

Conception and Realization of a Vibrating Machine to Isolate Copper from Plastic Obtained From Wire Waste

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Abstract

Electrical cables are mainly composed of metal and plastic. The core of the cable contains metallic wires, mainly made of copper, but can also be composed of other metals such as tin, aluminum, iron, nickel, zinc and phosphorus. The recycling of electrical cables begins with the separation of the plastic elements from the metal elements. These elements are then crushed into granules or chips to be reused. In order to achieve this goal, a machine has been developed to separate the metal from the plastic with a vibratory system, this machine allow us to get numerous data points and results by controlling and switching the speed of the engine to get the best insulation for copper/plastic.

Keywords: copper, plastic, recycling, vibrating machine.

1. Introduction

In a world constantly evolving, the question of responsible management of natural resources becomes increasingly crucial. Among these resources, electrical cables play a central role in our modern daily lives, supplying our homes with electricity and driving technological advancements. However, the exploitation of these materials has significant environmental repercussions. This is where the importance of copper and electrical cable recycling becomes essential.

Indeed, numerous researchers are currently dedicated to in-depth studies on innovative techniques and effective solutions to optimize the recycling of copper and electrical cables, thereby contributing to shaping a more sustainable future for our planet.

Among these visionary researchers, Li Yang and all have conducted a significant study on recycling electrically-conductive metal and insulating material from cable waste using ultrasonic technology. The traditional cable granulator technique, known for its copper losses and resulting inefficiencies, involves cutting and grinding cable waste to obtain metal (primarily copper) and insulating material (mainly plastic) [1].

Jing Xu and all presented a study on the environmentally friendly separation of copper, PVC coverings, and plasticizers from electric cables using acetone and ethyl acetate solvents. The research optimizes the stirring method with acetone, showing that longer cables require higher stirring speeds for efficient separation. The study establishes a positive correlation between stirring speed, stirring time, and separation efficiency. Additionally, plasticizer

extraction efficiency increases with higher stirring speeds and longer stirring times.

The research highlights the enhanced movement of solvents at higher stirring speeds, improving penetration into PVC coverings. Also explores empirical data and the calculation of relative energy difference (RED) to assess solvent efficacy. Overall, the study emphasizes sustainable and efficient cable recycling practices through the use of environmentally friendly solvents and optimized stirring methods [2].

Aicha Hadj Ali and her team introduced an innovative approach to particle separation using an Electrical Curtain Conveyor (ECC). The ECC, a three-phase vibrating conveyor, employs an attraction force to retain metal particles while allowing plastic particles to move through vibration. The study demonstrates successful separation with high purity values, dependent on the amplitude of the applied voltage. Two experiments were conducted, showcasing the ECC's ability to function both in a static state and a vibrating state. Recovery and purity rates of copper particles were calculated, and the ECC's design included features like controlled voltage adjustments and insulating tape for safety. The research highlights the ECC's potential in advancing recycling technologies by efficiently separating plastic and metal particles [3].

A. Tilmatine and all discussed the incorporation of electrostatic separation as a complementary method to mechanical recycling for industrial waste. They present the development of new applications using a pilot-industrial installation designed by them, focusing on samples from an Algerian company specialized in electric cable waste recycling. Preliminary experiments set limit values for process control variables, and pilot-

plant tests confirm the efficiency of electrostatic separation for copper-plastic granular mixtures. The article explores factors influencing the operation of a drum-type electrostatic separator, emphasizing both fixed design elements and adjustable factors during industrial operation [4].

In this paper, we employ an innovative approach to separation and recycling, using a method that considers multiple parameters influencing the separation process. This method diverges from conventional techniques, providing a comprehensive perspective on the factors influencing the efficiency of separation and recycling processes.

2. Vibratory Density Machine

The vibratory density machine made to separate the copper from the plastic of electrical cables, to achieve this result we have done several research to model prototypes, the realization of the machine has been accomplished using an electric motor and a crank rod system that pushes the table being attached to the blades that allows it to vibrate (Fig.1).

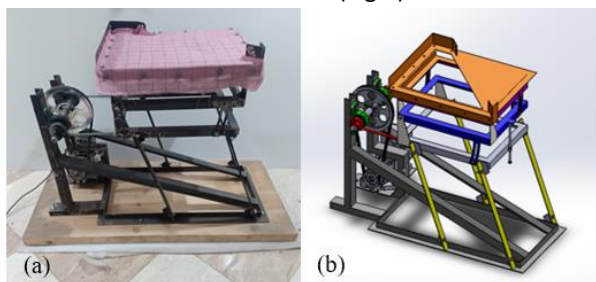


Fig. 1. (a) The vibrating machine, (b) Modelling of the machine.

3. Experimental Study

The aim of this experimental study is to explore the impact of the engine speed factor on copper/plastic separation.

In this work, an engine equipped with a speed controller will be used to vary the speed from 0 to 4500 (rpm).

The purpose of the copper/plastic isolation test is to study the machine's operation under different conditions, and to understand the behavior of copper/plastic particles when subjected to vibration. During these tests, 2 (g) of copper and 2 (g) of plastic will be weighed using an electronic balance (Fig.2) with accuracy of 10^{-2} (g).



Fig. 2. Electronic balance.

Secondly, the copper and plastic will be mixed and placed on the separating machine. (Fig.3).

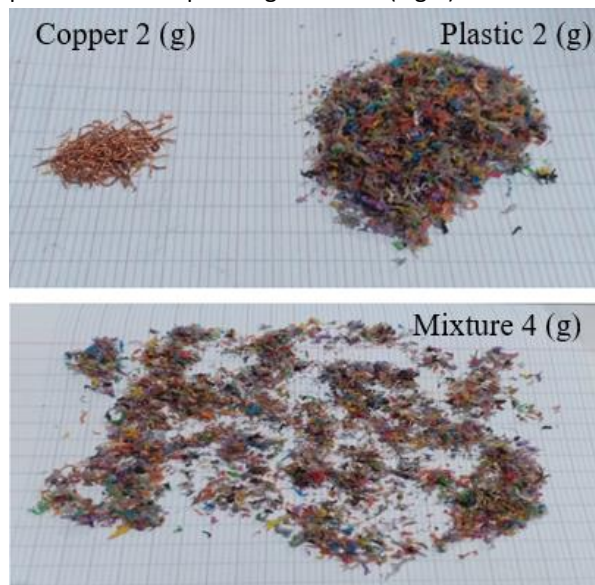


Fig. 3. Copper/plastic mixture 4g.

The tests are executed by varying the motor speed at (500, 700, 900, 1100, 1300, 1500 rpm), respectively, with the aim of understanding the effect of motor speed on copper/plastic isolation.

4. Results and Discussions

The findings of this study provide significant insights into copper/plastic insulation. In this section, we will present and analyze the results, drawing meaningful conclusions and implications for the field, in this experiment, numerous data points were gathered and summarized in the table below.

Table 1 Data from the experiment

Speed (rpm)	500	700	900	1100	1300	1500
Mix (g)	0,02	0,90	1,47	1,87	2,56	3,14

Copper (g)	0,02	0,88	1,40	1,72	1,68	1,76
Plastic (g)	0,00	0,02	0,07	0,15	0,88	1,38
Left-over (g)	3,98	3,10	2,53	2,13	1,44	0,86
Copper recovery (%)	1,00	44,00	70,00	86,00	84,00	88,00
Copper purity (%)	100,00	97,78	95,24	91,98	65,63	56,05
Plastic recovery (%)	0,00	1,00	3,50	7,50	44,00	69,00
Plastic purity (%)	0,00	2,22	4,76	8,02	34,38	43,95

The following graph illustrates the impact of speed on the recovery of copper and plastic. It can be seen that the quantity of plastic recovered increases with increasing speed, but at a slower rate than copper: between 500 (rpm) and 1100 (rpm), the quantity of plastic recovered does not exceed 20%, whereas copper achieves a recovery rate of over 80%, but this changes after 1100 (rpm), when the quantity of copper increases sharply to reach 70% (Fig.4).

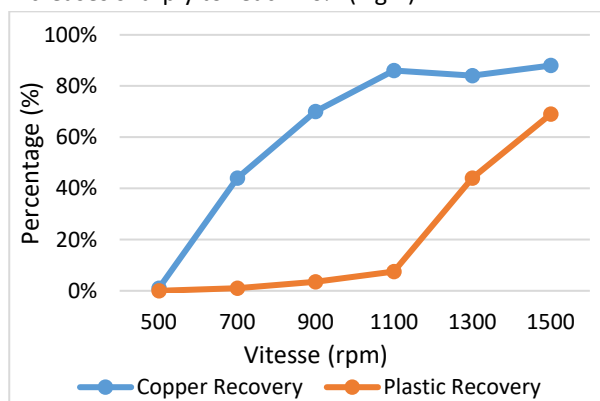


Fig. 4. Impact of speed on the recovery of copper and plastic.

The purity of copper decreases with increasing speed, as we can see that around 500 (rpm), we have a purity of 100%, but this decreases as speed increases, reaching a value close to 50% around 1500 (rpm). In contrast, the purity of plastic increases as speed increases, from 0% to a value close to 50% (Fig.5).

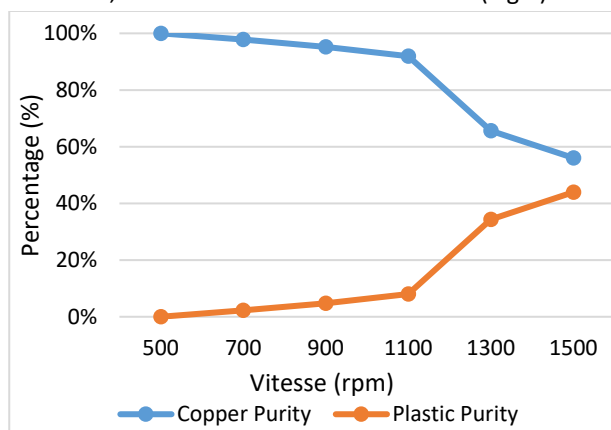


Fig. 5. Impact of speed on the purity of copper and plastic.

In the (Fig.6), it is clear that the amount of copper obtained increases as the speed of the separation machine increases. Moreover, an increase in machine speed also leads to a decrease in copper purity.

We can see that 1500 (rpm) is the best speed, with 88% of copper recovered but a purity of 56%, while at 700 (rpm) we have a low recovery rate equal to 44% but with a copper purity rate equal to 97%. We can also see that the two curves come closer together towards 1100 (rpm), which indicates that this is the optimum separation speed with a high purity and recovery rate.

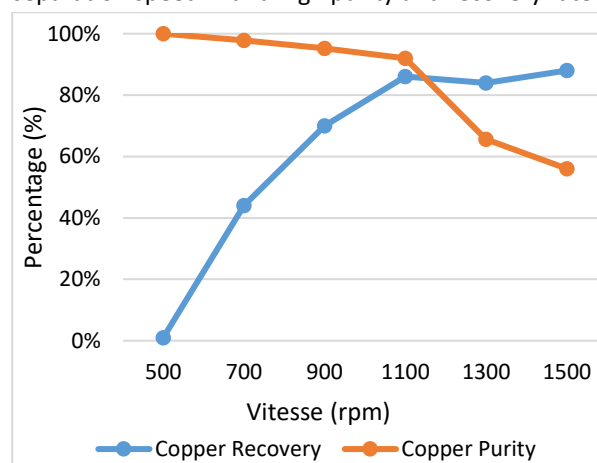


Fig. 6. Impact of speed on the purity and recovery of copper.

As the (Fig.7) shows, the purity and recovery rate of the plastic increases with increasing speed, but between 500 (rpm) and 1100 (rpm) we have almost the same recovery and purity rate, with minimum values that don't exceed 20%. After 1100 (rpm), however, we notice that the curves distinguish one from the other, with a value of 69% recovery and 43% purity.

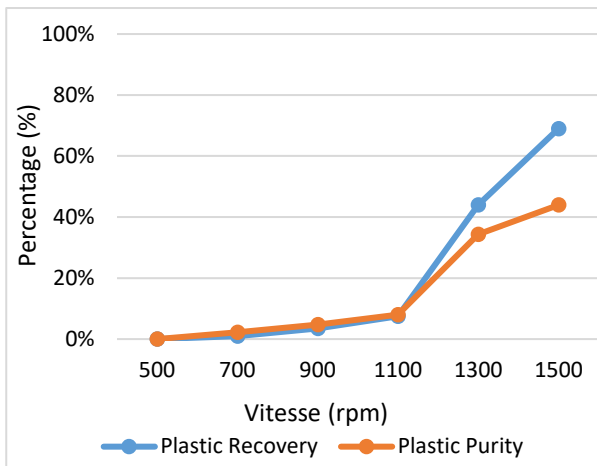


Fig. 7. Impact of speed on the purity and recovery of plastic.

5. Conclusion

The vibratory density machine revealed crucial information about the behavior of copper/plastic particles. Firstly, it appeared that increasing machine speed leads to an increase in the amount of copper and plastic separated, but this growth goes hand in hand with a decrease in the purity of the resulting material. In other words, increased speed promotes separation, but at the expense of purity. However, this study has identified an optimum speed of 1100 (rpm) that strikes a balance between high recovery and acceptable purity, offering the best separation performance. It is also essential to note that excessively high separation speeds induce more intense vibrations, resulting in a significant reduction in the purity of the final material. Thus, this research highlights the importance of striking the right balance between vibration machine speed and material purity in the copper/plastic particle separation process.

In perspective, I would like to do another experimental test using other parameters that could impact the copper-plastic separation.

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