Compact System as One-Stop Solution

Reprocessing. The dry reprocessing of plastics enhances the cleaning performance with simultaneous minimization of the required energy input. A one-stop concept couples the cleaning and extrusion of the plastics, thereby utilizing the heat generated and so contributing to an optimization of the recycling process.

Dry cleaner with post-cleaning stage

GÜNTHER KLAMMER
HERBERT ANGLBERGER
STEPHAN WÜSCHT

Dry reprocessing plants **(Title photo)** for plastics have already been on the recycling market for several years and during this time have undergone steady improvements. They connect a dry cleaner to a conical co-rotating extruder. Both plant components are produced by the Maschinen- und Anlagenbau Schulz GmbH (M-A-S), Pucking, Austria, and are thus ideally matched to one another. The high profitability of the compact reprocessing plant is achieved on the one hand through the energy saving, and on the other hand through the high degree of cleaning. Agricultural stretch films of LDPE or HDPE, thin-walled blow moldings or cups, for example, can be reprocessed particularly efficiently to high-quality pellets for renewed film production or injection molding.

Translated from Kunststoffe 12/2010, pp. 128–130
Article as PDF-File at www.kunststoffe-international.com; Document Number: PE110592

After chopping of the feed material in the shredder (A, **Fig. 1**) and transfer to a buffer hopper, cleaning takes place in the dry cleaner (B). This is a two-stage process with a main cleaning and post-cleaning step using the proven frictional separation principle.

Thanks to its functional principle, the dry cleaning and reprocessing plant is suitable for all plastics with soiling that can be removed by means of friction, such as soil, sand or organic impurities. Dry cleaners are available with throughputs of up to 1,000 kg/h.

The functional principle of the dry cleaner developed by the MAS-Partner Ekuma GmbH in Pucking combines the drying and cleaning of the plastics in a single machine. The heart of the plant is the rotor. It transports the shredded feed material from the buffer hopper (1, **Fig. 1**) to the 1st cleaning stage (2) and at the same time creates a fluidized bed in which the plastic flakes float. The material is dried by injecting hot air (3) and cleaned by friction between the flakes in the steel shell of the cylindrical chamber. Soiling removed in this way is continuously discharged via radially arranged screens and finally drawn off via a cyclone (4). An exhaust air filter can also be installed instead of the cyclone. After drying and cleaning in the 1st cleaning stage, the plastics are delivered via a pipework system (5) to the high-speed post-cleaning stage (6). Here any remaining finer residual soiling is removed from the plastic before the material is finally discharged via a further cyclone (7). The result is a clean, dry film free from foreign matter and any other substances that could impair recycling.

The material is then "parked" in a buffer silo that is large enough to be able to compensate fluctuations in production, but which must not be too large in order not to lose the energy already input into the material. Processing is performed on the conical co-rotating extruder from MAS (C) which ensures not only outstanding homogenization, but also has an enormously high efficiency so that the lowest possible melt temperatures can be employed. The energy input is 0.20–0.25 kWh/kg [1]. When processing LDPE, the subsequent underwater pelletization (E) can take place at a water temperature of up to 80 °C, so that the heat in the heat

Contact

M-A-S Maschinen- und Anlagenbau Schulz GmbH
A-4055 Pucking
Austria
→ www.mas-austria.com

exchangers can be returned to the drying process.

The quality of the regranulate and hence its recyclability depends on the process temperatures, the homogeneity, the freedom from bubbles and the purity. While the process engineering parameters are satisfied by the extruder, the melt filtration is also of very great importance in the overall concept. Here a specially developed and patented continuous melt filter (D) is used that can be employed down to a filtration fineness of 120 µm.

The MAS extruders cover an output range from 200 to 1,800 kg/h. The process engineering possibilities of the co-rotating principle also allow the compounding of additives and fillers, so that the regranulate can be molded to form high-quality products.

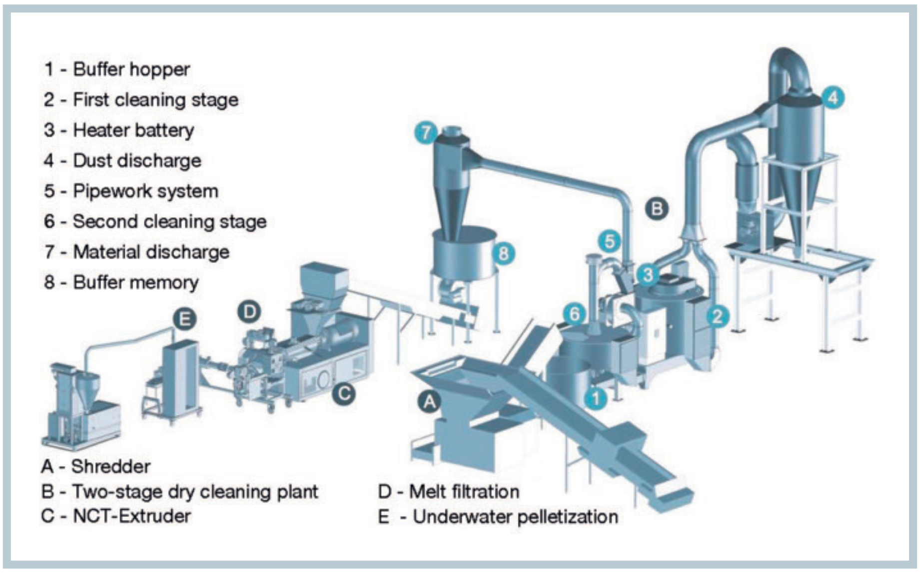

Fig. 1. Layout of the compact plant

Dry Cleaning versus Wet Cleaning

One of the main advantages of the dry cleaning process is the significantly lower investment cost resulting from the smaller space requirement and smaller number of plant components. Furthermore, the water-free function not only eliminates the need for waste water processing, but also a costly and time-consuming part of the operating permit application procedure. The plant has lower maintenance costs and shorter standstill times, requires less operating personnel and hence has lower operating, service and ultimately overall costs.

Table 1 shows a comparison of the operating costs for reprocessing in a wet and dry cleaning plant. These are average values calculated over longer periods which can differ, depending on the material processed. The breakdown shows that the operation of a wet cleaning plant involved far higher costs. The depreciation of the plant over six years, in EUR/t of material, is around four times that of a dry cleaning plant. Added to this are the higher costs for energy, for the disposal of wastes and waste water and the maintenance for a wet cleaning plant.

Drying Efficiencies in Comparison

The energy required for drying plastics depends on the input moisture content, the required output moisture content and the climatic conditions. The comparison is based on the following common parameters taken from practice (input moisture content 15 %, output moisture content 2 %; material LDPE industrial waste, slightly soiled, ambient air: 15 °C, 50 % relative humidity, drying air: 25 °C, 90 % relative humidity). Calculations using the Mollier h,x diagram [3] show a theoretical drying power requirement of 0.143 kW/kg material.

With dry cleaning, 0.1 kW/kg of this required power is input into the system by friction from the drives and the blower. Allowing for the measured values and the calculated efficiency ($\eta_{\text{dry cleaning}}$ = 0.9), a further 0.060 kW/kg is required that is won from the heat recovery concept. If necessary – in two cases out of ten – additional heat is input via the installed heater battery. The energy input is thus limited predominantly to the power of the drives.

By comparison, drying in the wet cleaning plant requires a preliminary dewatering via a centrifuge (0.075 kW/kg) to a moisture content of 15 %. For the subsequent thermal drying, 0.286 kW/kg is required based on the efficiency ($\eta_{\text{wet cleaning plant}}$ = 0.5) measured in practice. This gives a total required drying energy of 0.361 kW/kg.

The comparison above shows clearly that drying in the wet cleaning plant requires three times the energy compared with drying in the dry cleaning plant. This drastic difference can be explained by comparing the drying efficiencies of the plants measured in practical tests. The already lower energy input in the dry cleaner is further reduced by the heat recovery, ultimately resulting in far more cost-effective operation. With a material throughput of 1,000 kg/h (approx. 10 % impurities), an annual operating time of 8,200 hours, an electricity price of 0.07 EUR/kWh and a gas price of 0.0275 →

Item	Dry cleaner	Wet cleaner	Explanation
Investment costs [EUR/t throughput]	9.05	35.56	Write-off period 6 years, 30% residual value, 8,000 operating hours per year
Energy costs for operation and drying [EUR/t throughput]	13.58	27.88	0.07 EUR/kWh electric; 0.0275 EUR/kWh thermal [e-control] [2]
Maintenance [EUR/t throughput]	2.70	26.83	Material and maintenance personnel costs
Operating personnel [EUR/t throughput]	48.78	48.78	Two persons in four-shift operation
Fresh water costs [EUR/t throughput]		1.96	Fresh water costs for 1.4 m^3
Sludge and water water disposal [EUR/t throughput]		61.53	0.06 t sludge; 1.3 m^3 waste water
Dry waste disposal [EUR/t throughput]	9.90	–	0.06 t waste
Total	**84.01**	**202.54**	**Operating costs in EUR per t throughput**

Table 1. The comparison shows clearly that the operation of a wet cleaning plant involves significantly higher costs

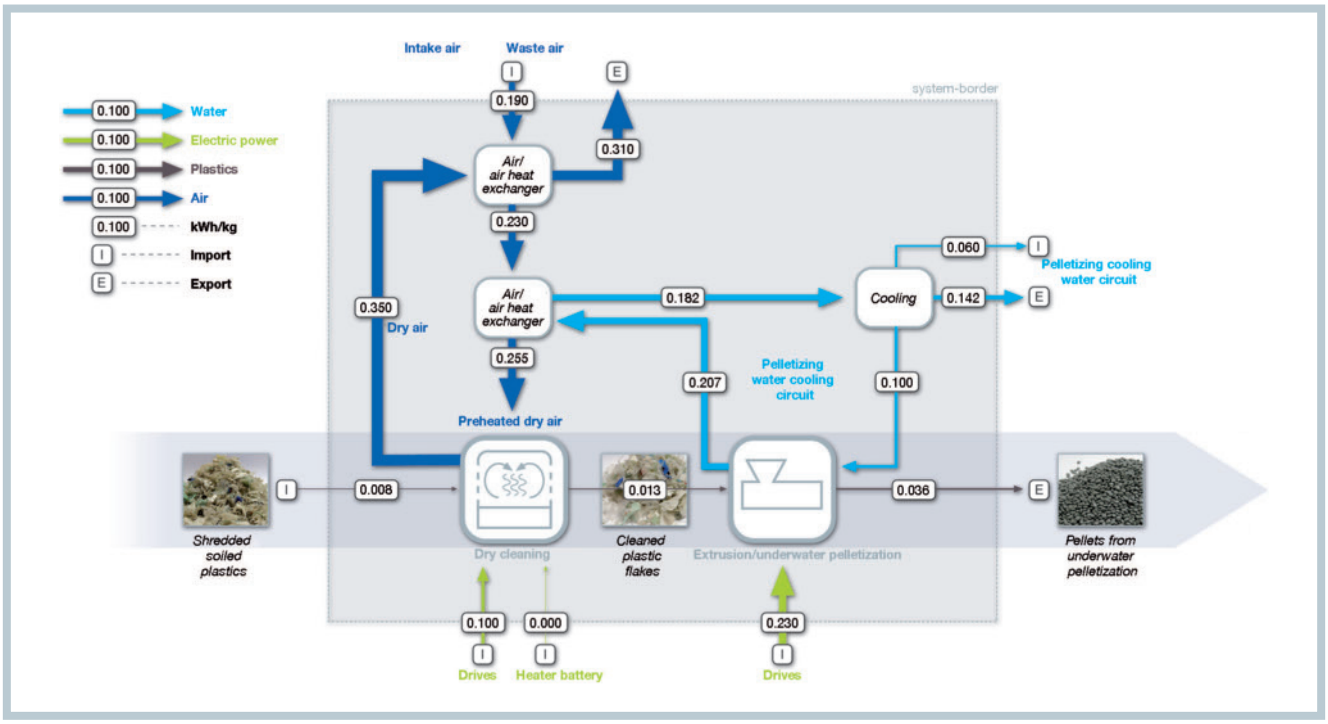

Fig. 2. Energy balance of the compact plant (fluxes in kWh/kg)

EUR/kWh, operation under the above conditions results in savings of over 170,000.- EUR per year.

Figure 2 shows the energy flux of a dry cleaner in combination with an NCT extruder in kWh/kg throughput. The balance shows that the heating power required for the dry cleaner is reduced to zero, as the energy input from the drives and the heat exchangers is sufficient to dry the material. The consideration of the flux takes into consideration the anergy, the non-productive part of the energy contained in the ambient air and hence in the system (see intake air).

A calculation of the drying in a dry cleaner (dwell time 60 s, flow velocity 42 m/s) underlines these figures, as dry in a wet cleaning plant requires a pipe length of around 2,520 m to achieve the same effect at the same expense. As a result the dry cleaner is suitable not only as a standalone solution, but also as a component in a wet cleaning plant – whether for preseparation of coarse soiling, for postcleaning or for significantly more efficient drying. The latter is already being successfully practiced.

Ecological Benefits

The water-free operation of a dry cleaning plant produces neither waste water nor sludge. Waste water processing is therefore not necessary, leading to savings in investment, waste disposal and operating costs and contributing to environmental protection. This further boosts the earnings, and hence maximizes the profitability of the dry cleaning plant.

The dry cleaning plant has an integral heat recovery concept that uses the heat of the dryer air and cooling water to preheat the dry air. The cooling water circuit of the underwater LDPE pelletizer allows up to 0.05 kW/kg heating capacity to be recovered that is used to dry the materials. The plant also has a heat exchanger to utilize the waste heat from the dryer. In total up to 0.18 kW/kg (outside temperature -10 °C) in heating capacity can be recovered. The dry cleaning plant can be safely used at temperatures between -10 °C and +30 °C. In fact, the lower the outdoor temperature, the higher the amount of energy recovered via the heat exchangers.

Conclusion

Dry cleaning is a cost-effective method of recycling that is gentle on the material. Lower costs for investment and for the operation of the plant allow profits to be increased and ensure a short pay-back period. Its use is profitable not only as a stand-alone unit, but also as part of a wet cleaning plant. The simple function and application and minimal maintenance underline the energy-efficient and environmentally safe operation. ■

REFERENCES

1 Klammer, G.: Conical Co-rotation. Kunststoffe international 99 (2009) 10, pp. 58–60
2 Evaluation of the industrial price survey, http://www.e-control.at/portal/page/portal/medienbibliothek/strom/dokumente/pdfs/industriepreiserhebung-strom-1-20101.pdf, on 12 Jul 2010
3 Cerbe, G.; Wilhelms, G.: Technische Thermodynamik. 15th edition. Hanser, Munich, Vienna 2006

THE AUTHORS

DIPL.-ING. GÜNTHER KLAMMER, born in 1967, is Managing Director of MAS Maschinen- und Anlagenbau Schulz GmbH, Pucking, Austria.

HERBERT ANGLBERGER, born in 1958, is Managing Partner and Technical Director of Ekuma Austria Maschinen- und Elektrobau GesmbH, Pucking.

STEPHAN WÜSCHT, born in 1988, studies Biotechnology and Environmental Technology at Wels Technical University, Austria.