Extrusion Process for Recycling of Plastics

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Abstract: Applications with existing machineryto boost the percentage recycling of plastics with an introduction to extrusion process integrated with controlling system, Use of extrusion system to recycle different types of plastics at different temperature and need for recycling and problems encountered while recyclinghave been discussed. Advancements in science and technology, effective plastic recycling and advanced ways of manufacturing pavement tiles for the need to fulfill the societal expectations and to provide them better waste management has let to these developments.With invent and help of these methods to recycle shows better performance output and increased durability of pavement tiles.

Keywords: Extrusion, Plastic Recyling, Plastic Extrusion, Plastic Pavement Tiles.

INTRODUCTION

Manufacturing is a process of giving required shape to raw material, such that it can fulfill the geometric requirements of a part which is assigned to a task. There are different manufacturing processes, which are basically carried out based on shape required and type of raw material. Manufacturing processes can be classified into Molding, Machining, Joining, Forming & Shearing and Additive machining.

Extrusion manufacturing process is one of the sub classifications of Forming & Shearing. It found its existence during England industrial revolution: was invented by Joseph Bramah in 1797 and this process was basically called as squirting during that period. This process can be defined as heating material to its molten stage and then pushing it against the die such that it obtains the shape of the die as it cools. Extrude means the machine to push or force out the material through an opening to get product as the extrudate. We can use different materials as extrudate like metals, concrete, polymers, modeling clay, ceramics and foodstuffs.

Extrusion can be classified as hot extrusion and cold extrusion. In hot extrusion, materials are melted to its molten stage or recrystallization temperature such that without any much effort material can be pushed against die. Whereas, in cold extrusion is carried out where material is kept under room temperature itself. Materials like aluminum, brass, copper, lead, tin, magnesium, zinc, steel, titanium and plastics are extruded using extrusion process. Extrusion process is also used in pharmaceutical and food and processing industries.

Plastics are recycled majorly using extrusion or injection moulding. In extrusion, molten material acquires shape of a die. Whereas in injection moulding material is injected in mould and material takes up shape of mould. Extrusion process is preferred for recycling because it is more economical and direct scrap cannot be used in injection moulding. Usually first extrusion process is taken to produce beeds which are later fed to injection moulding.

In extrusion, thermoplastics are melted to their molten stage and then forced against the die. There are different types of thermoplastics based on its density and its monomer's composition. These different plastic polymers have different melting temperatures which need to be maintained during recycling through extrusion process. These temperatures can be achieved and maintained using a controlling system. Controlling system must consist of temperature sensors and PID controllers.

Due to high generation of plastic waste there are several problems arising in the environment, that is not only harming the environment but also to the living organisms. Its non-biodegradable property exaggerates the situation and even burning of this waste causes high levels of air pollution. Most of the plastic waste that are generated on the land moves to the marine system. This causes several problems like flooding and poisoning of the water and adversely effecting marine life.

Best way of controlling pollution is to eliminate this waste at its initial dumping site itself. Way to eliminate is recycling, pavement tiles are the products which can be easily obtained by recycling. Pavements need to be constantly built and requires high maintenance. Hence, these tiles tend to have better properties and working life.

A. Need of Plastics:

Bakelite was first synthetic plastic which was invented, by Leo Baekeland in 1907. Many other plastics were invented still date which has multiple applications. It has derived its name because of its excellent plasticity nature. Their properties like high strength to weight ratio, durability, weather resistance, malleability, bacterial resistance and low cost has made one of most desirable substance among industries. Whether it is medical, packaging or aerospace industry, synthetic plastics have important role to play. Even in India's Mars orbiter plastics were excessively used. Hence, urbanization and changing of human lifeneed for plastic is excessively growing and it is difficult to find an alternate [1].

B. Need for Recycling:

Usually when we consider metals it is very costly to extract from ores and purify them, hence recycling is easily opted. Whereas in plastics, segregation of waste is difficult and time consuming. And net difference in cost of new plastic and recycled plastic is less, hence recycling of plastics is only 9% of plastics and remaining is land filled or dumped into oceans [2].

There are two types of plastics viz. thermoplastic and thermosetting plastic. Municipal solid waste (MSW) has observed an increase in solid waste in causing a widespread littering on landscape, in which 78% of total plastic waste consists of poly-olefins which is mainly a thermoplastic. Thermoplastics are cheaper and can be easily molded and it posses wide market globally. Increase in the rate of consumption these plastics causes water pollution which is a subject of threat to the environment due to its non-biodegradable property. Therefore it causes in adverse effects to our biosphere [3],[4].

C. Types of plastics in waste:

There are different plastics available in craps which were used based on its properties and composition [5].

i. Polyethylene terephthalene(PET):- It is Commonly known as polyester and used for synthetic fibers and bottles. It has meting temperature of 260^{O}C. It has resin ID code as 1, recognized by Plastics Industry Association. Resin ID codes makes segregation of plastic waste easier.

ii. High-Density Polyethylene (HDPE):- It is used in pipes and has melting temperature of 130.8^{O} C.Its resin ID code is 2.

iii. Polyvinyl Chloride (PVC):- Its is used construction pipes and wire insulators. It has melting temperature of 240^{O}C. Its resin ID code is 3.

iv. Low-Density Polyethylene (LDPE):- It is used in polythene carry bags and packing foams. It has melting temperature of 90^{O} C. Its resin ID code is 4.

v. Polypropylene (PP):- It is used in medical or laboratory equipments. It has melting point of 160^{O} C. Its resin ID code is 5.

vi. Polystyrene (PS):- It is thermocoal, which is used in packing industries. It has melting temperature of 240^{O} C. Its resin ID code is 6.

vii. Polycaprolactone (PLC):- It is used in 3D printed elements and has melting temperature of 60^{O}C. Its resin ID code is 7, it is classified under other section.

Resin Identification Number	Resin	Resin Identification Code –Option A	Resin Identification Code –Option B
1	Poly(ethylene terephthalate)	1 PETE	01 PET
2	High density polyethylene	2 HDPE	02 PE-HD
3	Poly(vinyl chloride)	3 V	03 PVC
4	Low density polyethylene	4 LDPE	04 PE-LD
5	Polypropylene	5 PP	05 PP
6	Polystyrene	6 PS	06 PS
7	Other resins	7 OTHER	07 O

D. Problems in Recycling:

Recycling of plastic waste is a major problem, this is because the plastic waste collected contains combination of plastics like hard plastic, plastic film and PVC plastics which need to be sorted, but it also contains potential impurities like non-plastic materials, coloured plastics and multi-polymer products. For Example, simple blown plastic bottles are made up of three different materials viz: (a)Polyethylene Terephthalate (PET), from which a bottle body is manufactured, (b)High Density Polyethylene(HDPE), using which a bottle cap is manufactured, (c)Low Density Polyethylene(LDPE), from which a label is manufactured. Not all plastics can be recycled the recycling potential was found to be 59% for plastic films, 52% for hard plastics and 79% for PVC waste [6].

The properties that classify the different types of plastic waste like hard plastic, plastic film and PVC waste are based on the characteristics present in it like colour, polymer, expected life-time, type of product, quality of product, product application. The plastic film waste is recycled and it takes the form of agglomerates. It is used for furniture, sandboxes, and fences. The PVC waste is divided as soft PVC and rigid PVC, but among these PVC waste soft PVC waste cannot be recycled because it contains high content of phthalates, so it has been land filled

E. Method of Plastic Recyling:

The best method available for plastic recycling is the mechanical form of recycling. In this type of recycling the waste plastic is grinded, washed and re-melted as in the case of extrusion moulding process. Almost all types of polymers are immiscible and it gets affected by the process of degradation that occurs during usage of mechanical recycling and manufacturing processes.In order to determine the type of polymer infrared spectroscopy process is employed [7].

Pavement Tiles using Sand

Waste generation has become a key issue that has existed in the human life from long ago. To overcome from this problem many countries has developed many waste management systems some of the waste generation takes places from the following like ex industries, hospitals etc. from among these waste some are biodegradable substance and some are non-biodegradable substance. Globally from each year around 300 million tons of plastics are produced. Only 9%-12% of the plastic are recycled which produced in the year between 1950's to 2018. Between these years around 6 billion tons of plastic has been generated. Remaining 79% of the plastic are left untreated due to high utilization of plastic in various fields such as medical and public health application there is rapid annual production of plastic in the world [8],[9].

Many solutions was proposed to manage the plastic waste some of them are using paper or cloth bag, minimizing the use of plastic wrapped products. But these methods yielded limited results, hence to boost recycling plastic composite pavement blocks were produced. However road construction from plastic waste is not new. If the plastic waste is converted into pavement blocks it has many advantages they are, by using plastic pavement blocks for road construction, capital cost and maintenance cost can be reduced. Plastic has the better resistance to the rain water like it does not absorb rain water and directs it to drains [10].

For manufacturing thepavement blocks they use raw materials such as pit sand, sea sand and combine it with plastic to form a perfect composite. Following process like thermoplastic and thermosetting plastic are separated and then plastic waste are washed, cleaned and dried. Next the plastic waste is torn or grinded into small pieces and then plastic flakes are mixed with pit sand and sea sand and poured in a hopper of extrusion moulding machine. Extrusion machine is controlled using a controller system to achieve specific temperature based on the proportion of different plastics waste consists ofplastic waste melts and acts as a binding material for sand and whole heated mixture is pushed by extruder and a mould of required shape is held at its outlet to collect the mixture. Composite mixture is allowed to cool down [11].

Pavement Tiles using fly-ash

The product obtained by disposing plastic waste is paver tiles which is produced for the societal use. These tiles posses better mechanical strength, it can resist strong acids, bases and organic solvents, very low flammability level [12]. Since plastics are non-degradable it is quite difficult to dispose using traditional technologies. By-product of coal obtained after combustion carried out in thermal power plants called fly-ash is also difficult to dispose. This fly-ash also causes air pollution and respiratory problems because of its finite size. These problems can be overcomed by performing twin screw extrusion moulding using a waste plastic matrix reinforcing with fly-ash, which results in increase in the tensile strength upto 9.68 MPa and reduction in flammability with linear burning of 4.36 mm/minute [13].

Plastics being highly flammable need to be added with lesser flammable fillers to improve this property. Fly-ash which is highly flame retarding filler material is accompanied to plastics such that it creates a protective surface above the plastic tiles.

For the manufacturing of these pavement blocks following processes need to be followed. Firstly, preprocessing of plastics waste and fly-ash need to be carried out. Thermosetting plastic are separated and then plastic waste are washed, cleaned and dried. Fly-ash is powered and impurities are removed. Later, mixture of both in proper proposition is fed to extrusion machine through hopper. Output from extruder is drawn in form of long filaments and is cut into small pieces. These cut filaments are kept in required tile mould and fed into oven, where composite get melted and it attains the shape of mould. These tiles on cooling can be further treated with triphenylphosphate(TPP) which also acts as a flame retardant, where it also reduces the rate of plastic burning by creating a synergetic effect and can resists different chemicals [14].

Pavement Tiles using Bitumen

Bitumen is one of the by-products of crude oil extracted after distillation process. It acts as binding material and has very good water resisting properties. It is semisolid in room temperature and acts as highly viscoelastic fluid above 100^{O} C. It has very good adhesion properties and provides stability to roads against vehicle's friction.

Pavement tiles can be made more flexible and with increased strength and service life by modifying bitumen binder with plastic waste. Waste plastics are freely available, whereas bitumen needed to be extracted from crude oil. Therefore using plastic reduces dependence on bitumen.

Manufacturing process of tiles includes following process, cleaning of plastics and preheating of bitumen is carried out initially and later fed extruder using hopper. In extruder plastic gets melted and mixed with bitumen [15]. Mixture output is collected and allowed to cool. Later this mixture is melted again and reinforced to matrix of sand and stones. Whole composite is collected in tile mould and it is hydraulic pressed to get perfectly bind tiles [16].

RESULTS AND DISCUSSION

Thereafter, we have discussed extrusion and plastic recycling processes. We have made study on current scenario of plastic recycling and the need to increase the recycling rate. Hereafter, we have compared the different types of plastics found in waste, after the comparison we found the need of controlling system to achieve different temperatures to melt these plastics. We also found extrusion to be simplest and easiest methods to recycle plastics. Multiple functions can be performed using a extrusion machine itself, by pre-processing and post-processing of products. By reinforcing plastics to different matrix materials, a much better composite pavement tiles can be manufactured. Hence, by further processing of waste plastics we can achieve much better products at negligible price and indirectly benefiting the environment [17], [18].

CONCLUSIONS

Recycling of plastics is more complicated but much needed to for betterment of our environment, it must be made much simpler and profitable. In this paper, we have discussed the important points for recycling and few examples which have limited processing but maximum benefits.

• Still, need to explore the new applications for waste plastics, rather than converting it back to second grade plastics.

• Products manufactured need to be simple and profitable.

ACKNOWLEDGMENT

The manuscript is prepared under the guidance of our Professor Dr. K S Ravi, We are thankful to him. We are thankful to our college "Vidyavardhaka College of Engineering" for providing us all the equipments. We also express our gratitude to our professors of Mechanical Department for guiding us throughout the work.

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