SOLUTIONS FOR SUSTAINABLE CYCLES

SUSTAINABILITY & CIRCULAR ECONOMY

CONTENT

I. CIRCULARITY OF PLASTICS

The elaboration and employment of innovative techniques and technologies is crucial to increasing resource efficiency, and thereby implementing a green, sustainable model for the global economy. The aim is to decouple economic growth from raw material consumption, reducing the overall use of raw materials. To this end, material cycles must be closed and optimised. Plastics and plastic composites (such as fibre-reinforced plastics) can make a significant contribution to increasing resource efficiency.

The recycling industry has established itself as an important supplier of raw materials, leading to a shift in popular perceptions from "waste disposal" to "producer", of high-quality secondary raw materials. However, only a comprehensive reorientation of the post-consumer handling of plastics, away from landfilling and incineration towards a quality-assured material cycle will make it possible to fulfil expected recycling quotas in the medium-to-long term.

More and more, producers from various sectors are voluntarily committing to working with the materials and supply industry to increase the exploitation of recycled materials in the production process, expanding the markets for recyclates. The factors of limited availability of virgin materials, and high cost pressure in production, also provide a significant boost to the viability of secondary plastics. High-quality secondary raw materials, being more cost-effective than virgin materials, therefore offer considerable favourable opportunities for market launch.

The ecological advantage of reintegrating wastestuffs, whether industrial or commercial, into the economic cycle as a source of raw materials is undisputed. Maintaining this advantage requires the continuous development of methodological and technological expertise for the reprocessing of plastics into high-quality, reproducible recyclates, with ecological and economical processing technologies. In order to realise this claim, we are intensively involved in research and development in the field of separation technology and plastics recycling. Our technology-oriented company can claim more than 30 years of specialisation in the technologies of density-selective separation and composite-separation for technical plastics.

Existing plastics from long-life products are available for recycling through logistics and collection systems. While it is the task of politics to determine the goals of sustainable development, and to enforce these goals through laws and regulations, science and industry are now called upon to develop methods and establish plant capacities with which these goals can be realised in practice.

The progress in legislation necessitates urgent action, in the interests of society, towards innovative recycling routes and mass flow technologies. However, the increase in composite plastic materials means that the development of plastic recycling processes still runs up against technological limits. It is therefore of strategic importance for our company to work towards efficiently overcoming these limits.

The state of separation technology is defined by the quality of the recycled material (recyclate). While in the early years of plastic recycling, the view was held that the quality of the recyclate should be measured against the virgin material, many years of practical experience have now altered that opinion such that recyclates should be understood as an entirely new category of material. This means in practice that new physical-mechanical test methods should be developed and used in their classification. The quality of the recyclate is thus characterised by its technical application properties.

As plastic recycling technology develops further, the risk grows that expectations placed upon methodologies for sorting, separating, processing, and application processes will become ever more limited to specific products, specific waste-flows, specific plastics, and the hope for universally applicable technologies and solutions in plastic recycling will dwindle. Thus far, the extensive return of plastic materials into the economic cycle from long-life products has been hindered by the lack of process engineering solutions for separating and purifying plastics from mixed fractions.

II. TECHNOLOGY & PROCESS DEVELOPMENT

Some manufacturers already implement take-back, reuse, recycling, and recovery policies for their products. With this in mind, the efficient separation of components from multi-material mixtures takes on paramount importance. Predominantly, the question of separation of these materials by type considers only material flows without the complication of plastic composites. Despite some promising work on recycling-friendly design over the last 20 years, there has also been an opposing trend towards the increased use of composite materials. This further widens the existing gap between the conditions of primary production, and the knowledge and methodological expertise required to return essential components to the economic cycle. With a few exceptions, plastic composites are currently not suitable for recycling. Strategies need to be developed to strengthen the sustainable management of these materials.

None of the automatic sorting methods commonly investigated worldwide, such as MIR, NIR, Raman-spectroscopy, pyrolysis, *etc.*, fulfil the spectrum of requirements for identification and sorting of plastics from long-life products. The great number of different types and grades of plastics offer a significant hindrance to this process. Furthermore, real waste mixtures typically contain a considerable amount and variety of foreign materials and impurities, such as metals, elastomers, foams, fibres, and more, which cause problems in identification and sorting. Even when the plastic materials can be identified with 100 % accuracy, the resulting sorted fractions can still contain composites (paper labels, adhesives, metal connections, *etc*.).

In practice, density sorting processes (float-sink separation, centrifugal separation) have become uniquely established as the only effective method for the production of high-quality recyclates. The state of the art in separation media allows for separation of materials with a density of up to 1.1 g/cm³. We are the only company in the world with expertise in the separation of plastics with a density of greater than 1.1 g/cm³, up to above 1.2 g/cm³. To date, there is no other process enabling such a high degree of product purity as can be achieved with our density separation process.

Our developments are primarily aimed at the market segment of high-purity, quality-tested, reproducible secondary plastics for reuse in injection moulding and extrusion processes. The new secondary plastic must be economically viable for the intended additional processing, and process development must be based on these boundary conditions. Our aim in developing further research projects is to broaden the range of plastics as secondary raw materials, and thereby make new, recycled products available to the market. This goal encompasses the entirety of the processes, process controls, and production techniques required to obtain the secondary plastics. The primary prerequisite for the development of branded products is the measurable reproducibility of the technical application requirements, and the material composition of the recyclate, in order to control the individual treatment processes (collecting, sorting, separating, regranulating, reprocessing).

This requirement for reproducibility and quality standards is independent of the value of the end product, whatever the intended end-use of the material (whether general-purpose or highly specialised). Alongside the standard of high-quality recycling, so-called "downcycling" can be considered an equally valid alternative. The method which is selected is determined by the nature of the input flow, and the resulting apparatus and process technology directed to achieve an appropriate, and most importantly reproducible, quality of the recycled plastics.

The objective and the novelty value of development projects consists of targeting the isolation of selected plastic composites (plastic mixtures from complex waste streams) or of composite separation, including the separation and washing cycles; and in the development of appropriate analytical methods for the identification, quantitative and qualitative analysis of composite plastics, for composite digestion and for determining the purity of the plastics.

As a result, the new process must be tested on a semi-industrial scale and allow a new product (in the form of a new secondary raw material) to be produced economically after an optimisation, investment and market launch phase. In terms of materials, the focus falls primarily on the recycling of technical plastics such as ABS and PC.

III. METHODOLOGICAL KNOW-HOW

The density fraction analysis (DFA) developed by founder Dr Ingeborg Pagenkopf is currently the only method on the market for qualitative and quantitative composition analysis of plastic mixtures. DFA, which is flexible enough to cope with the issues of large-scale processes (inhomogeneous distributions of components, extreme impurities), and accurate enough to determine material structures and their separability in waste, provides us with a method for analysing and evaluating waste streams that meets the latest requirements for reproducibility, diversity and efficacy.

We use density fraction analysis for real-time analysis of processes, for the technological control of the processing and utilisation of plastic mixtures, for the qualitative and quantitative determination of the composition of material streams of the same provenance, and for the evaluation of the separability of plastic mixtures and the efficiency of separation processes.

Plastic mixtures of different types or species are generally not recyclable. The principal questions to be asked when developing recycling processes are:

- Is the plastic mixture separable?
- Which physicochemical properties best allow an optimal identification and differentiation in the separation process?
- What purity of plastic product is feasible?
- What yield of product is attainable?
- Is (are) the separated plastic product(s) suitable for reintroduction into the production process?

Each material is characterised by, among other properties, its density. This parameter ensures a reproducible categorisation, and serves as the starting point for the method we have developed to separate plastic mixtures into their individual components, and to definitively distinguish and separate fused products, filled or reinforced plastics from unmodified materials.

Utilising our DFA method, it is possible to record the density range of plastic mixtures to a resolution of up to 0.001 g/cm³, generating density spectra with a high resolution and good reproducibility. Quantitative evaluation using DFA allows the prediction of mass balances of plastic separation processes.. In this way, polymer types (even in some cases different polymer types within a given class) can be separated from each other. The selection and development of industrial-scale technology for any separation process is determined by the input, mass flows, and the requisite quality of the end product. The methodology of density fraction analysis offers the opportunity to examine the costs, benefits, resulting product properties and associated new markets and areas of application in advance of technology developments in the recycling sector, in order to find the most effective variant on a case-by-case basis. In recent decades, new plastic separation technologies and product developments for secondary plastics have been established based on this methodology.

IV. EFFICIENT CYCLE MANAGEMENT

The pressure to take up developments for new process stages stems from the growing volume of waste and the increasing complexity of its composition. The design of a specific separation process is ultimately dominated by both the nature of the input and the market conditions of the secondary products.

The products of the electronics, medical technology and automotive industries are characterised by ever shorter production cycles, based on constantly increasing research and development expenditure. Increasingly sophisticated and complex production techniques place higher demands on recyclers, and we have always adapted to these realities with our own process developments. Direct contact with manufacturers is absolutely essential to the effective return of separated and purified components into the production cycle, in order to maintain thorough and up-to-date knowledge of the production processes involved, especially as pertains to composite materials and their proportions in the products. In this way, significant added value is obtained in comparison with market launch in non-species-specific applications.

It is often overlooked that also for virgin plastic materials, different grades are employed as needed for different applications, and often, custom-designed polymers are developed for specific functions. Changeover from one type to another requires test phases, and adaptation of the processing technology. It is customary to categorise these goods with the labels “A” or “NT” (not typical). The same quality, meaning the same processability as a minimum requirement, is expected for recycled materials. The development of branded products from recyclates still requires considerable development.

For an industrialised country with a constantly increasing volume of waste technical plastics from numerous industrial markets and a well-developed recycling/waste management infrastructure, the results of innovative product cycles will also have an impact on the utilisation, expansion and structuring of industrial processing facilities for waste management of plastic mixtures. In creating and launching to market the technology for separation of plastic composites which were previously considered inaccessible for recycling, a unique and novel service capacity is offered in Germany. This will have the further benefits of a reduction in the volume of waste, improved conservation of resources, and a reduction of the burden on landfill sites.

As part of ongoing industrial research, innovative approaches are being developed, hand-in-hand with producers of plastic materials. Step by step, plastic composites from waste streams with varying degrees of complexity being made available. It is important to avoid the focussing of efforts onto narrow, partial solutions, or those which risk being quickly superseded by new developments. For this reason, gaining new insight into the requirements for process steps which are not yet practised in waste separation, both upstream and downstream, is of inestimable value. This, ultimately, will be what determines the economic viability of the overall process.

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