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SPONSORED ARTICLE

SOLUTION OF WATER AND SEWAGE MANAGEMENT IN PLASTICS RECYCLING

ROZWIĄZANIE GOSPODARKI WODNO-OSADOWEJ W RECYKLINGU TWORZYW SZTUCZNYCH

***ABSTRACT**: In the time of dynamic development of polymer material's recycling, the effective treatment of waste water generated during the process of cleaning the above mentioned renewable raw materials has become a very important problem. Recycling of polymer plastics allows the reuse of raw materials which, in turn, contributes to reduction of demand for new materials. In order to play a role of sustainable solution, industry must, however, focus it's attention not only on production of recyclates but also on the effective and safe treatment of water used during the manufacturing processes. In this document we will discuss the complex solution of the problem mentioned above. This paper presents authorial solution in respect to treatment of waste water, arising during the process of plastics cleaning subjected to the recycling. Attributing to the application of advanced technologies and strategies, suggested solution is aimed not only at effective removal of contamination but also, to minimize the quantity of consumed water and the resulting waste. Discussed solution is a step towards sustainable processing of plastics, limiting it's negative effect on the environment, and, at the same time, keeping the high standard of purity of the produced material.*

Introduction

In the light of the rising problems connected with the global pollution, recycling becomes a key element of activities, aiming at limitation of the negative effect of man on our Planet. The problem of waste, especially of plastic waste is nowadays one of the most urgent ecological problems; the mentioned type of waste is generated today in enormous quantities due to the application of the materials of this type in a very wide spectrum of everyday use products. In the context of recycling, processing of polyethylene films such as LDPE, LLDPE or HDPE has become especially significant area. In the connection with their universal presence in everyday life, the mentioned foils and films become a permanent load to ecosystems, affecting negatively the state of the environment. Contamination of the environment with the discussed materials concerns not only humans but also numerous animal species which suffer from penetration of plastics to their natural habitats. Here we should pay attention to meaningful profits, resulting from recycling of plastics, with the special consideration of polyethylene materials. The reuse of raw material and especially production of re-granulate does not only contribute to environmental protection but also brings countless economic advantages. The re-granulate is an alternative to traditional granulate as it is characterized by similar parameters; therefore, it may be employed and reprocessed with a success. As it was earlier mentioned, it makes this product a good alternative to plastics in many industrial applications. Due to the fact that most of the waste films are soiled and joined together, there is a necessity to employ multiple stage cleaning process, facilitating their further processing. Washing of recycling-subjected films is complicated and is connected with considerable water consumption. It also generates another problem for industrial plants: what to do with the resulting sewage? When answering the above mentioned question PFTechnology; with location in Wierzbica near Radom, presents the authorial solution in a form of installation for pre-cleaning of process water coming from plastic recycling plant. The mentioned solution is a result of long-time research and practical experience, gained during this period. Implementation of the suggested solutions does not only solve the problem connected with the resulting waste water but also allows for effective treatment of consumed films and reduction of the amount of generated solid waste.

The treatment process of sewage coming from cleaning of flakes includes multiple stages, demonstrated at the draw (Fig. 1), aiming at effective removal of contamination and recovery of pre-treated liquid. The process commences with

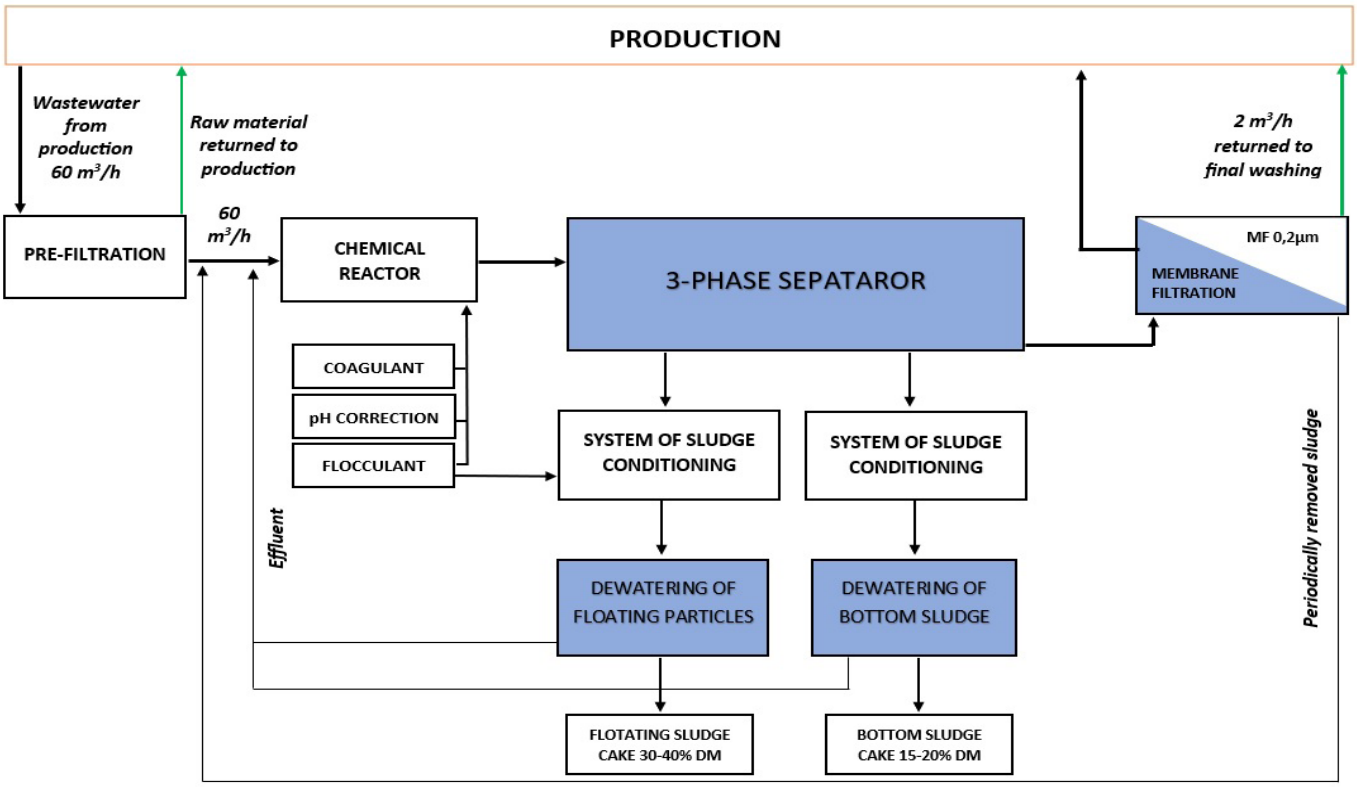

Fig. 1. Diagram of the installation for pre-treatment of wastewater from recycled plastics

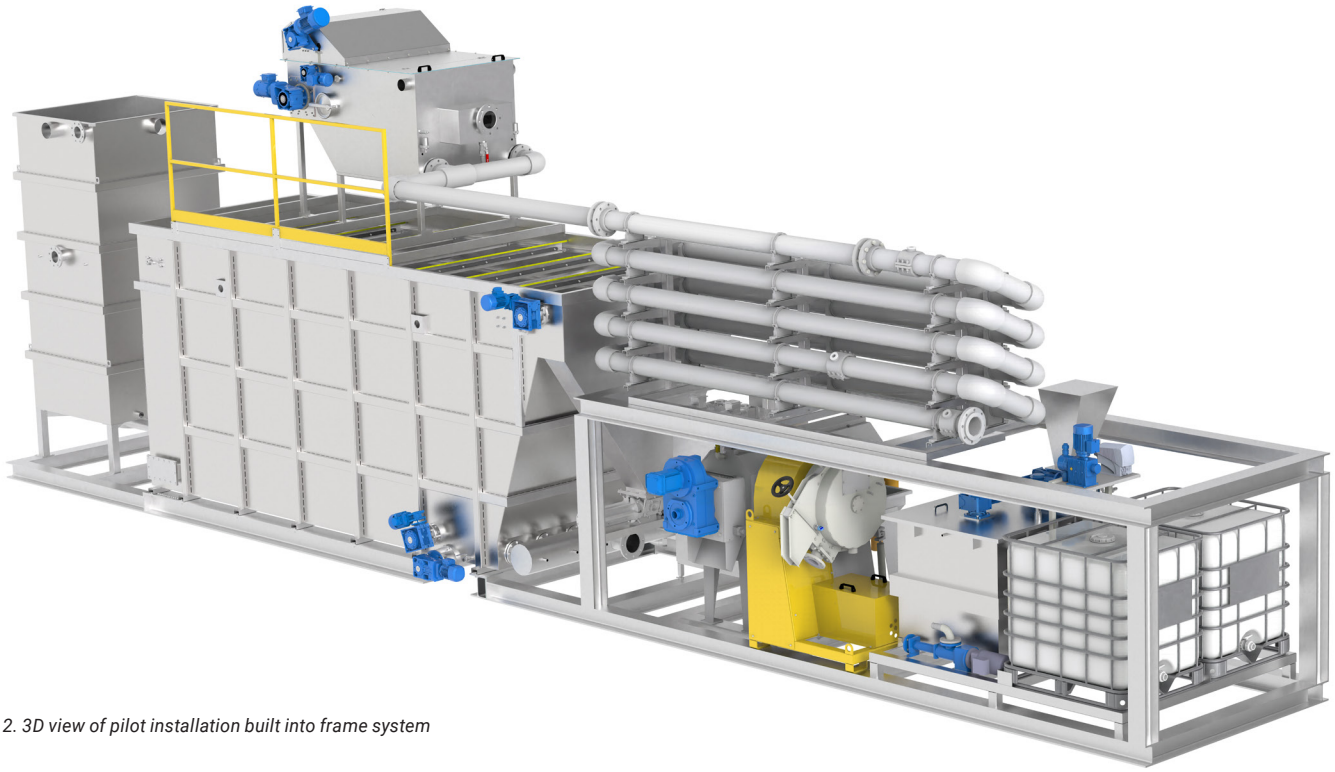

Fig. 2. 3D view of pilot installation built into frame system

the mechanical pre-filtration, adapted to the characteristics of sewages and the needs of the customer/further process. It should be mentioned that PF Technology has more than 20-year experience in respect of production of complete filtration systems. Preliminary filtration of the wastewater may be carried out in many stages, e.g. with the aim to separate greater particles of recyclate with the possibility of returning them to production. Then, the sewage is subjected to chemical treatment, consisting of effective separation of water-insoluble particles. Waste water prepared here is than directed to 3 phase separator where the

appropriate system of fine bubble aeration is employed; the mentioned system facilitates effective separation of the pre-treated wastewater from floating and bottom sludges. It should be stressed that the application of fine-bubble flotation with the respectively selected size of bubbles of floating gas ensures greater contact surface. It makes more effective adsorption of solid particles and, in consequence, the effective treatment of contaminated water and recovery of the pre-treated liquid for its further processing. Purpose of the discussed process is to separate three phases: floating particles sludge, bottom sludge and pre-treated liquid. It is worthy to mention that it is a key question for the effective treatment of waste water and recovery of the partially treated liquid for further treatment according to the suggested method.

The separated materials both the bottom and floating one, are removed from the separator unit with the use of removing systems and then, they are subjected to dehydration using specially designed dehydration equipment. The obtained effluent is again directed to the chemical treatment stage. The pre-treated liquid in 3-phase separator is subjected to microfiltration at the level of 0.2 μm, eliminating the particles of contamination below this size. It should be stressed that in spite of the fact that the degree of liquid purity does not allow discharge of such effluent to the ground waters, it gives the liquid optimal quality suitable for its re-use in the washing of foil flakes or for the supplementation of the system. The level of microfiltration has been selected as a result of economical analysis.

When a necessity of more accurate pre-treatment of the liquid arises, e.g. in order to discharge it to the sewer system or even to enable its discharge to the ground waters, there is a possibility of increasing the degree of filtration.

In the context of satisfying the standards of discharge to sewage system, especially elimination of chlorides, sodium and other salts, it is suggested to employ nanofiltration. It should be however mentioned that decision on the choice of microfiltration was not accidental due to the possibility of the reclaimed liquid reusal retentate what is consistent with the aim to increase the effectiveness of installation. Nanofiltration allows the separation of most pollutants, but may lead to the creation of a concentrate stream that is difficult to recycle and constitutes another technical and economic challenge. In practice, one reasonable solution includes subjecting the concentrate to vitrification, i.e. melting in plasma arc. PFTechnology has already commenced the studies in this respect.

The installation was designed and constructed in modular system, on the frame, in three linked segments (Fig. 2). Such solution assumes a complete mobility, easiness of connecting and launching at the customer's site. The idea of the above mentioned construction, facilitates an easy of access and eventual exchange of components, this installation solution was created during the conducted research, aiming at the choice of the optimal configuration of the equipment.

Modular system constructed in this way allows conducting of full-scale, long-lasting tests at the customers who wish to improve the effectiveness of work in their plants.

Analysis of operating work of the installation

Studies conducted between 2020 to 2023 allowed PFTechnology to determine the effectiveness of pretreatment in relation to multi-stage degree of preliminary treatment of waste water coming from recycling plant. Significantly, there was observed a very high correlation between the type and degree of contamination of the processed waste/input material in the recycling plant and the degree of contamination of raw waste water at the entrance to installation. The contaminated waste water derived

Tab. 1. Selected results of analysis performed with minimal doses of coagulants and flocculants

	Analyzed sewage	Tested parameter				
		pH	Total suspended solids (TSS)		COD	
			[mg/l]	Percentage reduction [%]	[mg/l]	Percentage reduction [%]
Sample 1 from recycling of clean industrial film	**Raw waste water**	7,7	207,6	-	262,3	-
	After phase separator	6,9	79,3	61,8	153,3	41,6
	After membrane filtration	7,2	22,7	89,1	54,8	64,3
Sample 2 from processed film, transparent	**Raw waste water**	6,9	811	-	1329	-
	After phase separator	6,8	180,7	77,7	218,3	83,6
	After membrane filtration	6,8	25,67	96,8	41,3	81,1
Sample 3 from processed film, mix	**Raw waste water**	7,6	1170	-	961,0	-
	After phase separator	7,4	284,4	75,7	326	88,5
	After membrane filtration	7,3	21,6	98,2	63,5	80,5
Sample 4 of highly soiled agricultural film	**Raw waste water**	7,8	3200	-	919	-
	After phase separator	7,3	240	92,5	276	70,0
	After membrane filtration	7,4	27,6	99,0	76,1	72,4

Photo 1. Comparison of effluent samples – raw effluent (left) and effluent after phase separator (right)

Photo 2. Comparison of effluent samples – effluent after membrane filtration (left) and effluent after phase separator (right)

from washing of the foil flakes of agricultural origin was most demanding in respect of the conducted process.

In respect to evaluation of effectiveness of the treatment process, the samples of the raw waste water from the main stream, the effluents pre-treated in 3-phase separator and after membrane filtration, were collected. The results of the tests are given in Table 1 and are referred to the waste, coming from processing of different batches of films. Analyses of the results were concentrated on specific parameters with stress on the level of total suspension which is a significant indicator of the quality of treatment process. Comparison of the samples enabled assessment of the effectiveness of preliminary treatment of raw effluent with a high variation and supplied information on the effectiveness of the whole treatment system.

As far as the content of total suspended solids (TSS) is concerned, it was possible to reach maximum ca. 90% reduction after passage via 3-phase separator. Additional microfiltration allowed cleaning the liquid and obtaining reduction equal to ca. 99% in relation to the raw effluents. Reaching such high reduction is however not economically justified as it would result in more frequent necessity of membrane replacement. To ensure the long durability of membranes, we should not treat the liquid with the TTS content higher than 300 mg/l because it may contribute to their fouling. Additionally filtrated liquid must be absolutely deprived of substances, containing oils, greases or other fats.

The discussed installation has also the task of limiting the generation of waste. To this end, the isolated sludge particles: bottom and floating ones were tested in aspect of dry matter content at the exit from dehydrating presses. It should be mentioned that the mass properties of the floating particles are similar to mass of the liquid what was a quite big challenge which was reached after the application of the appropriate dehydration process. The mean results of the dry matter content, as obtained during the tests were equal to 18.33% for bottom sludge cake and 33.31% for the floating sludge cake (Table 2). The above measurements confirm the effective work of dehydrating equipment and supply the important data on the reduction of the mass of the generated sludges, having a direct effect on the reduction of the mass of resulting waste.

Tab. 2. The results of the measurements of dry matter content in sludges

No. of sample	Percentage dry matter content in tested sample	
	Bottom sludge cake	Floating sludge cake
1	20,58%	30,62%
2	15,15%	32,77%
3	19,25%	36,53%
Mean	18,33%	33,31%

Photo 3. Floating particles in the phase separator

Photo 4. Dewatered sludge

Summing up

Recycling of polymer plastics is the indispensable process nowadays, what, in turn, generates the necessity of seeking of effective solutions to protect the environmental resources and reduction of expensive methods of its implementation. The solution submitted by PFTechnology connected with the preliminary treatment of the effluents and their reuse in a form of technological water in the industrial processes enables a considerable reduction of operating costs of recycling plants, with the preservation of the principle of sustainable development. Reduction of above mentioned cost is directly connected with the reduction in consumption of fresh water in the process of washing foil flakes and with the decrease of the amount of waste, mainly in a form of the separated dehydrated sediments.

During the long-lasting tests, we observed an additional, very positive application effect of the discussed installation, and namely, the elimination of unwanted odours resulting from the effluents generated during processing of foil flakes of different origin. In it's studies, PFTechnology confirmed the possibility of complete removal of the above mentioned odours. Currently PFTechnology is conducting test and studies with application of such solution in real life.

The application of the discussed innovative technology, developed by PFTechnology, will enable the effective solution of many problems, existing now in many enterprises from the plastics recycling sector.

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