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THE IMPACT OF PLASTIC RECYCLING ON CLIMATE CHANGE

DOI: 10.5937/PIM25109K

Abstract:
Mechanical plastic recycling is one of the methods of possible re-using plastic waste, which contributes to the reduction of greenhouse gas emissions, as well as to the reduction of climate change and global warming. Mechanical recycling can be performed on all types of thermoplastics, while in this paper will be analyzed the extrusion process of polypropylene waste. The paper will analyze the impact of mechanical recycling of black jumbo polypropylene bags on air pollution. There will be presented the results of total organic carbon emissions measurement during the process of extrusion of the mentioned material. The fumes from extrusion process are sent to an exhaust gas purification system consisting of a scrubber, air dryer, electrostatic filter and activated carbon filter. After the air purification system, the obtained measurement results are below the permitted limit values, which complies with the legal regulations in the field of environmental protection.

Keywords: *Plastic, Recycling, Air quality, Total organic carbon emissions*

Introduction

The production of plastic products from natural materials is based on large emissions of carbon dioxide that lead to global warming. The increasing use of plastic materials has led to the deposition of a huge amount of plastic waste. Reducing plastic waste is one of the priorities at the global level [1,2].

Plastic recycling contributes to the reduction of greenhouse gas emissions, as well as to the reduction of climate change and global warming. Despite these advantages, the percentage of plastic recycling at the global level is low. According to The Organisation for Economic

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Co-operation and Development (OECD) Global Plastics Outlook Database 2022, just 9% of the world's plastic is recycled.

The main problems, for not recycling enough plastic, are the properties of the material and the cost of recycled products compared to non-recycled products. Plastic recycling requires continuous large amounts of plastic, consumption of electricity, generation of waste water that must be purified and disposal of the residue from the plastic washing process, as well as maintenance of the exhaust gas purification system.

1. Mechanical plastic recycling

According to the ISO 15270:2008 (Plastics — Guidelines for the recovery and recycling of plastics waste) standard, the recovery of plastic materials is divided into two classes:

1. Recovery of materials (mechanical recycling, chemical recycling, and biological or organic recycling);
2. Energy recovery in the form of heat, steam or electricity production using plastic waste as a substitute for the primary resource of fossil fuels.

Mechanical recycling is the processing of plastic waste into secondary raw materials or products without significantly changing the chemical structure of the material [3]. It includes the following steps: collection, sorting, grinding, washing, drying, additional separation and extrusion of thermoplastics that are not contaminated. Thermoplastics such as polyethylene (PE) and polypropylene (PP) are suitable for mechanical recycling due to their wide use and their physical characteristics [4].

Contamination poses a significant challenge to plastic recycling, as impurities and non-recyclable materials reduce the quality and marketability of recycled plastics [5]. Contaminants such as food residues, grease, and incompatible plastics can compromise the integrity of recycled materials, leading to performance issues and safety concerns in downstream applications. Contamination also affects the efficiency of recycling processes, as it requires additional sorting, cleaning, and processing steps to remove impurities and ensure product quality. However, these additional steps increase energy consumption, water usage, and greenhouse gas emissions, offsetting some of the environmental benefits of recycling [6].

There is a huge consumption of water because of the dirty on plastic waste which has to be removed. So, the next problem is water purification which also makes additional cost and increases the price of recycled material.

The effectiveness of recycling efforts varies depending on factors such as collection rates, sorting efficiency, market demand for recycled materials, and technological advancements [7]. High collection rates and efficient sorting systems increase the quantity and quality of recycled plastics, improving the economic viability of recycling and reducing reliance on virgin materials. Comparing the environmental impacts of plastic recycling with primary production involves assessing factors such as energy consumption, resource depletion, greenhouse gas emissions, and pollution [8]. While recycling conserves energy and reduces greenhouse gas emissions compared to primary production, it still consumes resources and generates waste. The recycling process also generates emissions of gases pollutants to air [6,9].

2. Atmospheric emission from mechanical plastic recycling

In this paper will be analyze the emission of Total Organic Carbon (TOC) from a standard plant for mechanical plastic recycling. The capacity of the line for extruding PP jumbo bags is 500 kg/h. Waste bags are of industrial origin. The measurements were taken in June of 2024.

The exhaust air from the process of plastic extrusion is going throw the purification system before it is emitted to the atmosphere. It consists of: water scrubber system, dryer, electrostatic precipitator and activated carbon filter.

Weather conditions: air temperature t=27.4 ^{o}C, relative air humidity Rv=66.4%, air pressure P=1001 mbar.

Three measurements of the emission of gaseous substances (organic substances expressed as total carbon - TOC) were performed under operating conditions at the highest load of the stationary source of pollution before and after the air purification system. The measurement and analysis of the emission of organic gaseous substances was carried out according to the national standard SRPS EN 12619:2019 and RU.03. Testing of technological parameters, flow rate and volume flow was performed according to SRPS EN ISO 16911-1:2019, RU.07 and RU.15.

Following devices were used for the emission analysis:

- Portable analyzer for measuring total hydrocarbons, with flame-ionization detector "TESTA" FID 2010T
- Digital thermometer with external probe "TESTO" 925
- Digital anemometer "TESTO" 510i.

In the following text will be presented the obtained measurement results.

Table 1: *Measurement results of exhaust air*

No.	***Parameter***	***Unit***	***Measured values ± measurement uncertainty***		
			I measurement	*II measurement*	*III measurement*
1.	Medium speed air flow	m/s	3.4±0.1	3.6±0.1	3.5±0.1
2.	Exhaust air flow	m^3/h	4,712±71	4,990±75	4,851±73
3.	Exhaust air flow under standard conditions	m^3/h	3,990	4,221	4,102
4.	Exhaust gas temperature	°C	26.5±0,1	26.8±0,1	26.9±0.1

Table 2: *Measurement results for concentration of TOC before air purification system*

No.	***Concentration***	***Unit***	***Measured values ± measurement uncertainty***			***Emission limit value***
			I measurement	*II measurement*	*III measurement*	
1.	TOC	mg/m^3	71.50±4.74	61.66±4.62	35.33±4.38	/

Table 3: *Measurement results for concentration of TOC after air purification system*

No.	***Concentration***	***Unit***	***Measured values ± measurement uncertainty***			***Emission limit value***
			I measurement	*II measurement*	*III measurement*	
1.	TOC	mg/m^3	35.20±4.38	24.30±4.32	27.41±4.33	50

After the air purification system, the obtained measurement results are below the permitted limit values, which complies with the legal regulations in the field of environmental protection.

3. Discusions

To achive maximum of the plastic recycling there need to be some improving in collection and sorting system at first. This meens that more efficient sorting must be improved at the source itself. People could separate different types of plastic at there homes. Also, they can clean there bottles or packaging before thex throw them into the garbage. This will help to prevent the contamination of the waste plastic. But, this is not possible in industrial plastic waste. The biggest problem of industrial waste are impurities.

Improving collection systems, sorting processes, and material recovery facilities can increase recycling rates and reduce contamination [10]. Education of the population as well as financial benefits are tools that can contribute to a more efficient recycling system.

Public awareness and education initiatives are essential for changing attitudes, behaviors, and consumption patterns related to plastic use and disposal [6].

Improving the recycling of waste plastic materials from industrial activities can be done by setting targets, standards, and incentives in legal regulations [11].

4. Conclusion

In conclusion, currently plastic recycling is not economically justified compared to the price of recycled raw materials. It also consumes electricity, creates high consumption of water and generates waste from dirty plastic. From the process of mechanical plastic recycling gaseous pollutants are emitted in the air. Every plant with this kind of technological process needs exhaus air purification system which makes the technology more expensive.

Therefore, it is necessary to look at all benefits and costs of a plant in order it would be economically profitable.

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