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Research article

Energy Recovery from end-of-life tyres through an alternative to thermochemical process: A short review

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Abstract

End-of-Life Tyres (ELT) being generated worldwide is increasingly on the rise. Humanity has only limited number of environmentally sustainable options for safe disposal, material and energy recovery from ELT which make matters worse. An end-of-life tyre is a used tyre that cannot be put to reuse for its originally intended purpose and is not retreaded. Such tyres may have a further use as a raw material for other processes or ordained for final disposal. New research in the field of thermochemical treatments, directed towards energy and products recovery provide a very promising alternative to open space disposal or landfilling, achieving in the process, reduction of hazardous waste and potential contamination to soil and water resources. New research should be directed in this direction and investigate efficient and environmentally attractive processes for used tyres valorisation with energy and material recovery. In this review, a short summary of the recent advances in the field is given as well as areas of possible research.

Keywords: End of life tyres (ELT); Pyrolysis; Energy recovery; Material recovery; Landfill; Monofill; Thermochemical treatments

1. Introduction

The tyre is a complex and high-tech safety product representing continuous innovation in manufacturing. From a materials point of view, the tyre is a mixture of synthetic and natural rubber, steel and textile to which a range of specific substances such as mineral oil, reinforcing fillers and vulcanising agents are added to act as catalysts.

Approximately 80% of the weight of car tyres and three fourths of truck tyres is rubber compound. The compositions of tyres produced by different manufacturers are reported to be similar. Tyres contain a total of approximately 1.5% by weight of hazardous waste compounds listed in Annex 1 of the Basel Convention.[1]

Discarded stockpiles promote mosquitos development, which are vectors of diseases. Stockpiles and solitary tyre fires are hazards; which are not only difficult to extinguish, they contaminate surface and sub-surface water, air and soil. Leaching problems occur because of heavy metals and other compounds added to rubber. There is also visual impact on landscape as whole tyres occupy a large space of the landfill, decreasing landfill life cycle and that whole tyres have the tendency to migrate to the top of the landfills, breaking protection layers and increasing the instability of the sites. Tyres (shredded or whole) are non-biodegradable material; heavy metal leachates contaminate ground water.

End-of-life tyres are currently landfilled, stockpiled or used as silage cover in the agricultural industry. Appropriate management may include material & energy recovery, use for engineering purposes, storage or concluding disposal of end-of-life tyres in specially created monofills, or above ground storage where land owners bank on a subsequent increase in the economic value of end-of-life tyres.[2] Factors to be addressed in developing appropriate management practices include management of leachate associated with engineering activities, ensure that storage and disposal facilities are designed to ensure that environmental risks such as fire and leachate generation are eliminated or managed.[3] It is important that the design of storage facilities and monofills should also ensure that the potential for deterioration is minimised, if not eliminated and that the tyres can be retrieved relatively easily when, and, or if their value as a recoverable resource increases.

The problem of end-of-life tyres management affects not only the environmental protection but even the maintenance of resources, since problems related to the depletion of resources, energy demand and waste management, are directly connected and required an integrated approach.[4]

2. Energy Recovery

ELTs can be a low-cost source of fuel when located near a prominent fuel consumer. They can also be readily processed for a diverse range of infrastructure development projects. Substituting ELTs in place of new raw materials reduces associated environmental and economic costs, such as commercially viable exploration and mining for fossil fuels and other virgin raw materials, the associated land-use impact and Tyre derived fuel (TDF), as one of the leading options for ELTs, which are mainly used in cement kilns, but also in fuel intensive industries such as thermal power stations, pulp and paper mills, steel mills and industrial boilers as supplementary fuel.[5] Tyres have a high energy content and are an equal or better source of energy than many other solid fuels. This, alongside rising energy costs and increased environmental awareness in recent years, has led to an increase in use of TDF.

An alternative solution class for the thermal treatment of tyres is pyrolysis which is the thermal degradation of the tyre in an inert atmosphere. Pyrolysis of the tyres has been established for many years but is currently receiving renewed attention. Pyrolysis produces oil, char and gas products, all of which have the potential for use.[6] The products of ELTs pyrolysis are lumped into four categories, namely aromatics, liquids, char and gases.[7]

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[6] Karagiannidis, Avraam, and Themistoklis Kasampalis. "Resource recovery from end-of-life tyres in Greece: a field survey, state-of-art and trends." Waste Management & Research (2009).

[7] Al-Salema, S. M. "Kinetics and Product Distribution of End of Life Tyres (ELTs) Pyrolysis: A Novel Approach in Polyisoprene and SBR Thermal Cracking." Journal of Hazardous Materials 172.2-3 (2009): 1690-694. Web.

In this context, thermal treatment of end of life tyres could play an important role for the recovery of resources (matter and/or energy). During past several years, fundamental and applied studies showed that if carefully controlled, tyre pyrolysis can produce a number of valuable products.

The recovery of oil has a high calorific value. Increasingly, it is being used as a fuel, chemical feedstock or can be added to petroleum refinery feedstocks.[8] The char is used as a solid fuel, or can be upgraded for use as activated carbon or carbon black. The derived gas has a sufficiently high calorific value to provide the energy requirements for the pyrolysis process. Also, the steel reinforcement can be easily separated from the friable char and recycled back into the steel industry.[9]

New research in energy recovery indicates that Tyre Derived Fuel (TDF) can be used successfully as a supplementary fuel in properly designed fuel combustors with good combustion control and add-on particulate controls, such as electrostatic precipitators, or fabric filters.[10] Similarly material recovery is being used for civil engineering and general engineering applications. The process of complex processing of rubber waste through material and energy recovery in the specific conditions of the country has a very significant environmental benefit. It is an energetically interesting material, and its process is very friendly to the environment.[11]

Other innovative uses for ELTs are emerging as more research and development is carried out in this area. Steelworks equipped with electric arc furnaces provide an almost closed loop recycling possibility for ELTs. The method involves applying a quantity of scrap metal into an electric arc furnace, followed by a quantity of tyres (shredded or whole), to convert carbon monoxide gas to carbon dioxide in the furnace. New research in the area of Devulcanization (the process of breaking down and recycling rubber) methods include thermal, mechanical, ultrasound and biological treatment as a potential way of generating materials from end-of-life tyres.[12]

3. Analysis

Recent research in the field of energy recovery from ELTs has led to modest use in energy and material recovery applications, establishing it as an alternative to virgin raw materials.

New research in the field should concentrate on the positive environmental impacts of using ELTs as a resource, mostly derived from the accompanying reduction in virgin resource exploitation. Using ELT material in some products can also improve the properties of that end product.

Various efforts currently being pursued in many countries where different legal systems exist, need to be accelerated to reduce the number of tyres in landfills and waste piles and to find innovative, environmentally friendly uses for ELTs.

Another avenue for research is by way of tyre manufacturer programs which can play a key role in the development of ELT markets, as do government regulations, business norms, and standards. ELTs should be considered as a resource and not labeled as a waste. The involvement of tyre companies, ELT management companies, scientific laboratories, government regulators and industrial partners is necessary in research and development programs to find new, effective and environmentally sound uses for ELTs.

From the perspective of industrial ecology, further research should be directed into the way tyres are designed to facilitate recycling when they are discarded, like the prevention stage in waste hierarchy for end-of-life tyres.

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