IAMNRW - POLYMERS

The limited choice of materials still portrays the obstacles faced in diverse applications of selective laser sintering process. Most of the products are therefore manufactured using PA12. Currently, there are no suitable methods for the production of powders from other polymers. Within the framework of the EFRE-project, two different powder manufacturing methods shall be adapted and introduced here. The first method describes a cryogenic milling with an aftertreatment involving thermal particle rounding while the second method describes the PGSS process, also known as the high-pressure spray process. Through these production plants, new powders for the laser sintering shall be manufactured in the future.

PROJECT OVERVIEW

DURATION

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RESEACHER

Research Leader
Prof. Dr.-Ing. Hans-Joachim Schmid (PVT)
Prof. Dr.-Ing. Volker Schöppner (KTP)
Research Assistant
Moritz Rüther, M.Sc.
SathishKumar Ponusam, M.Sc.
Jan Hendrik Martens, M.Sc.

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Background

On the technical level, the processes described here are relatively well-known. As such, the PGSS method was developed at the Ruhr-University Bochum and used for the pulverization of polyethylene glycol and biological growths. Nevertheless, the application of this process for technical polymers such as PP, PA6 and PA6.6 is yet unsuccessful.

Furthermore, the cold milling process with an aftertreatment based on thermal rounding of the milled products were previously studied at the University of Erlangen. However, the aftertreatment process currently delivers a low yield of 30-50% and hence, is without any further process modifications relatively unsuitable for the mass production.

Despite these existing problems, the principles behind both of these methods coupled with the essential modifications of the process designs would enable the continuous productions of SLS-powders. Both processes are described in detail below and moreover, the adapted plant engineering as well as the research objectives of these processes are focused separately.

Particles from Gas Saturated Solutions (PGSS)

PGSS is a high-pressure spray process. It is based on the phenomenon that supercritical fluids (e.g. N2, CO2) can be easily dissolved in other substances. High pressures are required to reach the supercritical state of the fluid. If the mixture is expanded via a nozzle, the aggregate state of the dissolved fluid changes, its solubility decreases and it escapes from the surrounding matrix. The matrix is torn apart and fine droplets are formed. Due to the Joule-Thompson effect, the gas temperature also decreases as a result of the expansion, causing the droplets to cool and finally solidify.

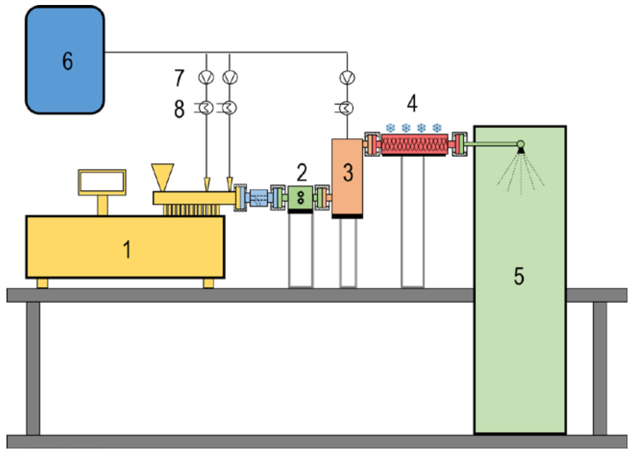

FIGURE 1 Schematic layout of the PGSS plant

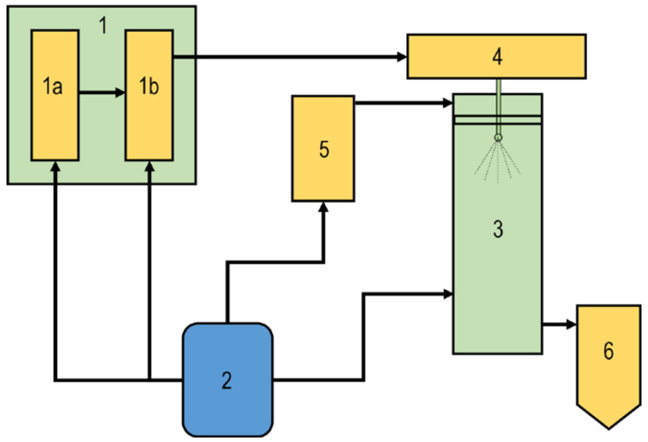

FIGURE 2 Schematic layout of the cryogenic mill and the downer-reactor

The supercritical fluid used here is CO2 (6 in Figure 1), which is preconditioned by diaphragm pumps (7) and heat exchangers (8). The dissolution of CO2 into the polymer matrix is essential for the process. In the plants at the Ruhr- University Bochum, this was done by static mixers. In the plant presented here, the supercritical fluid is fed into a twin-screw extruder (1 in Figure 1) during the compounding itself. In addition, further homogenization takes place in a dynamic mixer (3). If necessary, further fluid can be injected into this mixer. A gear pump (2) and another heat exchanger (4), which also functions as a static mixer, are used to regulate the pressure and temperature of the polymer/CO2 mixture. These three mixing stages are intended to ensure a homogeneous mixture. At the end, a nozzle in a spray tower (5) produces the spray, out of which the particles are formed.

The main objective of the project is to enable a continuous production of SLS-powders from granulated polymers. For this purpose, the PGSS system must be parameterized. In addition, the behavior of gas-laden melts is to be investigated in depth. At the moment the plant technology is being set up.

Cryogenic milling & particle rounding in the gas phase

In this initial process, the granules are fed continuously to the cryogenic mill (1 in Figure 2). Prior to the grinding step, the granules are embrittled in a screw cooler (1a) integrated into the mill, in which the cooling process is achieved by an external supply of the liquid N2 (2).The embrittlement of the granules occurs when the process temperature is lower than the glass transition temperature of the polymer. The brittle granules are then fed to the grinding chamber (1b) which is also cooled down by the liquid N2 to ensure the particles do not undergo a phase transition into the elastic region due to the heat generation. Due to the mechanical stresses during the milling step, the resulting particles often exhibit ragged surfaces with sharp edges and therefore, possess low bulk densities and flowabilities. To improve these features, the particles are then continuously dispersed into a hot downer-reactor (3) by using a powder disperser (4).The aim of this procedure is to heat the particle up to its molten state, thereby improving its sphericity due to the resulting effect of the surface tension. Thus, a pre-heated secondary N2 gas (5) is fed to the downer reactor to enable the particles to rapidly achieve its molten state. After the thermal rounding of the particles is completed, the hot multiphase flow is instantly quenched using the liquid N2 and the cooled, round particles are then separated from the flow using a gas cyclone (6). The secondary N2 gas also acts as a sheath gas to avoid particle losses due to the frequent collisions between the particles and the hot reactor wall.

Through the parametrization of the milling and thermal rounding processes as well as the modification of the gas distribution system in the downer-reactor, this project offers the possibility to attain a high continuous yield of SLS-powders.