Low-temperature Modification of Discarded Printed Circuit Board

ZHOU Cui-hong[1], LIU Mai-xi[2], PAN Yong-tai[1], CHEN Mao-he[2], QIAO Xue-feng[1]
(1. Department of Environmental Engineering, Beijing Institute of Pectrochemical Technology, Beijing 102617, China; 2. School of Chemical and Environmental Engineering, China University of Mining and Technology, Beijing 100083, China)

Abstract: Introduce cryogenic grinding and the components of Printed Circuit Board (PCB). Study the low-temperature modification of PCB, including mechanical property to find the influence of the different low-temperature on impact strength, flexural strength, shear strength of PCB. Tests show that impact strength and shear strength of PCB change sharply at -30℃. Used ZKB-2 type double roll shear crusher to crush PCB to 20mm× 20mm particle size, in a temperature range of -30℃ ~ -10℃, the product yield is 17% higher than room temperature, and much lower temperature may deteriorate the product quality of crusher. Used R type mill to grind sample to minus 3mm under different working condition, the average power is decrease in evidence at -30℃, freezing time for 5 minutes is best.

Key words: printed circuit board (PCB); low-temperature modification; crush; grind
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Grinding under low-temperature modification will obtain smaller particle, regular particle size and less pollution, separation various materials due to different fracture toughness. By using this technology materials property (mechanical property, fracture toughness, chemical property) will be changed at low temperature. The material which can often not be ground finely at room temperature will be ground in a brittle condition by cryogenic grinding process, therefore, it is an efficient way to grind materials of PCB. Mechanical technology for recovery Printed Circuit Board include dismantle, crush and separation. Effective crush is a crucial step before subsequent handling, even before chemical and hydrometallurgical approaches[1-3].

Due to microcosmic analysis of the materials of PCB, it is found that materials are made of copper, alloy, colophony and so on[4].

1 Experiments of low-temperature modification

After doing strength tests at low temperature, we can discover strength and brittleness will change of PCB. The impact strength tends to decrease with the lowering of cooling temperature and drops to a lowest value at a temperature of approximately -30℃. When the temperature varies from room temperature to -30℃, there is a rapid drop of the impact strength. Yet the drop starts to slow down at a temperature of below -30℃. As for the flexural strength, it tends generally to first decrease and then increase and at the point of -30 ℃, the flexural strength and failure strength all fall down to a minimum value and then rise up again rapidly. The shear strength is found to increase all the way along with the lowering of temperature. It indicates that when cooled down to around -30℃, PCB becomes low in strength and high in brittleness and hence is easy to crush. Therefore, -30℃ is a crucial temperature point, shown in Fig.1. The PCB is preferably crushed through impact and flexural means.

2 Experiments of cryogenics grinding

2.1 Cryogenics crush and results

In this experiment, used ZKB-2 type double roll shear crusher crush PCB to 20mm× 20mm particle size. Firstly put PCB into freezing device, adopted direct injection of liquid nitrogen and mixed with ethanol to adjusting different temperature. Then put the material into crusher chamber. In crush process, we recorded power consumption every 30 seconds. Studied the pow-

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作者简介: 周翠红 (1973年生), 女, 博士, 副教授; E-mail: zhoucuihong@bipt.edu.cn

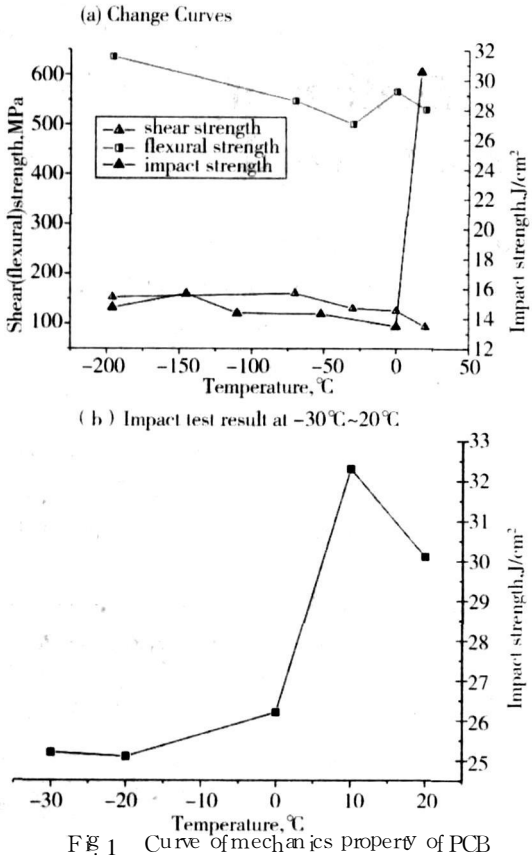

Fig. 1 Curve of mechanics property of PCB at low temperature

er diversification, calculated percent of production capacity under 0, -30, -70, -100℃ at different frequencies.

The freezing treatment can help increase the yield of the product of crusher. In a temperature range of -30 ~ -10℃, the product yield is 17% higher than that at a room temperature. If the temperature does not go down below -30℃, no noticeable increase of the ratio of over-crushed material is observed. However, a much lower temperature may deteriorate the product quality of fine crusher.

2.2 Cryogenics grinding and results

In this experiment, we used R type grinding mill to grind sample to minus 3 mm under different working condition. Firstly put 200 g PCB into freezing device, adopted direct injection of liquid nitrogen and mixed with ethanol to adjusting different temperature. In grind process, also recorded power consumption every 30 seconds. Studied the power diversification under different freezing temperatures and freezing time.

2.2.1 The influence of different freezing temperatures

Adjusted running frequency is 30 Hz, froze PCB for five minuets and crushed for five minuets too. Recorded power at -60, -50, -40, -30, -25, -20, -15, 21℃ (room temperature), analyzed the change tendency shown in Fig. 2. From the figure we can see when crushing at different temperature, the power is big at beginning, then becoming low and especially at room temperature. The beginning power is higher, the average power is lower between -30 to -60 ℃, and the average power is decrease in evidence at -30 ℃.

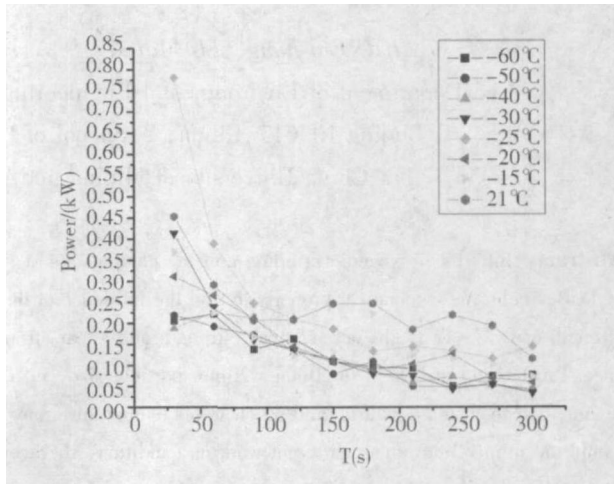

Fig. 2 Power change at different freezing temperatures

2.2.2 The influence of freezing time

Adjusted running frequency is 30 Hz, and grind for five minuets too. Recorded power at different freezing time (3, 5, 10, 15 minute), then analyzed the change tendency in Fig. 3. It concludes that the average power is lower at 5 m, 10 m freezing time. In freezing process of 5 m there is no need to add liquid nitrogen. So freezing time for 5 minutes is best.

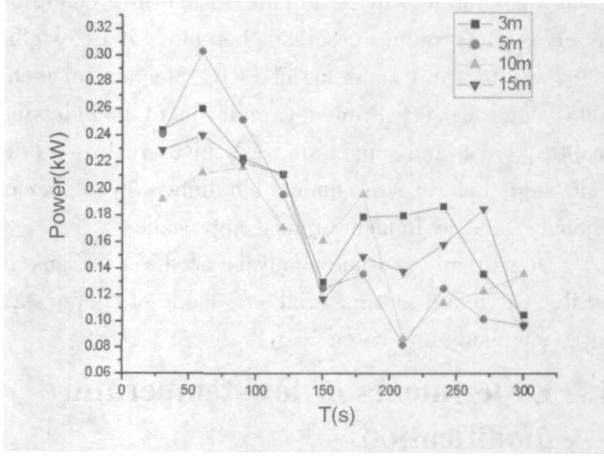

Fig. 3 Power change at different freezing time

3 Conclusions

Mechanical recycling of end-of-life Printed Circuit Board oriented towards overall material recovery from obsolete electronics is being implemented worldwide. High efficient liberation is key technology in recovery process. Using low-temperature modification can achieve a desired liberation, less power consumption. From the research we can draw these conclusions:

(1) Liquid nitrogen is suitable for direct injection. This allows for accurate and direct control of the temperature for cooling.

(2) By microcosmic analysis of the materials of PCB, it is found that materials are made of copper, alloy, colophony and etc.

(3) From the experiment we can know the best working condition for cryogenic grinding are: cooling temperature at -30 ℃, freezing time is 5 mintues.

(4) Cool the material to its embitterment temperature may also reduce the time to achieve a desired liberation, thereby decreasing the electrical energy consumption.

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废旧电路板低温改性研究

周翠红[1]，路迈西[2]，潘永泰[2]，陈茂和[2]，乔雪峰[1]

(1. 北京石油化工学院环境工程系，北京 102617；
2. 中国矿业大学北京校区化学与环境工程学院，北京 100083)

摘　要：介绍了电路板的组成和类型，重点研究了废旧电路板在低温状态下冲击强度、弯曲强度和剪切强度的改性变化。实验结果表明，冲击强度和剪切强度在 -30℃时变化明显。在此基础上进行了粗碎实验和细碎实验，先使用 ZKB-2型双辊式剪切破碎机将电路板破碎到 20 mm×20 mm的块状，测试在低温状态下的功耗并计算其生产能力，在 -30℃ ~ -10℃范围内，生产能力可提高约 17%，再降低温度会使产品质量受到影响。然后使用 R型冲击破碎机对废旧电路板进行细碎实验，将物料破碎到 3 mm以下，并记录在不同工况下的参数。实验结果表明在 -30℃左右平均功率下降得较快，冷却 5 min对低温改性最有利。

关键词：电路板；低温改性；破碎；细碎

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