Plastic separation of automotive waste by superfast near-infrared sensors

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Abstract

Superfast near-infrared sensors for the fractionation of pure plastics from used automotives have been developed by LLA, utilised in a separation plant for shredded waste. The complete separation technology was developed in co-operation with the car producers DaimlerChrysler, Ford, and BMW, and with the plant builder Steremat.
The conventional recycling for used cars will be more and more difficult due to the increasing portion of plastics, which is expected to be 25% in the year 2005. The large variety of polymeric material, around 40 different types will commercially be used in automobiles, is an additional problem. The required purity cannot be achieved by manual dissection.
The new sensors are involved in a recycling technology, covering all processes from dismantling, shredding, chemical removal of lacquers, identification and mechanical separation up to reuse of separated plastics. Using two different near-infrared sensors the detection and identification of plastic material is performed by analysis of their characteristic spectra.
The two-step sorting technology starts with a sensor of high productivity of more than 1 ton/hour for the detection and sorting of bright and coloured polymers, as well as for black polypropylene. Subsequently, in the second step a *long-wavelength*-NIR sensor detects other black material like PC, PMMA, ABS, PC/ABS blends and others.

Introduction

The number of automobiles is constantly increasing, resulting in a higher number of cars to be recycled each year. Within the next ten years more than 100 million used cars are estimated for recycling only in Europe, world-wide a dramatic higher number is prognosticated. In parallel the classic recycling of old automotives will be inhibited by an increasing content of plastics, which is expected to be 25% in the year 2005.
The large variety of polymeric material, around 40 different types will commercially be used in automobiles, is an additional problem. In contrast with household waste, here polypropylene (PP) and polyethylene (PE) are dominating besides polystyrene (PS) and polyethylene terephthalate (PET), a larger variety of plastics is used in the automotive industry and no fraction dominates. Depending on the application polycarbonate (PC), acrylonitrile-butadiene-styrene (ABS), polyamide (PA), polyurethane (PUR), polyphenylene oxide (PPO), polybutylene terephthalate (PBT) and polymethyl methacrylate (PMMA) occur, too. Moreover, plastic blends like PC/ABS, plastics blacked by graphite or filled with additives complete the variety of used material.
The reuse of plastics is required not only for environmental but commercial reasons, too, because:

- resources for production of plastics, e.g. oil and gas are running short
- the use of recycled material is an profitable alternative
- incineration is not a real alternative and leads to contaminated residuals, to be stored on special landfill sites
- waste storage is limited.

New Separation Technology

LLA Instruments GmbH has developed superfast near-infrared sensors for the fractionation of pure plastics from used cars, used in a separation plant for shredded waste. The complete separation technology (Fig. 1) solving the initially described problems was developed in co-operation with the car producers DaimlerChrysler, Ford, BMW, and with the plant builder Steremat. It covers all processes from dismantling, shredding, chemical removal of lacquers, identification and mechanical separation up to reuse of separated plastics.

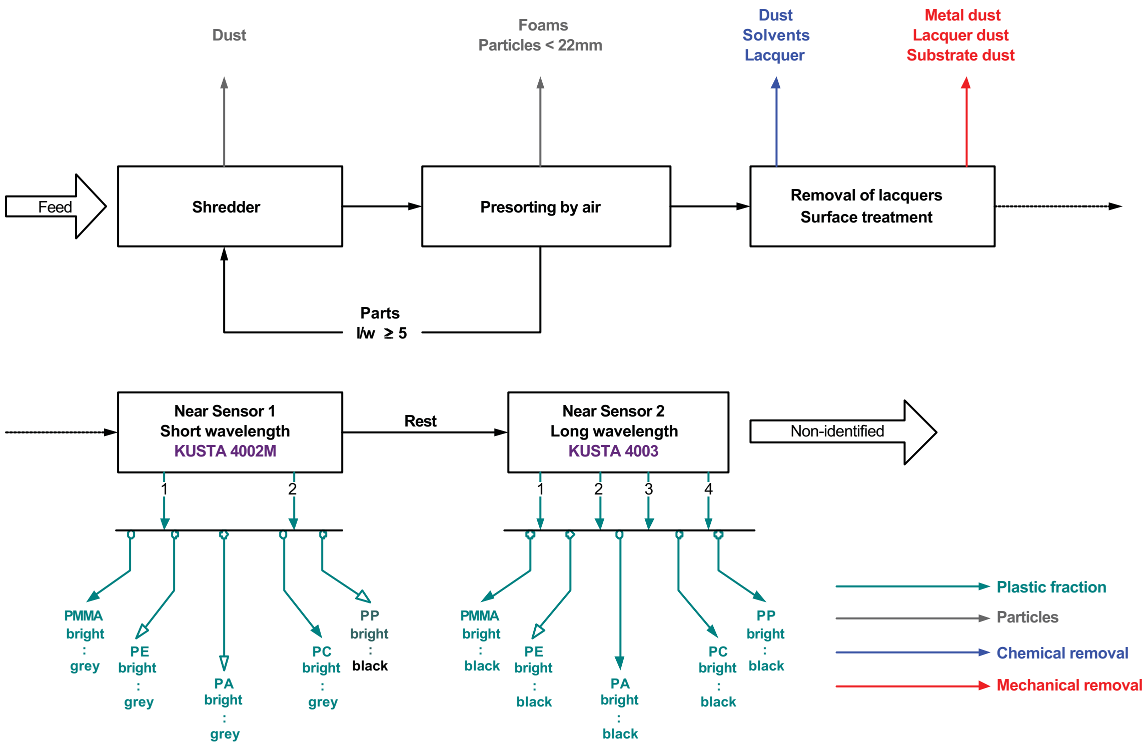


Fig.1: New Separation Technology for Plastics from Automotive Waste

The recycling of used cars starts with the manual dismantling of the car by removing plastic parts from the vehicle.

During the first step of the new technology the collected plastic material from used cars is shredded to a size between 30 mm x 30 mm up to 70 mm x 70 mm.

The mechanical pre-sorting using air in the second step has the aim to remove foams and particles smaller than 22 mm from the material flow. These foams, which consist mainly of polyurethane, and particles are not pneumatically ejectable after near-infrared (NIR) identification in the later process steps, because of their low weight resp. small size. Their early removal is required to avoid a disturbance of later sorting processes.

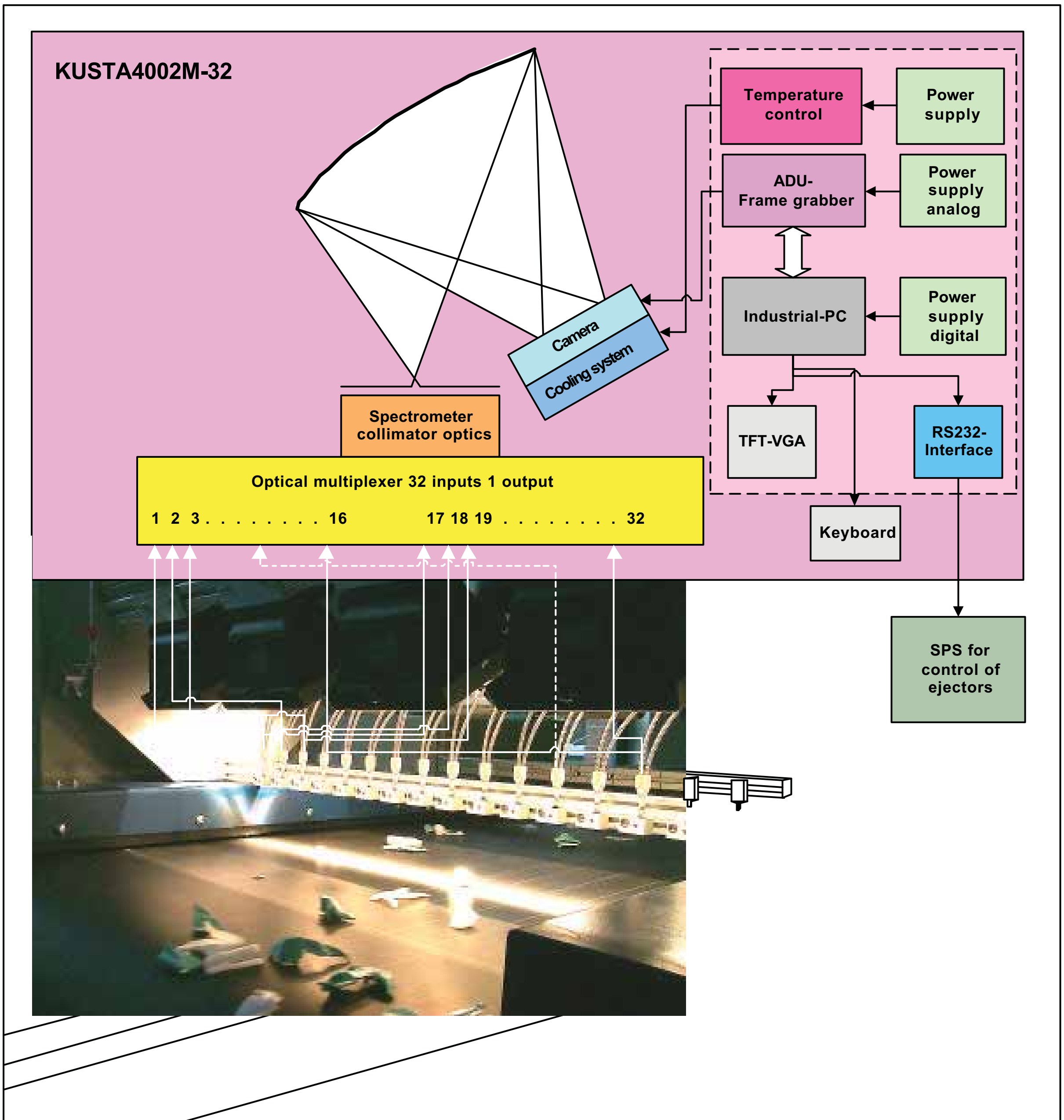
To prepare the remaining plastics for recognition by near-infrared sensors and later reuse the material passes the third process step. Here, the plastic samples typically coated on one side with a lacquer, depending on the car part where they are used, are treated chemically or mechanically. The lacquer layer is removed, all sides of the plastic have the same surface. The plastic part is now ready for identification by NIR, independent of the side facing the spectrometer. As additional effect the partial increasing of surface roughness has been achieved, suppressing disturbing reflectance from the polymer surface. An enhanced reliability of the identification is reached.

The heart of the technology is the consecutive arrangement of two different near-infrared sensors in steps 4 and 5 of the recycling process. By the combination of a common NIR-spectrometer with an optical multiplexer (KUSTA 4002M-32, Fig. 2) and a single recently developed NIR-spectrometer KUSTA 4003 (Fig. 4) the high-sophisticated sorting task occuring in car recycling is solved. Not only a large variety of polymers and blends are identified, but grey and black polymers are recognised, too, covering all parts from a used automotive.

At the first NIR-sensor KUSTA 4002M bright, colored and grey material is identified as well as black PP. Two fractions are sorted out, the desired type of polymer is free selectable from the choice of PA, PE, PP, PMMA and PC by simply pressing a switch. The remaining 3rd fraction (see Fig. 3) mainly consists of black parts, which now pass the second NIR-sensor KUSTA 4003. Here, black polymers are identified and 4 fractions are blown out to containers on the left and right side of the belt, only the non-identified fraction will be collected at the end of the conveyor belt.

KUSTA 4002M-32 (Fig. 2), consists of a near infrared spectrometer in combination with a 32-head optical multiplexer. This is a further development of the system KUSTA 4002M-16, widely used for the identification of plastics from household waste.

The spectrometer itself features a special designed holographic concave grating and an infrared linear detector array. In combination with a fibre optics the system is characterized by a very short measuring time, a high sensitivity and a high spectral resolution. The combination of one spectrometer with an optical multiplexer permits the use of 32 measuring heads covering the entire width of a conveyor belt (Fig. 3).



Measuring time per channel	approx. 470 µs
Measuring time per scan	1.11 ms
Measuring area	3 cm² (∅ 44 mm)
Measuring distance	100 mm

Fig.2: KUSTA 4002 M, near infrared spectrometer in combination with 32-head optical multiplexer

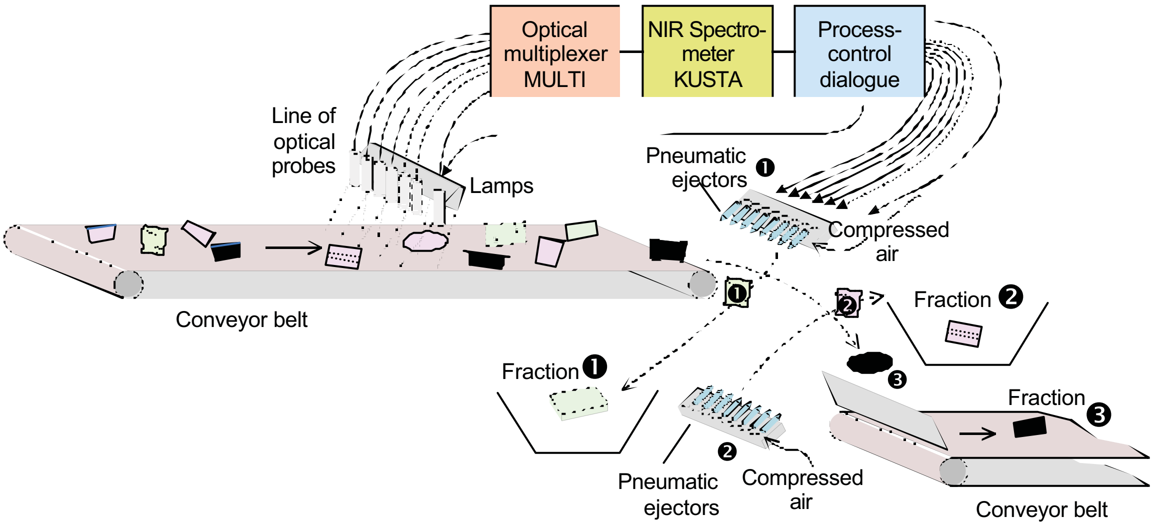
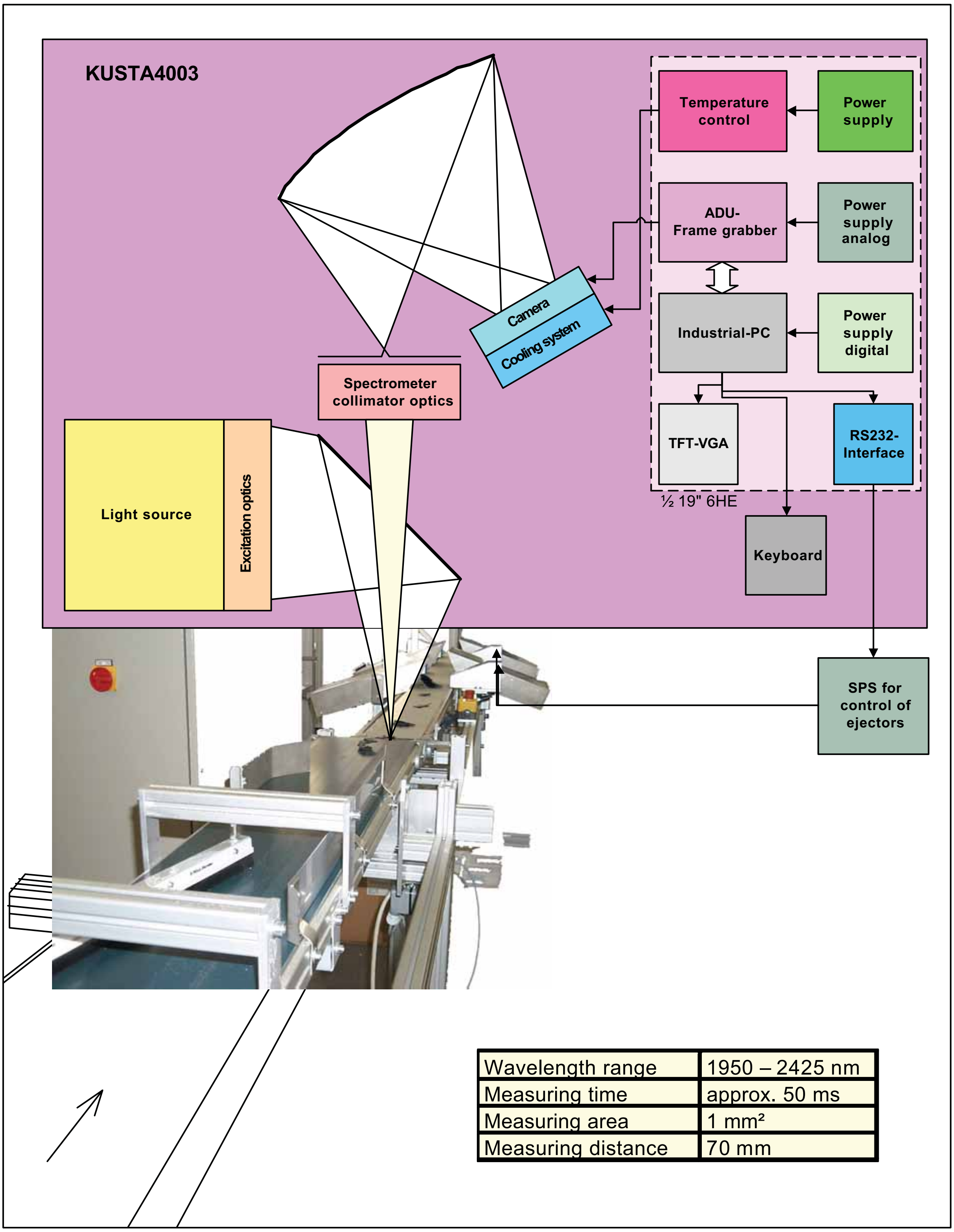


Fig.3: Principle of first sorting step by KUSTA 4002M-32 - fractions 1 and 2 are free selectable

While passing the illuminated area under the measuring heads with high speed the plastic bodies reflect light which is collected and spectrally analysed. Due to characteristics in NIR-absorption bands the plastic type is recognised and given as electronic code, containing also the information about the position on belt, to the process control, which is linked to pneumatic ejectors. A new arrangement of the pneumatic system permits the ejection of two different pure fractions besides the third fraction remaining in the sorting line. A productivity of more than 1 ton/hour is achieved.

Subsequently, the remaining mainly black plastics pass a long wavelength near-infrared sensor KUSTA 4003, shown in Fig. 4.



Wavelength range	1950 – 2425 nm
Measuring time	approx. 50 ms
Measuring area	1 mm²
Measuring distance	70 mm

Fig.4: KUSTA 4003, NIR-spectrometer for identification of black plastics

In contrast to the NIR spectrometer used in the first sorting step KUSTA 4003 is working at a higher wavelength range paying particular attention to the NIR-absorption bands of black polymers. The different optical arrangement in combination with an illumination unit of high intensity permits the identification of black samples despite of a low reflectance degree.

The above described sorting plant (Fig. 1) is installed in Zwickau, Germany, and run by a commercial company. The German automotive industry (DaimlerChrysler, Ford, BMW) use it for the plastic separation from automotive waste.

Acknowledgement:

This work is managed by the the German Aerospace Center DLR and funded by the Federal Ministry of Education and Research of Germany.