Overview Recycling Technology for Plastics

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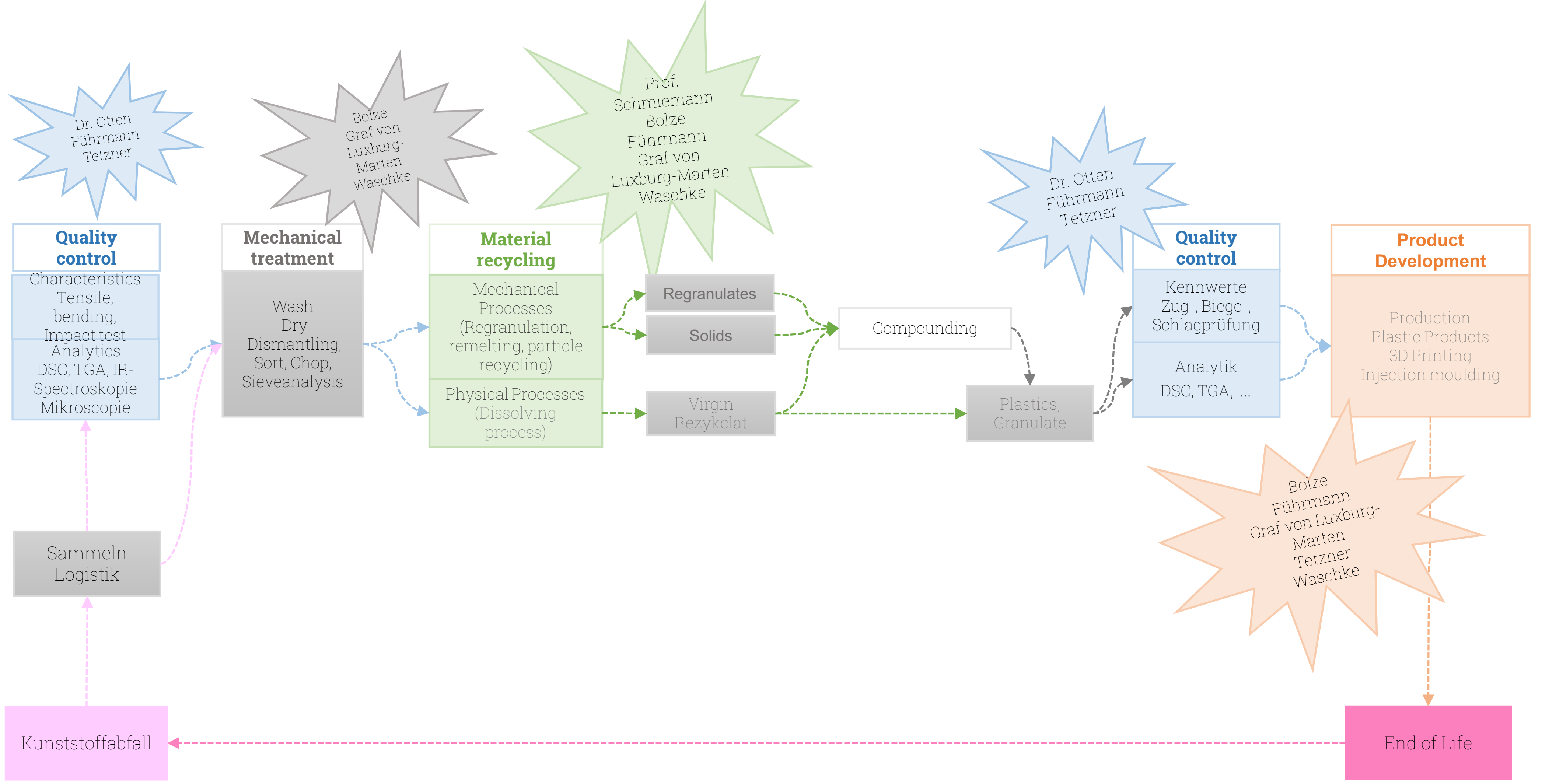

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REVFIN

Plastic Waste

Plastic Waste

- „Post-Production“-Waste
- „Post-Industrial“-Waste
- „Post-Consumer“-Waste
- Landfills and waste disposal sites

„Post-Production“-Waste

Waste generated at various stages of production

- Raw material extraction and processing
- Raw material production and material production (domestic scrap)
- Semi-finished product production (new scrap)
- Component and final production

„Post-Industrial“-Waste

Waste from, among other things

- Product distribution and marketing (e.g. transport packaging)
- The construction of buildings/installations etc. (e.g. construction site waste)

„Post-Consumer"-Waste

Waste from the categories

- End-of-life products (EoL)
- Buildings/installations after end of use etc. (e.g. building rubble)
- Product packaging (sales packaging)

Examples „Post-Consumer"-Waste

Disposable packaging:

- Plastic bottles for drinks such as bottled water, soft drinks or sports drinks. Plastic bags for single-use shopping. Packaging films for food such as sweets, cheese or meat.

Examples „Post-Consumer"-Waste

Food containers and packaging:

» Plastic containers for ready meals, yoghurt, butter or margarine. Disposable plastic crockery such as plates, bowls, cutlery and drinking straws.

Examples „Post-Consumer"-Waste

Cosmetics and care products:

» Plastic bottles and containers for shampoos, shower gels, lotions or cleaning products. Plastic packaging for cosmetic products such as lipsticks, mascara or nail varnish.

Examples „Post-Consumer“-Waste

Electronics:

- Plastic housings for electronic devices such as mobile phones, computers, televisions and household appliances. Disposable battery casings and electronic packaging made of plastic.

The challenge of post-consumer waste

Post-consumer waste:

- Is a significant environmental problem Much of it ends up in landfills or in the environment It damages ecosystems and Affects the quality of life

The challenge of post-consumer waste

- To reduce post-consumer waste and minimise environmental impact, measures such as recycling, reuse, composting and the promotion of more environmentally friendly alternatives are needed.

The challenge of post-consumer waste

- By governments, businesses and consumers working together, we can jointly develop solutions to close the loop on plastic waste and create a more sustainable future.

Landfills and waste dumps

- Landfills for mixed waste
- Mono landfills and interim storage facilities
- Waste dumps from mining, metallurgy and others

Landfills and waste dumps

- The disposal of plastic waste in landfills and dumps poses a significant environmental problem.
- Plastics are often difficult to degrade and can take decades or even centuries to decompose.
- When plastics end up in landfills and landfill sites, they can have various negative effects.

Negative effects

Soil and groundwater pollution:

- Plastics can release pollutants when they decompose in the soil, and these can leach into groundwater and affect the quality of drinking water.

Air pollution:

- The incineration of plastic waste in landfills and dumps can release toxic gases and particles that can worsen air quality and cause health problems.

Negative effects

Ecosystem damage:

- Animals can mistake plastic waste for food and swallow it, which can lead to injury, suffocation or death. Plastics can also destroy habitats and impair biodiversity.
- Aesthetic impairments:
- Plastic waste in landfills and dumps can spoil landscapes and detract from the attractiveness of areas, which can have a negative impact on tourism and the local economy.

Collect - Logistics

Collecting methods

» Local collection (e.g. from households)

» Regional collection (e.g. from companies)

» Centralised collection (e.g. from industrial areas)

» Container systems Take-back systems (e.g. deposit systems)

The challenge of collecting

Contamination

» Separation of different types of plastic

» Infrastructure at local, regional and central level

» Educating and sensitising the public

Logistics: Transport

- Local transport (from collection centres to interim storage facilities)
- Regional transport (between different collection centres and sorting plants)
- Centralised transport (from large industrial areas to recycling plants)
- Route planning taking into account local, regional and centralised needs
- Warehouse management at various locations

Logistics processes

- Material flow optimisation at local, regional and central level
- Use of technologies to improve logistics, such as IoT and data analysis
- Traceability of plastic waste along the entire supply chain

Technological innovation

- Automation in sorting at regional and centralised level
- Improvements in packaging technology for more efficient transport and storage

Legal framework conditions and guidelines

- EU directives on waste management and their implementation at local, regional and national level
- National laws and regulations in the area of waste management
- Certifications and standards for sustainable waste management

Quality control
Part I

Qualitätssicherung Teil I

- Important analytical methods in quality assurance are differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), infrared spectroscopy (IR spectrometry) and microscopy. These techniques play a crucial role in characterising materials and ensuring their quality in various sectors such as the plastics industry.

Differential Scanning Calorimetry (DSC)

- DSC is an analytical method used to determine the thermal properties of materials. By measuring heat or energy flows within a material as a function of temperature changes, important information about phase transitions, melting points, glass transitions and reaction enthalpies can be obtained. In quality assurance, DSC is often used to check the purity of substances, the stability of products and the identification of impurities.

Thermogravimetric analysis (TGA)

» TGA is a method used to determine the composition of materials and their thermal behaviour. It measures the change in weight of a material as a function of temperature or time while it is subjected to a controlled increase in temperature. This technique is useful for the identification of constituents in a sample, the study of decomposition processes and the determination of moisture content and thermal stability.

Infrared spectroscopy (IR spectrometry)

» IR spectrometry is a powerful analytical method for identifying molecules based on their characteristic absorption patterns in the infrared range of the electromagnetic spectrum. By measuring the absorption of infrared radiation by a sample, functional groups and structural features can be identified. In quality assurance, IR spectrometry is used to determine the chemical composition of materials, recognise impurities and check conformity with specifications.

Microscopy

- Microscopy includes a variety of techniques for analysing materials at the microscopic level. These include light microscopy, electron microscopy and others. These techniques can be used to analyse the surface morphology, structure, composition and other properties of materials at the sub-microscopic level. In quality assurance, microscopic methods are used to identify defects, assess surface properties and verify compliance with specifications.

Application and importance

- These analytical methods play a vital role in quality assurance in a wide range of industries including pharmaceuticals, chemicals, food, electronics and plastics. They enable the precise characterisation of the composition, structure and properties of materials and ensure that they meet safety, efficacy and performance requirements.

Mechanical treatment

Mechanical treatment

- Mechanical processing of plastic waste includes a variety of processes for sorting, shredding, cleaning and recycling plastics.
- These processes are critical to efficiently converting plastic waste into reusable raw materials, thereby reducing the environmental impact of plastic waste.

Mechanical treatment

- Sorting (optical, manual)
- Crushing (shredding, granulating)
- Cleaning (washing, screening, air separation)
- Drying
- Sieve analysis

Sorting

Optical sorting:

» Modern optical sorting systems use sensors such as infrared or near-infrared spectroscopy to identify plastic waste by material type, colour and even specific types of plastic.

» These systems provide accurate and efficient sorting of plastic waste and are particularly useful for large waste streams.

Sorting

Manual sorting:

- Manual sorting may be necessary, especially for complex waste streams containing different types of plastics.
- The plastic waste is manually sorted by material type, colour and other characteristics to produce high quality recycling streams.e waste streams.

Shredding

Shredding:

- Shredders shred plastic waste into smaller pieces, increasing the surface area and making it easier to process.
- Depending on the requirements, different types of shredders can be used, including single or multi-shaft shredders and different types of grinders.

Shredding

- Granulation: Granulators are used to turn shredded plastic waste into uniform pieces.
- These can then be used to make new plastic products or as a raw material for other industrial applications.

Cleaning

Washing:

- Washing systems are used to remove contaminants such as dust, dirt, labels and food residues from plastic waste.
- Water, detergents and mechanical movement are used to prepare the plastic for recycling.

Cleaning

Screening:

- Screening systems separate large contaminants such as stones or metal parts from the plastic waste.
- This is done by passing the waste through screens of different mesh sizes, which retain the contaminants.

Cleaning

Air separation:

- This technology uses streams of air to separate light contaminants, such as paper or plastic film pieces, from heavier plastics.
- Targeted streams of air separate the light contaminants while the plastics continue to be transported.

Drying

Drying:

- Drying of plastics is an essential stage in plastics processing and manufacturing.
- Drying is very important in plastics processing and manufacturing as it improves the quality of the final product, increases processing efficiency and minimises production losses due to moisture.

Sieve analysis

Screen analysis:

- Sieve analysis is an essential tool in the development of sustainable recycling solutions.
- By accurately characterising particle size distribution, companies can develop more efficient recycling processes and produce high quality recycled plastic products.

Mechanical treatment: examples

PET bottle recycling:

- PET bottles are collected and roughly sorted to separate different types of plastic.
- Labels, caps and contaminants are then removed from the bottles by shredding, washing and drying.
- The PET is then granulated and made into new PET bottles or other products.

Mechanical treatment: examples

Plastic film recycling:

» Plastic film is collected and subjected to optical sorting to identify different types of film.

» After shredding, the films are washed and cleaned of impurities.

» The cleaned material is dried and processed into granules, which are then used to make new film or other products.

Material Recycling

Material recycling

Definition

» Material recycling is the process of reusing materials by returning them to the production process to make new products.

» Unlike energy recycling, which involves burning waste to generate energy, material recycling aims to maintain or improve the physical properties of materials.

Material recycling: Importance

Conservation of resources:

- Recycling materials conserves natural resources and reduces environmental impact.
- Waste reduction: Reusing materials reduces the amount of waste that has to be landfilled or burned.
- Economic benefits: Recycling materials can help reduce the cost of raw materials and create new revenue streams through the sale of recycled materials.

Material recycling

Mechanical processes

- Regranulation
- Remelting (extrusion)
- Particle recycling

Physical processes

- Dissolving processes

Regranulation

Regranulation

- is the process of converting plastic waste into granules or pellets.
- After compounding, these regranulates are fed back into the production process to make new plastic products.

The regranulation process

Shredding:

- First, the plastic waste is shredded into smaller pieces to reduce its size and make it easier to process.
- This can be done by cutting, crushing or shredding.

The regranulation process

Cleaning:

- The shredded plastics are thoroughly cleaned to remove impurities such as labels, adhesives or foreign materials.
- This can be done by washing, sieving or air separation.

The regranulation process

Melting and granulating:

» The cleaned plastic pieces are then heated and melted.

» They are then extruded through a die and moulded into granules or pellets.

» These pellets can then be cooled and collected to produce recycled plastic pellets that can be used to make new products.

Mechanical process: remelting

» Remelting, also known as extrusion, is another common mechanical process in plastics recycling in which plastic waste is heated and moulded into new shapes.

Remelting process (extrusion)

Preparation:

» The plastic waste is first collected and sorted. They can be in the form of pellets, flakes or other forms.

Heating:

» The plastic waste is heated in an extruder to melt it. This achieves a uniform temperature and consistency.

Remelting process (extrusion)

Moulding:

- After the melting process, the molten plastic is extruded through a nozzle. This allows the plastic to be moulded according to the requirements of the end product.

Cooling and curing:

- The moulded plastics are cooled to stabilise them and maintain their shape. They can then be cut or further processed to produce the end produc

Compounding process

- Compounding is an important process step in plastics processing that aims to mix plastics with various additives and fillers in order to modify or improve the properties of the final material.
- This process is often used to produce customised plastic mixtures that meet specific requirements such as strength, hardness, colour, UV stability, flame retardancy, thermal conductivity and much more.

Advantages of compounding

Quality improvement:

» Recycled plastics can be blended with additives and fillers to improve their mechanical, thermal and chemical properties and adapt them to the requirements of different applications.

Advantages of compounding

Increased reuse:

» It allows recycled plastics to be used in new products, encouraging reuse and helping to reduce landfill waste and pollution.

Advantages of compounding

- Economic benefits: By recycling and compounding plastics, companies can save costs as recycled materials are often cheaper than virgin materials, while reducing dependence on non-renewable resources.

Mechanical process: Particle recycling

- Particle recycling is the process of shredding plastic waste into fine particles or powders that can be reused as fillers, additives or raw materials in various applications.
- This mechanical process of plastics recycling allows plastic waste to be processed efficiently and produces recycled plastics that can be used to make new products.

Particle Recycling Proces

Shredding:

» The plastic waste is reduced to small particles or powder. This can be done by grinding, shredding or other mechanical processes.

Sorting and cleaning:

» The shredded plastic particles are checked for impurities and foreign materials and cleaned if necessary.

Use as an additive:

» The cleaned plastic particles can then be reused as fillers, additives or raw materials in various applications. This can include the manufacture of plastic products, construction materials or other materials.

Physical processes

- The dissolution process for plastics is a physical process in which plastics are dissolved in a solvent in order to separate or shred them.
- Overall, the physical dissolution process for plastics is an important method in the recycling process that allows plastics to be separated, purified and returned to their original raw materials.

Sequence of a dissolution process

Selection of the solvent:

» The first and most important step is to select a suitable solvent capable of effectively dissolving the plastic to be dissolved.

» The choice of solvent depends on the type of plastic and the desired results.

» Different plastics have different chemical compositions and therefore require different solvents.

Sequence of a dissolution process

Preparation of plastics:

- The plastics to be treated are first brought into a suitable shape to aid the dissolving process.
- This may involve crushing or cutting the plastic into smaller pieces or particles to increase the surface area and facilitate contact with the solvent.

Sequence of a dissolution process

Exposure to the solvent:

» The prepared plastics are then exposed to the chosen solvent.

» The solvent penetrates the polymer structure and causes the polymer chains to separate.

» This allows the plastic to be dissolved or separated.

Sequence of a dissolution process

Separation or cleaning:

- Once the dissolution process is complete, various methods can be used to separate the dissolved plastic from the solvent.
- This may include filtration, distillation, extraction or other separation processes.
- The dissolved plastic can then be extracted from the solvent and further processed.
- The result is virgin recyclate.

Benefits of the dissolution process

Selective separation:

» The dissolution process allows selective separation of different plastics due to their different solubilities in different solvents.

Cleaning:

» The dissolving process can also be used to clean plastics from impurities or foreign materials.

Raw material recovery:

» The dissolving process can be used to break plastics down into their starting monomers or other chemical compounds, allowing raw materials to be recovered and reused.

The challenge of the solution process

Solvent selection:

» Choosing the right solvent can be challenging and requires careful consideration of factors such as solubility, environmental impact and cost effectiveness.

Energy and cost intensity:

» The dissolution process can be energy- and cost-intensive, especially when treating large volumes of plastic or when complex separation processes are required.

Characteristic
Part II

Characteristic Part II

- A fundamental aspect of quality assurance is the determination of tensile, flexural and impact strength tests.
- These test methods are critical in assessing the structural reliability of materials and ensuring that they meet the requirements and specifications for their intended use.

Tensile testing

- Tensile testing is one of the most basic and widely used mechanical tests to determine the strength of materials under tension. In this method, a specimen is subjected to a tensile load which causes it to deform along its longitudinal axis and eventually break.
- The main parameters measured in a tensile test are tensile strength, elongation and elastic limit.

Flexure test

- The flexure test, also known as the bending test, is used to determine the bending strength and stiffness of materials.
- A specimen is loaded in a specific manner to produce a bending stress.
- This test is particularly important for materials used in applications where they are subjected to bending loads, such as structural elements in buildings or components in mechanical systems.

Impact testing

- Impact testing, also known as notched bar impact testing, is an important method of assessing the ability of a material to withstand impact loads without failure.
- In this method, a specimen is subjected to a sudden shock or impact to determine its response to rapid, impact-like loading.
- Parameters measured include the energy required to destroy the specimen and the type of fracture behaviour.

Applications

- Plastics are used in a wide range of industries, from automotive and packaging to electronics and medicine.
- Quality assurance of plastics is therefore essential to ensure that they meet requirements for strength, durability and safety.
- These tests enable manufacturers to ensure that their products meet the required standards and meet the needs of their respective applications.
- A sound understanding of these test methods is therefore essential for quality assurance of plastics.

Product Development

Product development

- Product development from regranulate is becoming increasingly important in various industries due to its ecological advantages and economic opportunities.
- The focus here is on two important manufacturing techniques, namely injection moulding of test specimens and 3D printing, using regranulate or filament as the starting material.
- The basic concepts, processes, applications and potentials are highlighted.

Injection moulding of test specimens from recycled pellets

Injection moulding technology:

» The basic principles of injection moulding are explained and the specific requirements for processing recycled pellets are discussed.

» The process steps from injection of the material to demoulding of the test specimens are described in detail.

Injection moulding of test specimens from recycled pellets

Material Selection and Preparation:

» This section covers the selection of suitable regrind types for injection moulding, the preparation and conditioning of the material, and the mixing ratio and additives for optimum results.

Injection moulding of test specimens from recycled pellets

Mould design and construction:

- Design aspects for recycled pellet test specimens are explained, including factors influencing shape and construction and consideration of material behaviour during injection moulding.

Injection moulding of test specimens from recycled pellets

Quality control and testing:

» Methods for quality control of injection moulded parts made from recycled pellets are presented, including mechanical testing methods and evaluation of results and process adjustments.

Injection Moulding Application Examples

Packaging materials:

» Plastic packaging for food, cosmetics, detergents and other consumer goods

Automotive:

» Various interior parts such as dashboards, door panels, handles and consoles

Injection Moulding Application Examples

Electronics industry:

» enclosures for electronic devices such as computers, tablets and mobile phones

Home appliances:

» Parts of household appliances such as washing machines, refrigerators and dishwashers

Medical devices:

» medical device components and consumables

3D printing with regrind

The basics of 3D printing:

» This section explains the different 3D printing processes, how they work and their applications, as well as the basics of 3D printing with regranulate or filament.

3D printing with regrind

Use of regranulate and filament in 3D printing:

- Discusses the challenges and opportunities of using regranulate in 3D printing, including material selection, preparation and process parameters.

3D printing with regrind

Process Optimisation and Quality Assurance:

» Strategies for optimising the 3D printing process for regranulate materials and methods for quality control of printed components are discussed.

Examples of 3D printing applications

Prototypes and models:

» Rapid prototypes and models can be produced cost-effectively, which is particularly beneficial in the product development and design process.

Custom components:

» Bespoke parts and components for a variety of applications, allowing great flexibility in production.

Decorative and design objects:

» Decorative objects, works of art and design objects, opening up creative possibilities for artists and designers.

Examples of 3D printing applications

Lightweight structures:

» Lightweight designs and structures that require high strength with low weight, resulting in material and energy savings.

Replacement and repair parts:

» Replacement and repair parts for a wide range of applications, improving parts availability and extending product life.

End of Life

- Used plastic products pose a serious challenge to the environment and require a coordinated and comprehensive response at local, national and global levels.
- By promoting recycling, developing environmentally friendly alternatives and raising public awareness, we can help reduce the environmental impact of plastic waste and create a more sustainable future.

End of Life