranging from 1 tonne (9.81 MPa) to 2 tonnes (19.61 MPa). The maximum compaction pressure can only reach 19.61MPa since it is very hard to compact the mixture at higher pressure due to the presence of KCl. Other than that, the higher compaction pressure may deform the shape of KCl, which will deteriorate pore development.

The compaction stage was performed at relatively low pressures, ranging from 9.81 MPa (equivalent to 1 tonne) to 19.61 MPa (equivalent to 2 tonnes). Applying compaction pressures exceeding 19.61 MPa (as stated, seems to be a potential error and is disregarded based on the 2-tonne limit) proved challenging due to the presence of the KCl space holder, which impeded effective densification. Furthermore, applying higher compaction pressures risked deforming the morphology of the KCl particles, which could subsequently compromise the controlled development of the desired pore structure. A summary of the mixing ratios and the applied compaction pressures for the different samples is presented in Table 2.

Table 2. Mixing parameter and compaction pressure

Material	Compaction Pressure (MPa)	%wt of Mixing
Copper	9.81 to 19.61	NIL
Mixture of copper and KCl	9.81 to 19.61	10 - 30

Subsequently, the green compacts underwent a sintering process within a tube furnace, employing a heating rate of 5°C/min [26] and maintaining a sintering temperature of 700°C for a duration of two hours under an argon atmosphere, as depicted in Figure 3. Given that the SDP method relies on the physical characteristics of the space holder to define the resulting pore structure, meticulous selection of the sintering temperature is paramount. Considering the melting point of KCl at 770°C, any temperature exceeding this threshold could induce the degradation and melting of the KCl particles during sintering, inevitably leading to the collapse of the intended pore morphology. Consequently, a sintering temperature of 700°C was chosen as an optimal balance, sufficient for achieving inter-particle bonding of the copper while preserving the structural integrity of the KCl space holder. A prior study by [27] also demonstrated the successful fabrication of porous copper at a comparably low sintering temperature of 650°C. The samples were allowed to cool for

10 minutes following the sintering cycle before proceeding to the subsequent dissolution stage. To account for dimensional changes resulting from the sintering process, the linear shrinkage of the samples was quantified by measuring their dimensions before and after sintering using a Vernier calliper with a resolution of 0.01 mm.

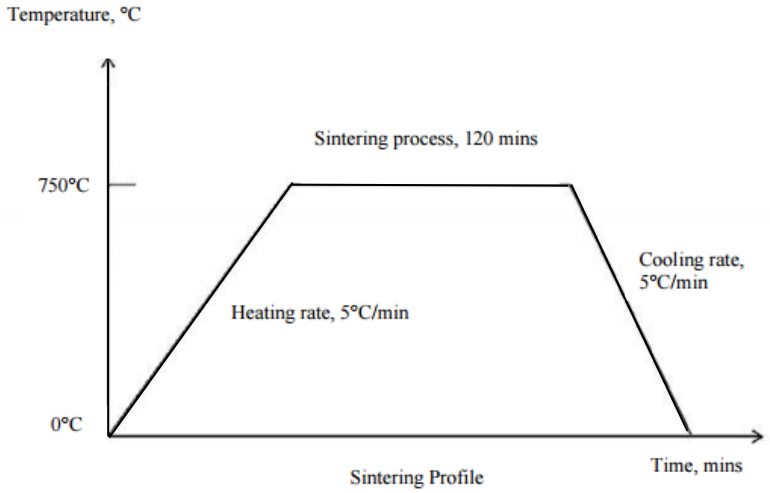


Fig 3. Sintering profile for porous copper

2.3 Dissolution Process

Potassium chloride (KCl), being a water-soluble space holder, can be effectively removed from the sintered copper matrix via a water dissolution technique. In this study, several dissolution methods were explored; however, this paper focuses on the results obtained using a heated ultrasonic bath maintained at 50°C [28]. This apparatus features an integrated thermometer, enabling precise water temperature control. Prior to immersion, the sintered samples were accurately weighed using an analytical balance with a resolution of 0.1 mg. Subsequently, the samples were submerged in the ultrasonically agitated water bath. The dissolution process was monitored in real time by periodically measuring the weight loss of the samples over a defined duration. For each measurement, the samples were removed from the bath, dried with heated compressed air for 15 minutes to ensure complete removal of surface water, and then weighed three times to ensure consistency in the reading. Ultimately, the dissolution time was determined by calculating the rate of weight loss reduction over time, using Eq. 1 as referenced in [29]Subsequent analysis will investigate the influence of both the initial compaction pressure and the dissolution time on the resultant porosity development within the copper samples.

$$\%\, W\ Loss = \frac{(W\ initial - W\ after)}{W\ intial} * 100 \quad (1)$$

where $W_{initial}$ is the initial weight of the sample before dissolution, and W after is the weight after the samples have been through the dissolution process in a certain period of time.

2.4 Pre-Compaction and Visual Inspection

The pre-compaction stage is crucial in the fabrication of porous copper, ensuring the homogeneity of the copper-KCl mixture before the uniaxial compaction process. Achieving uniform dispersion of the space holder within the copper matrix is essential for developing controlled

porosity. The pre-compaction process aims to determine the optimal compaction pressure at which the green sample can maintain its structural integrity with minimal strength. Furthermore, this process is crucial for identifying the range of compaction pressures that will not compromise the structure of the space holder. The process begins with powder preparation, where the required amount of powder is accurately weighed using a high-precision scale. Additionally, a small amount of acetone is incorporated into the powder mixture to reduce friction during compaction. Light tapping or vibration may help settle the powder and eliminate air gaps. Once the samples are successfully prepared, the sample will be examined, and visual inspection will occur.

Visual inspection is primarily conducted to monitor and examine the physical structure of the compacted green sample. This is important to ensure that the sample maintains its intended shape and that the KCl is properly distributed within the microstructure.

2.5 XRF Analysis on Samples After the Dissolution Process

X-ray Fluorescence (XRF) spectroscopy is an essential analytical technique employed in this study to evaluate the effectiveness of potassium chloride (KCl) removal after the dissolution process. The presence of residual elements within the porous copper samples was investigated to confirm the purity of the final structure and assess the completeness of space holder elimination. After undergoing dissolution in an ultrasonic bath at 50°C for 5 hours, the porous copper samples were carefully dried using heated compressed air before XRF analysis. The samples were placed on a flat XRF sample holder, ensuring a uniform surface for accurate elemental detection. Spectral data were acquired, focusing on the presence of potassium (K) and chlorine (Cl) signals, indicating incomplete KCl removal. Additionally, other potential contaminants originating from the fabrication process, such as oxygen (O), silicon (Si), aluminum (Al), and iron (Fe), were monitored.

2.6 Volume and Density Measurement on Porous Samples

The measurement of volume and density is crucial in determining the porosity properties, as practiced by another researcher [30]. The volume and density of porous copper samples were measured using a laboratory balance, following the principle of Archimedes buoyancy to ensure accuracy. The Archimedes method is highly suitable for porous structures, accounting for both open and closed porosity. This technique accurately assesses the density and porosity of porous samples by evaluating their displacement in a fluid medium. An analytical balance was used to measure the volume and density of porous copper samples following Archimedes' principle. Following this principle, the procedure involves immersing the samples in water. Subsequently, the weights of the dry and wet specimens were measured to determine the sample weights. Distilled water is the typical measurement medium. The density and volume of the sample were determined using Eq. 2 and 3. Measurements were repeated three times to ensure accuracy, with special attention to moisture removal and air bubble elimination to prevent errors. This method provides a reliable evaluation of density, volume, and porosity in porous copper, supporting structural analysis and material characterization.

$$\rho_{sample} = \frac{w_{dry}}{(w_{dry} - w_{wet})} \times 100 \quad (2)$$

where ρ_{sample} is the density of the porous sample, Wdry is the weight of the dry porous sample, Wwet is the weight of the wet porous sample, and ρ_{water} is the density of water at 25°C.

$$V_{sample} = \frac{W_{dry}}{\rho_{sample}} \times 100 \quad (3)$$

where V_{sample} is the sample volume, W_{dry} is the weight of the dry porous sample, and ρsample is the density of the porous sample.

2.7 Porosity Measurement and Microstructural Analysis

The primary objective of this investigation is to quantify the porosity of the fabricated porous copper samples as a function of varying initial KCl content. The porosity of the samples was determined using a gravimetric method [27], which involves the precise measurement of the sample's density. The mass of each sample was accurately measured using an analytical balance, and its geometric dimensions were repeatedly measured to obtain average values. An analytical density balance (Mettler Toledo), operating on the principle of Archimedes buoyancy, was employed to determine the density of the porous samples by evaluating the apparent weight loss upon immersion in water. Subsequently, the percentage of porosity was calculated using the following Eq. 4. For microstructural analysis, the samples were cut using a BUEHLER Isomet 5000 precision linear saw. Then, followed by grinding and polishing process with different grid size.

$$Porosity\ (\%) = 1 - \frac{(Porous\ copper\ density)}{Copper\ bulk\ density} \times 100 \quad (4)$$

where Porosity (%) is the percentage of porosity for the porous samples.

3. Results

3.1 Visual Analysis of Compacted Porous Samples with KCl Distribution

Initial preparation of the samples involved the admixture of copper (Cu) and potassium chloride (KCl) without introducing supplementary lubricants, followed by compaction under a pressure of 9.81 to 19.6. The green compacts, representing the initial state after compaction, reveal the spatial distribution of the space holder within the copper matrix. The sample without KCl exhibits a smooth surface (Figure 4c), indicating uniform copper particle packing. Conversely, the samples containing KCl display a textured surface, directly reflecting the heterogeneous distribution of KCl particles, which act as discrete inclusions within the copper powder particle (Figure 4a,b). The visual inspection unequivocally revealed a heterogeneous distribution of the space holder material, with a significant proportion observed aggregating at the specimens' base (Figure 4a). Consequently, this condition rendered the sample structure susceptible to fracture and compromised its ability to maintain a cylindrical geometry, attributable to the extensive coverage of the lower surface by KCl. This phenomenon can be elucidated by the disparity in density between the constituent powders, which likely induced segregation during the compaction preparation phase. Notwithstanding the utilization of a high-speed mixing apparatus intended to yield a homogenous blend, particle separation presumably occurred during the transfer of the mixture into the mold prior to the application of compaction force. However, this issue can be mitigated by incorporating a minimal quantity of acetone during the mixing stage. This liquid acts as a binding agent, facilitating a more uniform dispersion of Cu and KCl before the subsequent compaction procedures. The resultant sample, depicted in Figure 4b, exhibited robust physical integrity, devoid of macroscopic fractures. Crucially,

the absence of discernible non-uniformity in the KCl distribution substantiates the effective amalgamation of the constituent particles

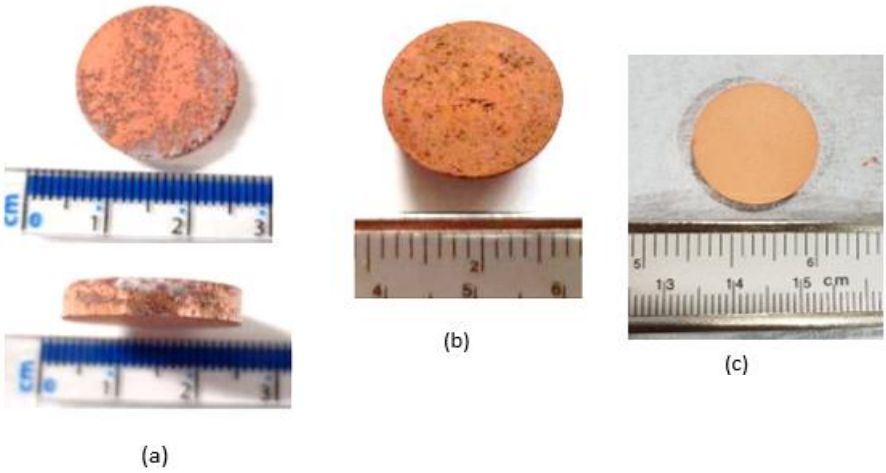


Fig. 4. Macroscopic images of compacted porous copper samples: (a) Defective sample with 10 vol.% KCl showing segregation at the base; (b) Non-defective sample with 20 vol.% KCl displaying uniform space holder distribution; (c) Sample without KCl

3.2 Impact of Compaction Pressure on Structural Integrity of Porous Copper

Applying uniaxial pressure had a major impact on the microstructure and mechanical properties. As mentioned by[16], the compaction is affected by many factors, such as powder size and morphology. Figure 5 presents a macroscopic examination of how compaction pressure influences the structural integrity of the porous copper samples under a specific compaction pressure range. The compaction process, a fundamental step in powder metallurgy, serves the dual purpose of shaping the powder mixture into a desired form and imparting sufficient green strength to the resulting compacts, enabling easy handling during subsequent processing. In the case of pure copper powder, which is devoid of any space holder (0 wt% KCl), effective compaction was achieved across a wide pressure range, spanning from 9.81 MPa (1 tonne) to a maximum of 49.03 MPa (5 tonnes). This observation underscores the inherent capacity of copper powder to undergo substantial plastic deformation and consolidation under applied pressure, culminating in the formation of robust compacts, as shown in Figure 5b. The compaction pressure should be carried out with a minimum of 9.81 MPa since the samples with lower pressures (below 9.81MPa) are easy to break and difficult to handle (Figure 5a).

Introducing KCl particles as a space holder material imposed a notable constraint on the maximum achievable compaction pressure. Specifically, the copper-KCl mixtures could only be reliably compacted up to 19.61 MPa, a limitation that necessitates a detailed analysis of the underlying mechanisms. The presence of KCl particles within the copper matrix inherently reduces the overall compressibility of the powder mixture since these KCl particles demonstrated fracture structure or were deformed above this pressure. As mentioned by [31], higher compaction pressure is a consequence of released elastic stress from powder compaction during green body fabrication, leading to lateral cracking [41]. As documented in previous studies [32], [33], the application of pressure beyond the critical threshold of the space holder induces its fracture, leading to a subsequent transformation of the initial spherical geometry into an elliptical form. This phenomenon is further supported by Torres *et al*. [22] which reported a comparable deformation of NaCl at 350 MPa.

Consequently, while high compaction pressures are unsuitable due to this potential for space holder damage, inadequate pressure also results in diminished sample strength. Thus, the adjustment of the pressing pressure is needed where the optimum ranges between 9.81-19.61 MPa. However, these pressure values are much lower compared to the previous study (around 120-180 MPa) since this study [34] was applied for large size of samples (25mm).

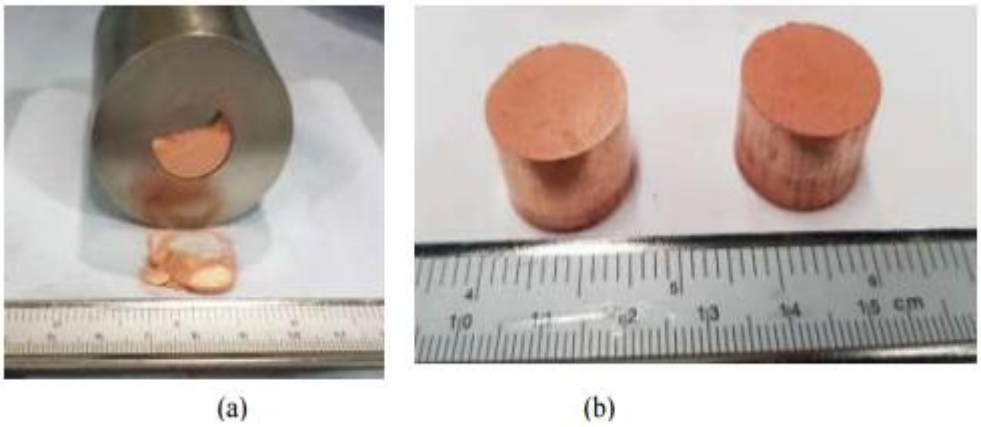


Fig. 5. (a) the compaction sample with compaction pressure below than 9.81 MPa, (b) final compaction copper with the acceptable pressure range (9.81MPa and 19.61MPa)

3.3 Analysis of Porous Samples Post-Dissolution Process

The water dissolution process for compacted samples prepared at 19.61 MPa is presented in Figure 6, which demonstrates that the KCl particles were successfully removed. This finding supported that KCl has good solubility in water [28]. The efficacy of this method in selectively removing the space holder particles without inducing significant structural anomalies in the pre-sintered specimens was clearly demonstrated. The time required for complete space holder removal exhibited a consistent trend across all samples, typically ranging from 4 to 5 hours. Using a 60°C water bath enhanced the kinetics of KCl dissolution, thereby expediting the dissolution process. The most significant microstructural transformation occurs after the dissolution process, where the removal of KCl particles leaves behind a network of interconnected pores within the copper matrix. Notably, the morphology of these pores closely replicates the size and shape of the leached space holder particles, providing direct evidence of the effectiveness of the space holder technique in precisely controlling pore morphology.

The efficacy of the KCl removal process was further substantiated by X-ray Fluorescence (XRF) analysis, as detailed in Table 3, where the absence of detectable potassium (K) or chlorine (Cl) signals confirms the successful removal of the space holder phase. This means the dissolution process successfully removed all the space holders at 50°C for almost 5 hours. Traces of low amounts of other elements present in the XRF spectra are likely attributable to contamination introduced during the sintering process, possibly originating from the ceramic container used for sintering.

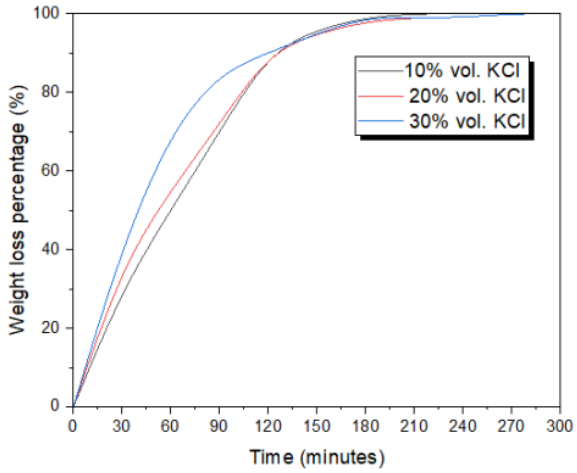


Fig. 6. Space holder removal from the sample subjected to a compaction pressure of 19.61 MPa

Table 3
XRF analysis of samples after the dissolution process

Temperature (°C)	KCl content (wt%)	XRF result
700	10	CuO 98.906%, P_2O_5 0.061%, Al_20_3 0.427%, SiO_2 0.059%, Ta_2O_5 0.548%
700	20	CuO 99.577%, Fe_2O_3 0.018 %, P_2O_5 0.064%, Al_20_3 0.436%, SiO_2 0.140%, Ta_2O_5 0.696%, Rh 0.069%
700	30	CuO 99.592%, Fe_2O_3 0.031 %, P_2O_5 0.067%, Al_20_3 0.309%,

3.3 Porosity analysis and density measurement on porous samples

Table 4 and Figure 7 show the porosity percentage of porous copper with different percentages of KCl weight, which provide quantitative analyses of the porosity characteristics of the fabricated porous copper, offering crucial insights into the influence of space holder content on the final pore volume within the material. The porosity was measured by Equation 2, and the volume and density of porous samples were determined by the Archimedes method. The result demonstrates that an increase in the space holder weight percentage will increase the porosity percentage of porous copper. The pores formation was formed according to the shape of the space holder known as macropores[30] while small and tiny pores are formed, which are called micropores. In contrast with compaction pressure, increasing compaction pressure reduces the porosity of porous copper.

Figure 7 demonstrates the relationship of compaction pressure and KCl % towards porosity development. This direct correlation underscores the effectiveness of the space holder technique as a powerful tool for tailoring the porosity of metallic materials. By precisely controlling the volume fraction of the space holder, it becomes possible to engineer materials with specific pore volumes, enabling them to meet the diverse requirements of various applications. The result shows that the KCl managed to create pores within the microstructures, and as predicted, a higher weight of KCl will create high-porosity samples.

Table 4
The porosity of each porous copper under different compaction pressures and KCl %

Compaction pressure (MPa)	KCl %	Density (g/cm-^{3})	Porosity percentage (%)
9.81	0	8.61	3.90
	10	7.88	12.1
	20	6.73	24.9
	30	5.87	34.5
19.61	0	8.55	4.60
	10	7.91	11.7
	20	6.87	23.3
	30	6.12	31.7

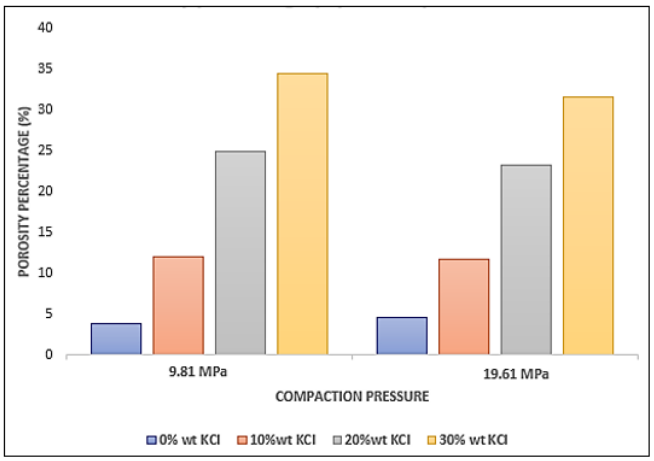


Fig. 7. The relationship of compaction pressure and KCl % towards porosity percentage

However, while a linear relationship between KCl content and porosity was anticipated, the results reveal a slight but consistent deviation from this ideal behavior. The measured porosity values are consistently 2% to 4.8% higher than the initial weight percentage of KCl in the mixture. This discrepancy can be attributed to a combination of several interacting factors. This probably contributed to the effect of the low sintering process and also due to the low compaction pressure compared to the previous study [22], [33]The setting of compaction pressure for this study has been selected as low as possible to create more space and pores within the microstructures.

Even at the relatively low sintering temperature of 700°C, some degree of copper particle rearrangement and densification inevitably occurs. This densification process reduces the overall volume of the sample while the pore volume remains largely unchanged, as the KCl particles maintain their original size and shape until they are removed during the dissolution stage. Consequently, the porosity percentage, calculated as the ratio of pore volume to total volume, slightly increases. Furthermore, non-uniform compaction within the die can lead to variations in local density throughout the sample. Regions with lower local density may exhibit higher porosity after dissolution process, contributing to the overall increase in the measured porosity values. Finally, pores located near the surface of the sample may be partially open or interconnected, potentially leading to a slight overestimation of the total pore volume during density measurements.

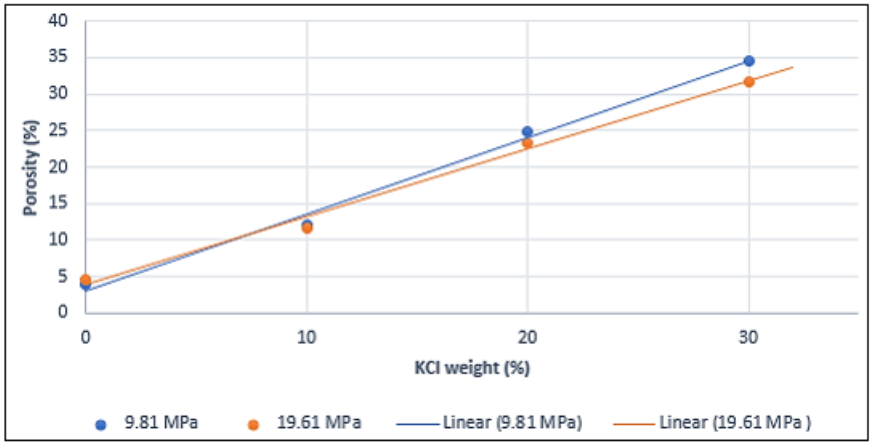


Fig. 8. The effect of porosity on KCl content

Figure 8 demonstrates a clear and predictable trend: increasing the weight percentage of KCl in the initial powder mixture directly correlates with an increase in the final porosity of the resulting porous copper. The results show a similar pattern as previous studies [17], [30] As shown in Figure 8, it clearly displays that the increase of KCl weight % will increase the porosity formation of porous copper. The samples without a space holder demonstrate almost 5% porosity while an increasing 10% to 30% of KCl shows a linear pattern of porosity formation for both compaction pressures. As similar trend to the previous study, an increasing of compaction pressure is tendency to reduce the porosity formation with 2.8% to 8.1% different of both compaction pressure. This observation aligns perfectly with the fundamental understanding that higher compaction pressures promote more efficient packing of the copper particles, thereby minimizing the interstitial spaces between them, which subsequently become pores after the dissolution process.

4. Conclusions

The outcome of this report is to develop the technique and process to create porous copper by powder metallurgy. The conventional compaction method has been selected as the main processing method since it shows successful results from previous studies. The porosity properties are controlled by employing space-holder materials. In the present work, the porous copper was fabricated with a lower porosity percentage than in previous studies. The selected amount of potassium chloride is between 0, 10, 20 and 30% weight and provides porosity of 3.9% to 34.5%. Two different compaction pressures have been selected to investigate the effect of compaction pressure on porosity development. It confirms that higher compaction pressure may reduce the porosity percentage and increase the strength of the samples. Moreover, the dissolution process was successfully performed under distilled water at 50°C to remove KCl from the copper structure, which leaves pores. The findings collectively provide a comprehensive understanding of the intricate process-structure-property relationships that govern the fabrication of porous copper using the space holder technique. The careful control of key processing parameters, namely compaction pressure and space holder content, enables the precise tailoring of porosity. This critical material characteristic dictates performance across a wide range of applications of porous metals.

Acknowledgment

This research was funded by the Ministry of Higher Education of Malaysia and The Freshgate Trust Foundation UK.

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