VIBRO-ACOUSTIC PRODUCTS FROM RE-CYCLED RAW MATERIALS USING A COLD EXTRUSION PROCESS

SUBTITLE

A continuous cold extrusion process has been developed to tailor a porous structure from polymeric waste, so that the final material posses particular vibro-acoustic properties.

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Chapter 1

Developing Acoustic Materials from Polymeric Waste and the Manufacturing Issues

1.1 Introduction

There are a limited number of technical solutions for the efficient recycling of polymeric waste on a large scale, because chemically cross-linked polymers used are one of the most difficult materials to recycle. In the United Kingdom alone, there are approximately 48,000 tonnes of used tyres disposed each year and 80 million tons of post manufactured carpet waste, of which only a small fraction about 5% of the waste is recycled, whilst the vast majority ends up in the landfills according to waste resources action plan (Wrap). The resistance of nylon fibres and rubbers to biodegradation are factors which suggest that the rational use of these materials requires rapid and effective remedial measures to be taken. A survey of the literature reveals that much of the research to date in the polymeric waste recycling refers to a wide range of chemical processes to recycle the waste by breaking the polymers into monomers (Muzzy et al. 2005). Alternative methods based on the consolidation of granulated polymeric waste have been developed to produce materials with acoustic properties equal or better than those available commercially (Rushforth et al. 2006). Acoustic performance of reconstituted granulated waste is not an inherent property, but depends upon numerous factors, including particle size distribution, ratio of grains to fibres, and the type of adhesive used to consolidate the particles.

Blending of recycled polymeric granulates is a promising approach for developing new families of acoustic absorbers and impact damping materials. The batch process involves mixing the granular waste with a controlled amount of binder followed by the moulding process. The issues with the batch process are that it involves hard manual duties and its discontinuous nature. For continuous processing on an industrial scale a novel process has to be developed to consolidate and structure granular and fibrous particles to produce new porous composites with unique combination of pore geometry and size distribution that will give them enhanced vibro-acoustic and thermal insulation performance.

The ability to model processes such as extrusion operations has increased dramatically in recent years (Burbige et al. 1995). These investigations pave the way for scaling-up from multi-phase batch processes to a continuous process. Especially noteworthy is the ability to program the screw geometry (Wang et al. 1996) to obtain a desired residence time distribution as well as the capability of predicting mixing efficiency of various element combinations. To make the whole process of recycling more efficient, useful models exist like the model developed by Haque et al. (2000) which captures the complex plastic recycling and land filling scenarios making the whole process of recycling and land filling more efficient.

1.2 Aim and Objectives of the study

The aim of this research was to develop a continuous process for producing porous media with the desired vibro-acoustic and thermal insulation properties.

Objectives included:

i. Reviewing existing porous material markets and manufacturing methods
ii. Developing a new manufacturing method
iii. Using the developed process to produce materials from a range of recycled waste
iv. Measuring and predicting the acoustical properties of the developed products
v. Using the obtained results to improve the quality of the production process
vi. Comparing the acoustical and non-acoustical properties of the developed products against that typical for existing commercial products

The new process must consolidate and structure granular and fibrous particles from a range of plastic, rubber and textile waste into new vibro-acoustic composites with unique combination of pore geometry and size distribution that will give enhanced environmental noise, thermal insulation and vibrational control performance. The newly developed materials will be required to possess the desired physical properties and good acoustic performance competitive with top commercial products. This research not only answers the urgent call to find alternative to landfill and low-impact recycling, it offers a clean, continuous and energy-efficient technology that re-uses waste profitably and in applications that enhance the quality of life by shielding us against environmental noise (with an estimated annual damage in the EU of 38 billion EUR, BEAT 2007) . The technolgy developed must have a low carbon footprint and enable finer tuning of particles, fibre and binder structure, crucial to high noise control, thermal insulation and impact sound insulation performance.

The acoustical behaviour of the products made will be studied based around several parameters such as pore size distribution, porosity, tortuosity, flow resistivity and dynamic stiffness. The new family of these generic poro-elastic materials will have a very low manufacturing cost. The new process will need to be a continuous, low energy consuming process that re-uses waste plastic and rubber materials that are otherwise dumped in landfills at an increasing cost both to the economy and the environment.

1.3 Structure of this thesis

This thesis is organised as follows. In Chapter 2, a literature survey is carried out and explores sound propagation through acoustic materials. Also the tailoring of acoustic materials from waste is discussed. Finally the cold extrusion process is considered for extruding polymeric blends. In Chapter 3, the material manufacturing process is explained. In Chapter 4, acoustical properties of porous media and characterisation methods are explained. In Chapter 5, experimental results are presented of the extruded materials. The materials produced using the cold extrusion process are characterised using acoustic and non-acoustic techniques. The extruded materials are modelled and the results discussed. Chapter 6 provides auxiliary properties of the developed porous products. Chapter 7 provides conclusions from the results obtained along with suggested further work.