Research the possibility of separating hydrophobic gel used in gel cables from metal and plastics using wet methods

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Abstract. This article presents basic information on gel cables and methods of processing them. The wet recycling plant for waste gel cables currently used in the industry is presented. The advantages and disadvantages of this installation are discussed. Current gel cable recycling technologies do not ensure the recovery of all raw materials. The article also shows the reproduction of an industrial installation on a laboratory scale. Laboratory tests included determining the efficiency of the separation of hydrophobic gel from metal and plastic. The moisture content of the resulting products was measured. The final section of the article identifies further research directions.

1 Introduction

The full processing of gel cables is a challenge for recycling companies. Its essence is the management of the hydrophobic gel used in this type of cable, which, due to its adhesive properties, prevents it from being processed with other cables [1].

Standard gel cables consist of outer insulation, Al. shield, foil, copper core, inner insulation, foil strips, hydrophobic gel and steel cable. The hydrophobic gel, the recoverability of which was tested, occurred from 4-10% of the cable weight [2]. Gel cables are used in areas exposed to moisture.

2 Methods

The main material that is recovered from cables is copper, which is important due to its depleting natural resources. Copper from cables is a high enough quality secondary raw material to be used as a full-fledged product. However, in order to meet the objectives of the Closed Economy, it is necessary to focus on other raw materials from which gel cable is composed as well. Methods for recycling waste cables and wires have been known for a long time. They are mainly based on multi-stage shredding and separation [3].

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However, they cannot be used when recycling gel cables, which contain hydrophobic gel in their structure [2]. The adhesive properties of the gel prevent this type of cable from being processed with others.

A number of methods have already been developed for processing gel cables. There are three main methods: dry, wet and their hybrid combination. Wet methods use a solvent or paraffin heated to a suitable temperature to separate the gel from the rest of the raw materials, and suitable equipment to enable this operation. The disadvantage of these methods is the formation of waste - contaminated solvent. In dry methods, hot air is used to purge the raw materials from the gel. The last hybrid method uses both approaches. However, the latter method requires sophisticated and elaborate apparatus and significant consumption of various media - electricity, coupled air, solvents and water [4]. In Poland, Rado Sp. z o. o. has developed a line for producing copper powders obtained from gel cables. Tests carried out on the line confirmed the possibility of building the line on a semi-technical scale. The company submitted the work to the patent office, but did not obtain a protection right. The submitted solution included such processes as cable shredding, leaching, hot washing, processing into metal and plastic fractions, and liquid phase distillation [5,6].

A line containing all processing for gel cables was created by Eldan Recycling. The input material is whole cables, directed to pre-shredding and then the magnetic fraction is separated using a magnet. The remaining fraction - a mixture of copper, plastic and gel - goes to a granulator, where the material is cleaned of the gel with the help of water washers. After purification, the copper fraction is separated from the plastic. Detergents are added to the water for a better cleaning effect. Also in this method, a waste of post-process water remains together with the gel. The aforementioned process line is shown below in Figure 1 [7].

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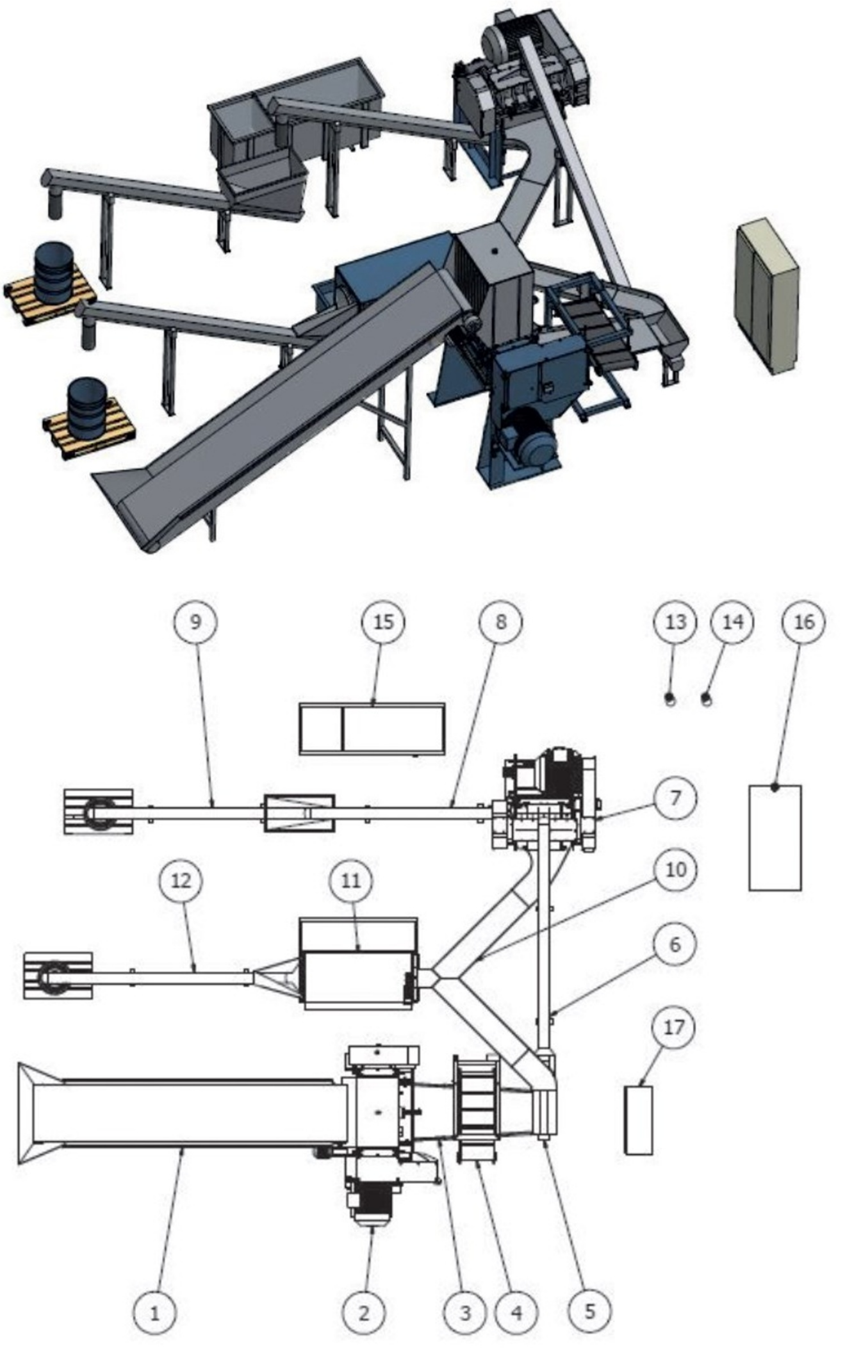

Fig. 1. Layout Jelly Plant [7]. Elements: 1 – inlet conveyor, 2 – pre-granulator PG1200, 3 – outlet chute, 4 – overband magnet DM1850, 5 – screw conveyor, 6 – screw conveyor, 7 – fine granulator FG952, 8 – screw conveyor, 9 – wash unit, 10 – water conveyor channels, 11 – rotating filter (for plastic fraction), 12 – screw conveyor (plastic fraction), 13 – pipe system: water, 14 – pipe system: steam, 15 – water tank, 16 – steam generator, 17 – electrical power board.

3 Study of gel osdeparation using a solvent.

Based on an analysis of the state of the art [4], hot water (above 80°C) was used as the solvent for the hydrophobic gel applied to the test material. The first step was to grind the cables then the test material was placed in a container filled with hot water. With the help of a slow-speed stirrer, it was put into a swirling motion in the process. After the process of interaction of the solvent with the test material, the analysis of the obtained products was carried out.
The research methodology is shown in Figure 2.

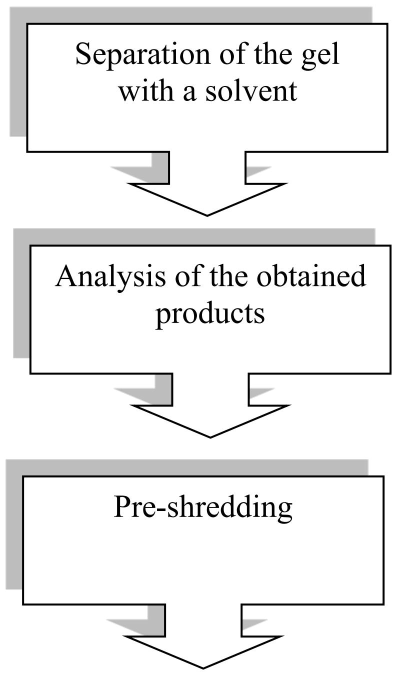

Fig. 2. Diagram of the research methodology.

3.1 Gel separation process using solvent

Five trials of the process of separating the hydrophobic gel with a solvent were performed. Figure 3 shows a view of the test stand. The test material was placed in a metal container, and then 2000 ml of hot water with a temperature above 80^{o}C was added. In order to maintain the required temperature, the metal container was placed on a hot plate with a set temperature of 92^{o}C. The temperature was controlled by a thermocouple immersed in the mixture of water and test material, and the reading was recorded on a temperature gauge. In addition, an electric stirrer was introduced into the tank to provide a swirling motion of the test material and hot water. Table 1 groups the results obtained.

Fig. 2. A view of the test bench of the process of separating a hydrophobic gel with a solvent.

Table 1. Results of hydrophobic gel separation process using solvent.

Test No.	Initial Test weight [g]	Final Test weight [g]	Moisture content [%]	Amount of gel separated [%]
1	153.62	161.69	3.14	36.44
2	154.87	156.75	3.80	42.40
3	148.03	157.73	3.77	44.29
4	164.67	175.74	3.51	41.30
5	146.70	155.61	4.61	53.91
Average	153.58	161.50	3.77	43.67

4 Result.

After making 5 tests to separate the gel with solvent, the average result was 43.67%. This is below the expected result. The presence of gel was noticeable in the decanted liquid. This means that the process generates secondary waste in the form of contaminated effluent.

Moisture content was determined in the tested materials, the average result was 6.06%. The high moisture content and the low degree of gel decanting made it impossible to continue testing on subsequent separators.

5 Summary and discussion.

The tests performed showed that the average amount of separated gel from gel cables using solvent was 43.67%. This means more than 50% of the gel content in the cable remains on the plastic and copper. In further studies, optamalization of technical parameters (e.g., time and temeprature) is planned to increase the amount of separated gel from the remaining raw materials. Since the process generates secondary waste in the form of effluent, the next stage of the research was planned to analyze the resulting effluent, such as Chemical oxygen demand or dry matter , and evaluate its compliance with the parameters of effluent discharged to external tanks.

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References

1. Sojka D., Pikoń K., Klejnowska K., Lewandowska M., Kriogeniczne rozdrabnianie jako pierwszy krok w recyklingu odpadowych kabli żelowych. Przemysł Chemiczny 101/8 (2022) s. 576-579, DOI: 10.15199/62.2022.8.6
2. Sojka D., Pikoń K., Klejnowska K., Lewandowska M „Określenie morfologii odpadowych kabli żelowych" Współczesne problemy ochrony środowiska i energetyki 2021 (red. M. Bogacka, K. Pikoń), Wyd. Politechniki Śląskiej, Gliwice 2022, ISBN 978-83-964116-0-0..
3. Kozłowski J., W. Mikłasz, D. Lewandowski, M. Potempa, M. Gawliczek, D. Sojka, Recykling odpadów poużytkowych w Polsce zawierających metale nieżelazne w strategii na rzecz zrównoważonego rozwoju, Wyd. Politechniki Śląskiej, Gliwice 2019
4. Sojka D., Pikoń K., Klejnowska K., Lewandowska M. Gołębiewska-Kurzawska J.,, State of the art of recycling gel-containing copper cables in the context of sustainability and circular economy. Przemysł Chemiczny 102/10 (2023) s. 1074-1080, DOI: 10.15199/62.2023.10.13
5. Bajorek J., Gardeła A., Ochrona przed Korozją 2022, 65, No. 3, 68
6. https://ewyszukiwarka.pue.uprp.gov.pl/search/pwp-details/P.399713?lng=pl, access 19.03.2024.
7. eldan-recycling.com/pl, access 19.03.2024.