112材料工程系大學部實習成果觀摩競賽

Study on the Application of Spherical-Irregular-Dendritic Composite Copper Powder in Heat pipes

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Abstract

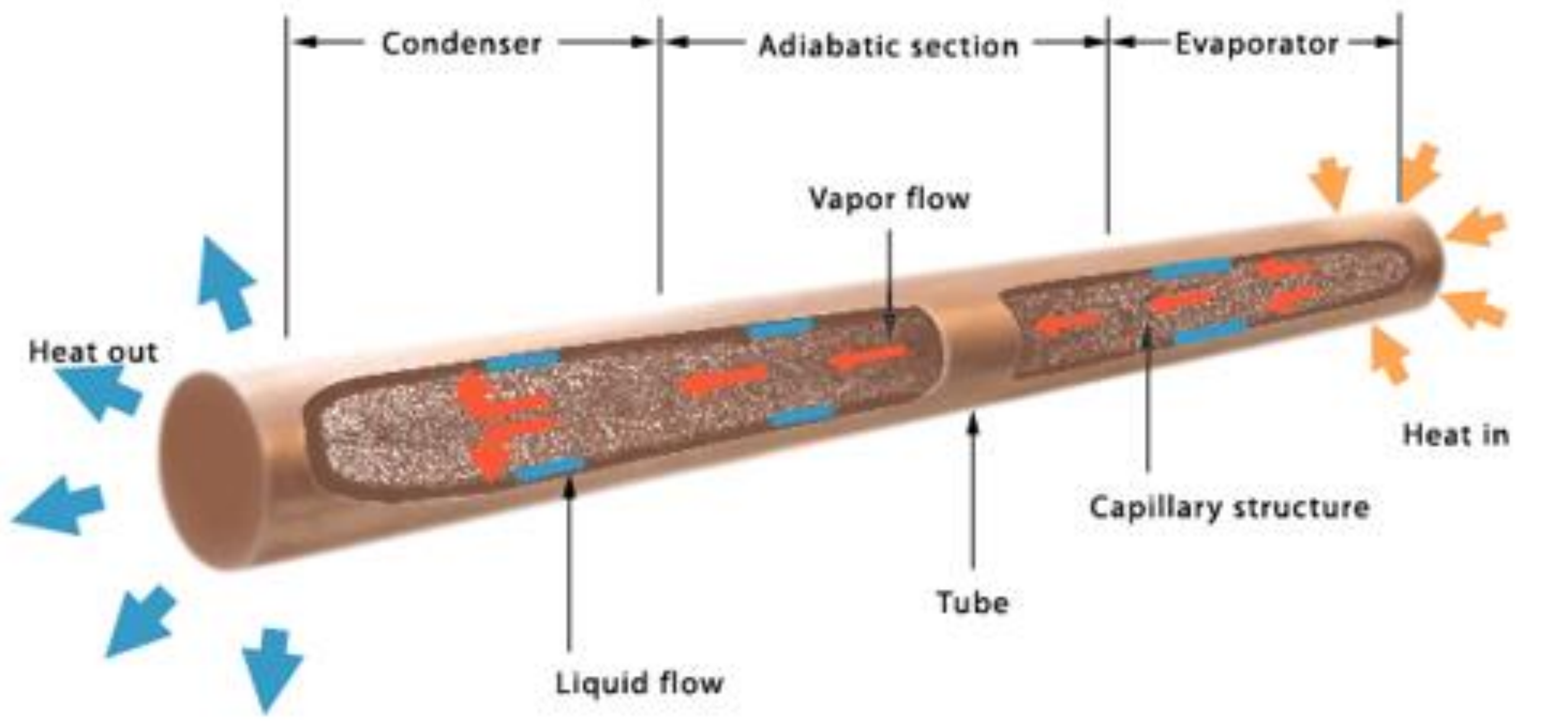
Porosity and capillary performance are the most critical parameters closely associated with the thermal performance of heat pipes, and these parameters are deeply influenced by the powder used. This study systematically investigates the impact of copper powder particle size and surface morphology on porosity and capillary performance. Sintered porous samples and heat pipes were prepared using a blend of copper powders of different sizes: spherical (60-100 mesh, 100-150 mesh, 150-200 mesh), irregular (60-100 mesh, 100-150 mesh, 150-200 mesh), and dendritic (325-450 mesh). The results indicate that both types of copper powder exhibit increased porosity and capillary performance with larger particle sizes, attributed to enhanced connectivity between internal pore structures. Compared to spherical powders, irregular powders exhibit superior capillary efficiency and higher porosity. Interestingly, the addition of dendritic copper powder did not effectively enhance the maximum heat transfer capability of the heat pipes. This is presumed to be due to the significant disparity in particle size between spherical, irregular, and dendritic copper powders, leading to unintended pore filling and a subsequent reduction in porosity.

Introduction

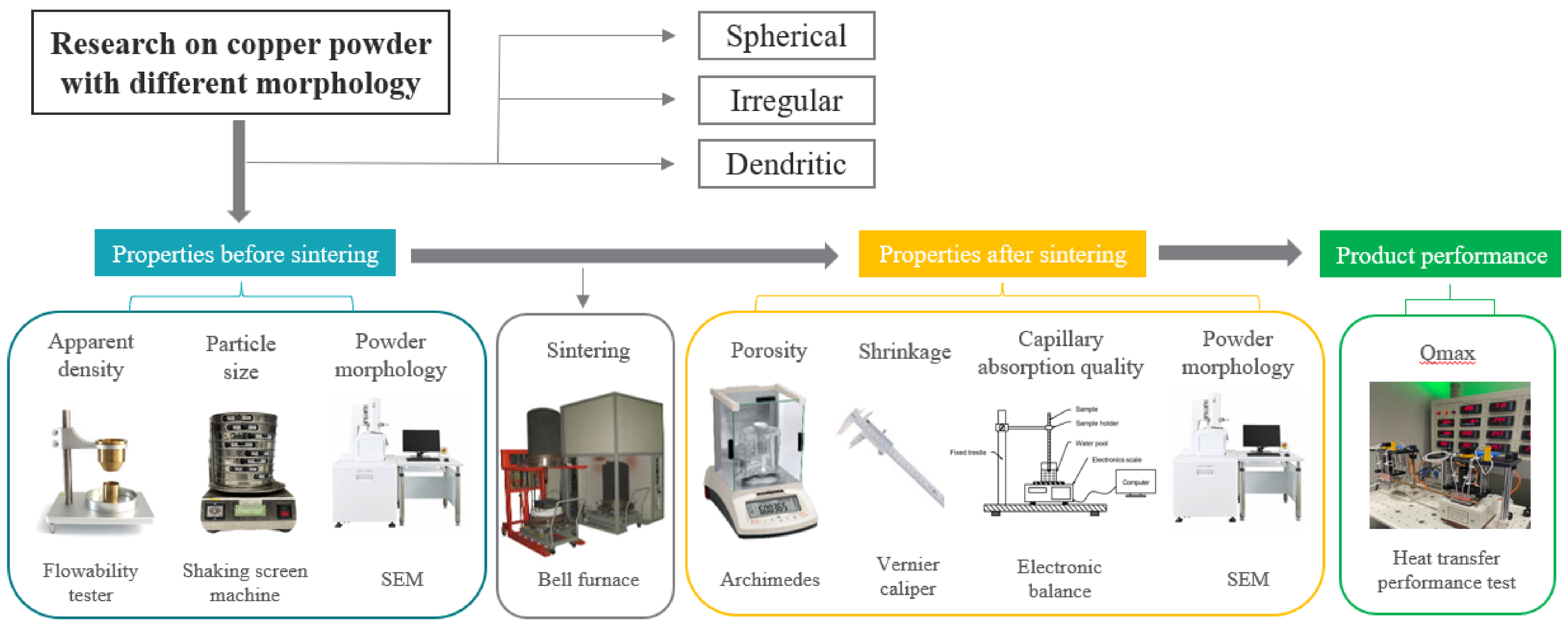
"Heat pipe" is a device that operates within the saturated working region of a liquid-vapor phase change process, known as latent heat operation, to facilitate the smooth transfer of heat from a heat source to an area where heat dissipation is possible. This heat transfer mechanism is referred to as the two-phase heat transfer process.

Depending on its operational configuration, a heat pipe can be divided into three distinct sections: evaporator section, adiabatic section, and condenser section.

In a heat pipe, the liquid at the high-temperature interface absorbs heat, vaporizes, flows within the pipe to a lower-temperature region, and then condenses at the low-temperature interface. The condensed liquid is drawn back to the high-temperature section through the action of the capillary structure, where it evaporates again. This process continues in a continuous cycle, ensuring uniform temperature distribution and achieving effective thermal management.

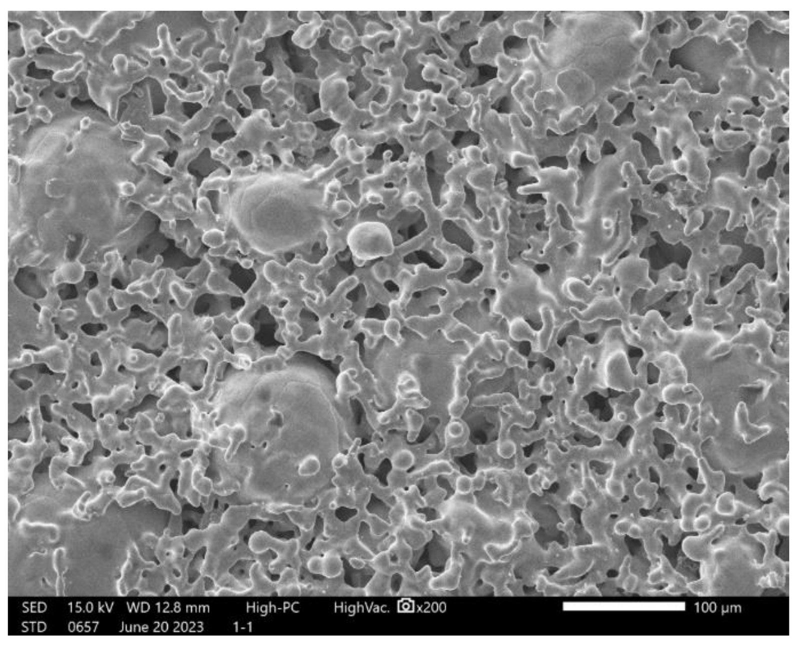


Experimental

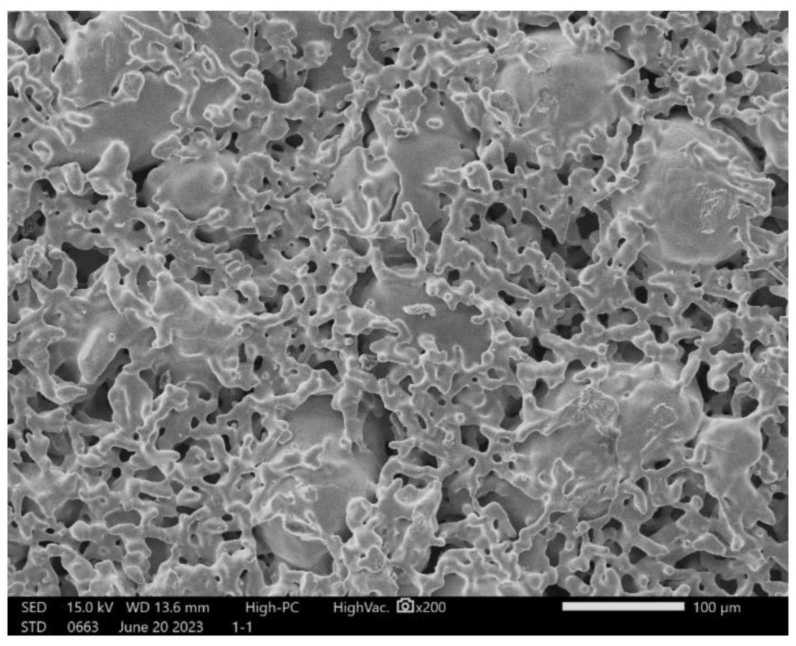


Results and Discussion

During the preparation of powder compact samples, it was observed that magnetic vibration filling of powders led to the agglomeration of dendritic copper powders, as shown in Figure1. This agglomeration phenomenon made it difficult to distinguish differences in the proportion of added dendritic powders using surface morphology detection.



(a)



(b)

Figure 1. Spherical + dendritic surface shape after sintering (a)10% ‧ (b)20%

Table 1. Apparent density, Shrinkage rate and Porosity of copper powders with different morphologies and particle sizes

Shape/Mesh size(目)	Apparent density(g/cm³)	Shrinkage rate(%)	Porosity(%)
Irregular 60-100	1.881	10.42	64.34
Irregular 100-150	1.909	12.97	62.25
Irregular 150-200	2.03	13.72	58.78
Spherical 60-100	4.249	3.69	38.85
Spherical 100-150	4.077	4.31	40.35
Spherical 150-200	4.076	5.32	38.91
Dendritic 325-450	1.673	26.76	45.64

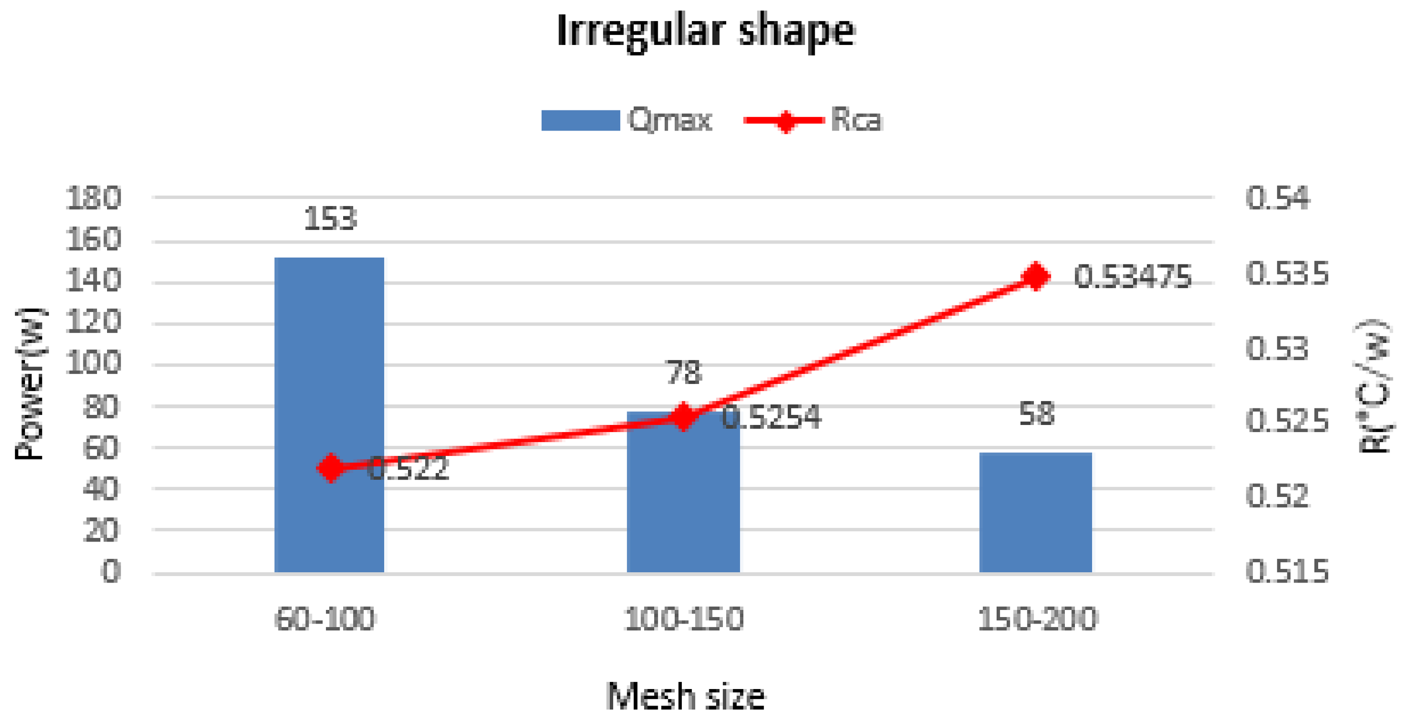


Figure 2. Maximum heat transfer and thermal resistance of Irregular shape

Conclusion

This experiment was primarily divided into two parts for performance testing: capillary absorption mass measurement and maximum heat transfer testing. In the capillary absorption mass measurement and maximum heat transfer testing, the fundamental characteristics of capillary structures, including porosity, shrinkage rate, apparent density, and so on, were discussed in relation to the effects caused by variations in copper powder proportions with different morphologies.

This study found that powder-sintered heat pipes exhibit better heat dissipation performance when the copper powder possesses the following characteristics: a. Larger average particle size, b. Tendency toward irregular powder morphology, c. Higher porosity, d. Higher mass flow rate.

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