Development of Chemical Sorting Technology for Removing Impurities from End-of-Life Automotive Plastic Parts

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This study defines a solvent-based sorting technology that selectively dissolves the target resin to be recovered as “chemical sorting,” and has the objective to establish a concrete process, equipment configuration, and operating conditions with a view toward industrial applicability to heterogeneous mixed waste derived from end-of-life vehicles (ELVs). Glass fiber reinforced polyamide 6 (PA6-GF), which is a challenge to recycle, was selected as the target material, and the air intake manifold, a large component that is relatively easy to collect individually, was examined as the verification model. Composition analysis of collected air intake manifolds (not limited to specific vehicle models) revealed that PA6 accounts for approximately 66 wt%, mm-size contaminants such as metal fragments, rubber, and insert nuts account for approximately 5 wt%, and µm-size glass fibers (GF) account for approximately 29 wt%, as shown in Fig. 1. These results confirmed the presence of mixed contaminants that differ greatly in particle size. Use of a single filter is likely to result in unstable continuous operation due to blockage and clogging. Therefore, a two-stage separation concept was adopted as the basic approach, as shown in Fig. 2, with mm-size contaminants removed using a coarse filter, and µm-size GF continuously separated using a decanter centrifuge that enables control of separation performance via the centrifugal force and the feed flow rate to the equipment. Furthermore, solvent recovery and concentration after resin dissolution assumes devolatilization using a general-purpose tank, and the process flow design incorporates a pelletizer capable of stable pelletizing even under residual solvent conditions.

The validity of each process step of dissolution, separation, and devolatilization in the designed process flow was verified. In particular, verification in the separation process used model solutions prepared with assumed viscosity conditions (100 mPa·s, 500 mPa·s, 1000 mPa·s) at temperatures that enable continuous dissolution of PA6, and a GF content of 30 wt%. In addition, to clarify the relationships among flow rate, centrifugal force, solution viscosity, and GF separation rate, GF separation tests were conducted at room temperature by continuously feeding the model solutions to a decanter centrifuge while varying the centrifugal force (500 to 2100 G) and flow rate (200 to 1400 L/h).

Figure 3 shows the decanter centrifugal separation test results. The GF separation rate was strongly influenced by flow rate and model solution viscosity, and varied widely depending on the conditions. In particular, under the high-viscosity condition of 1000 mPa·s, a marked decrease in the separation rate was observed, and even at the same centrifugal force, the separation rate decreased with increasing flow rate. These results indicate that viscosity is one of the main factors governing separation performance, and that when operating an actual chemical sorting process, it is important to set the operating condition ranges based on the appropriate flow rate condition range.

The overall findings obtained from each process step confirmed that a chemical sorting flow consisting of solvent-based dissolution, centrifugal separation, and solvent recovery by vacuum devolatilization is feasible for composite waste containing PA6-GF.

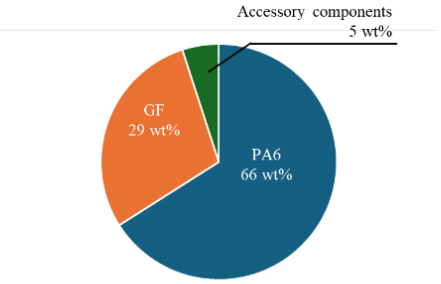

Fig.1 Results of composition analysis of the intake manifold

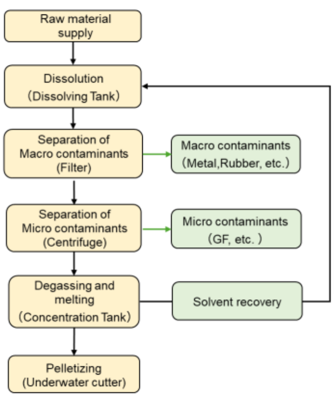

Fig.2 Process block flow for chemical sorting

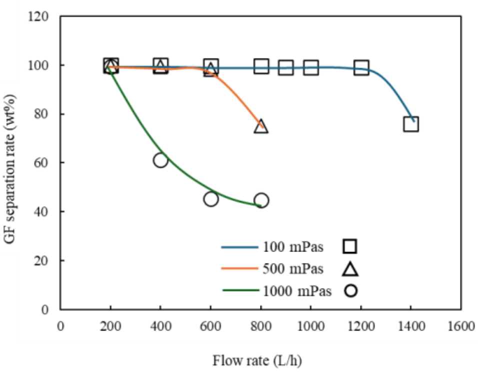

Fig.3 Relationship between GF separation efficiency (wt%), flow rate, and viscosity in a centrifuge