UNIVERSITÀ DEGLI STUDI DI NAPOLI "FEDERICO II"
DIPARTIMENTO DI INGEGNERIA CHIMICA,
DEI MATERIALI E DELLA PRODUZIONE INDUSTRIALE

Advisory agreement between the Trustee of the Simpe s.p.a bankruptcy and the Department of Chemical, Materials and Production Engineering

Answer to question n°3

Prof. Roberto Andreozzi

Prof. Andrea D'Anna

Prof. Almerinda Di Benedetto

Prof. Giovanni Ianniruberto

Prof. Pier Luca Maffettone, Department Chair

INDEX

Question n° 3

Tell the consultant which is the estimated value realizable from the sale of the industrial plant of Simpe SpA, particularly the one made by the CP3 and SSP subsystems, accounting for the fact that the sale itself will take place as part of the bankruptcy procedure.

Requested documents

In order to properly answer to Question n°3, the Department of Chemical, Materials, and Production Engineering (DICMAPI) requested the following documents:

1) Layout of the CP3/SSP chemical plants.
2) Description of the adopted technology and of the production process.
3) List of the most important equipment's, with the corresponding technical data sheets and warranty certificates.
4) Construction period and company of the chemical plants.
5) Copy of the purchase contracts.
6) Test reports.
7) Maintenance reports.

We point out that no test reports have been received since the chemical plants have never been tested. We only received (see attachments) a document proving the mechanical completion of the construction of both plants. Furthermore, no maintenance report has been received.

Brief description of the process

In the CP3 plant (CP3 being the acronym of Continuous Polymerization 3) 450 ton/day of PET are produced through a polymerization process in the liquid state (or *melt polymerization*) starting from terephthalic acid and ethylene glycol. The esterification section of the plant, built in the period 2001-2003 to originally use dimethilterephtalate (as in the CP1 and CP2 plants), was converted in the period 2007-2010 to terephtalic acid. A description of the melt polymerization process is reported in the answer to question n°2.

In melt polymerization processes, fiber grade PET with an average molar mass ranging between 16,000 and 19,000 (i.e., with intrinsic viscosties in the range 0.58-0.68 dl/g) is typically obtained. In order to produce bottle grade PET it is necessary to increase the molar mass to values higher than those obtained through a melt polymerization, by using a Solid State Polymerization (SSP).

Indeed, the SSP technology allows one to obtain molar masses of the order of 27,000 (corresponding to an intrinsic viscosity of the order of 0.90 dl/g), as is typical for bottle grade PET. In other words, SSP makes it possible to produce materials with properties not attainable through the melt polymerization process. In the SSP process a reduced amount of degradation products is obtained, thanks to the fact that processing temperatures are lower. Figure 1 shows a schematic of the SSP process [1].

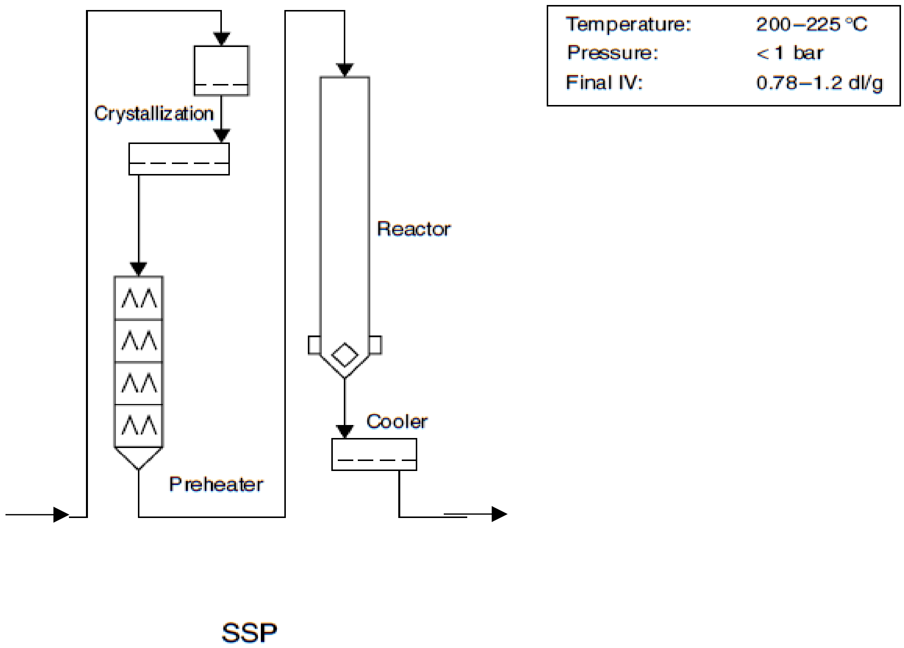

Figure 1 – Schematic of the SSP process

As reported in the literature [1], it is possible to split the SSP process into four steps:

- crystallization
- annealing
- SSP reaction

- cooling.

Crystallization

The amorphous feed material is crystallized in a two-stage process. In the first stage, a spouting bed, with high gas velocities, is used to achieve a vigorous pellet motion, thereby preventing agglomeration as the pellets quickly heat up and crystallize. In the second stage, a pulsed fluid bed, with lower gas velocities, is used to achieve quieter bed motion and to guarantee a minimum pellet residence time. Air is typically used as heating medium in both beds, whereby the gas temperature generally does not exceed 185 ◦C. Higher temperatures can be employed, but nitrogen rather than air is used to prevent oxidation and the yellowing of pellets.

The spouting bed temperature is generally in the range 150–170°C. The material temperature at the outlet of the pulsed fluid bed is usually less than 180°C.

During crystallization, both the moisture and the acetaldehyde are removed from the pellets. In the case of moisture, this is critical before the pellets are heated to SSP temperatures above 180°C. Moisture present at higher temperatures can lead to hydrolysis and a drop in the intrinsic viscosity. In particular, that drop has been shown to increase significantly at temperatures higher than 200°C. Even at temperatures lower than 180°C, a small intrinsic viscosity drop can be expected, depending on the initial moisture content.

Annealing

Before the crystallized material can be processed at the higher SSP temperatures, the melting point of the crystals formed in the crystallization stage needs to be increased to above the intended SSP temperature. This shifting of the low melting-point peak, known as annealing, significantly reduces the risk of sintering later on in the SSP column. The heating medium is nitrogen in order to prevent thermo-oxidative degradation of the pellets. The nitrogen flows in a cross-flow manner, entering from one side through the roofs, and then flowing through the pellets before being collected in an adjacent set of roofs and leaving the vessel on the other side. The pellets are heated in a series of two to six such preheater sections to a temperature of 210 to 220°C. The process takes places over residence times of up to 4 h, during which the molecular weight and the intrinsic viscosity begin to increase, the acetaldehyde is significantly reduced to less than 5 ppm, and the crystallinity increases to ca. 50 vol%. Having shifted the beginning of the low-melting-point peak above the SSP reaction temperature, the pellets are now ready for processing in the SSP column. The material can be pneumatically conveyed from the preheater to the reactor under nitrogen.

SSP Reaction

The reactor column is designed to provide the necessary residence time to achieve the material final intrinsic viscosity specification. Typical residence times in the range of 10–20 h at temperatures of 210°C are required to reach the desired intrinsic viscosity. The reactor column has a diameter between 2 and 4m and a height of up to 30 m. Nitrogen enters at the bottom of the reactor and flows countercurrently up through the pellets in order to remove the reaction by-products, ethylene glycol and water. The gas-to-solid mass ratio is typically kept below unity. The final material viscosity is controlled by either the residence time or the reaction temperature. The temperature in the reactor is limited by the tendency of the pellets to sinter. This is a function of the material characteristics, the pre-treatment in the annealing section, the column dimensions and design, the pellet shape and the pellet sink velocity through the column.

Cooling

Cooling of the pellets begins at the outlet of the reactor. Nitrogen enters the reactor cold and the pellets are cooled in the reactor discharge section to ca. 180°C. The pellets then pass into a fluid bed cooler, where they are cooled within 5min to typically less than 60°C by fresh air.

Estimated residual value of the CP3/SSP plants

As just mentioned, the chemical plant in its current configuration is made up by two sections:

- Melt polymerization section (see attachment 1), called CP3;
- Solid state polymerization section (see attachment 2), called SSP.

The SIMPE chemical plant for the production of bottle grade PET has a production capacity of 450 ton/day.

From the received documents, it is possible to state that:

- The CP3 section in its current configuration is the result of a revamping process of an older plant. The revamping process started in 2007 and its overall cost was 9.6 M€ (attachment 3);
- The SSP section has been built starting from 2008, for a total of 8.15 M€ (attachment 4);

In spite of the agreement between Simpe SpA and the contractor (Cover impiantistica srl), the revamping process of the CP3 section and the construction of the SSP plant lasted much longer than agreed, with a break between 2010 and 2012, to then be completed in 2013. This is proved by attachment n°5.

In order to estimate the cost of a chemical plant for the production of bottle grade PET, we simply start from the construction cost of the SSP section, in view of the fact that the latter corresponds to 15% of the overall cost, as suggested by Figure 2 below:

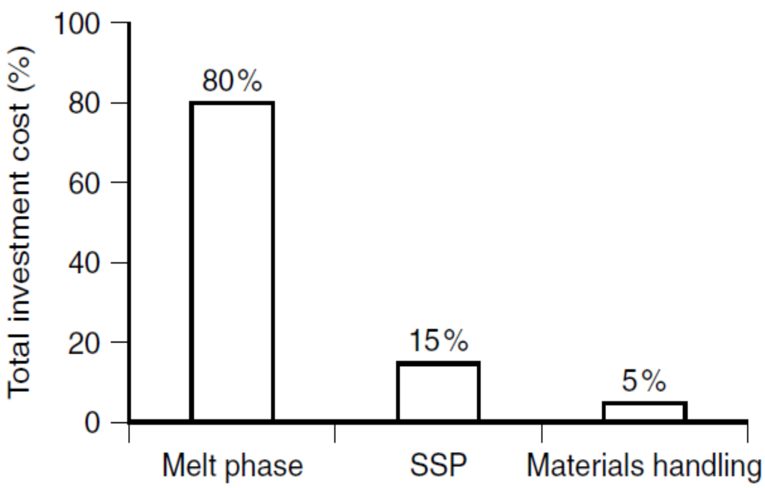

Figure 2 - Investment costs for a bottle grade PET plant [2].

Hence, the cost of a new melt polymerization plant, like CP3, would have been of the order of 43.5 M€ in 2008. However, a revamped plant (like CP3) cannot be considered as equivalent to a new one. In view of the fact that, as mentioned above, the CP3 esterification section has been made new, we here estimate that the value of the revamped CP3 section is equal to 90% of the value of a new plant. Hence, we estimate that the CP3 section, after the revamping process, had a value of the order of 39 M€, so that the whole plant (CP3+SSP) for the production of 450 ton/day of bottle grade PET had in 2008 a value of about 47 M€.

In order to estimate the present value of the plant we must keep in mind that the plant has never been tested. For this reason, in case of sale, it will be necessary to carry out the testing, and such a procedure, in view of the productivity of the plant, requires an investment in raw materials of the order of 0.5 M€ per day. Since the plant is expected to reach steady state conditions in 4-10 days, we estimate that 2-5 M€ of raw materials are needed for its testing. Other costs should be added to the cost of raw materials, but these may be offset by the possible sale of the PET produced during testing. In any case, it is estimated that approximately 2-5 M€ must be deducted from the residual value of the CP3+SSP plant.

To estimate such a residual value is common practice to consider a write-down of the cost of 10%/year in the case of running plants, and of 20%/year in the case of an out-of-service plant not subject to regular maintenance [3].

In this case, however, there is a difficulty related to the quantification of the percentage of completion of the construction works at the time of their suspension in 2010. In the absence of any specific documentation, in the following we will perform a conservative estimate by assuming that the construction works were "almost" completed in 2010 and by taking into account that the SSP+CP3 plant has never run and that maintenance is not documented.

In the following we perform the estimate by accounting for the fact that, for reasons linked to the economic difficulties of the company, the plant was completed after three years, rather than in the twelve months foreseen by the contract. The timing of construction of a plant is often ignored in the estimation criteria since it is usually short, but in the present case we cannot ignore it.

During the construction phase, the value of the plant obviously increases; however, we must also account for the depreciation due to aging of what already built. In this case, assuming a constant speed of construction of the plant in the three years from 2007 to 2010, the value of the fraction of plant built after one year is equal to 47/3 M€. At the end of the second year, the value of the plant takes into account the second fraction built (with value equal to 47/3 M€), and the aging of the first fraction. Adopting a depreciation of 10% per year, the value of the system after two years is therefore approximately equal to 30 M€. At the end of the third year, the value of third fraction must be added to the depreciated value of what was built in the first two years. The estimated value of the plant at the end of the three years of construction, namely in 2010, then amounts to about 42.5 € (to be compared with 47 M€ in the case of a plant built according to the contract schedule).

In order to determine the present value of the plant starting from the 2010 estimate, we consider an annual depreciation of 20% since there is no documented maintenance. Therefore from 2010 up to now, the plant has suffered a further depreciation of approximately 67%, and its final value would correspond to about 14 M€. By subtracting the cost of the raw materials for the startup and testing (approximately 2-5 M€), the total estimated value is in the range 9-12 M€.

In case the plant had to be moved elsewhere, its initial value should be reduced by about 2 M€, the cost of the civil infrastructure, estimated to be about 4% of the total value of the plant itself [4]. Based on the above considerations on the depreciation from 2010 to 2015, the final value of the plant, excluding the civil infrastructures, then should be equal to about 13.4 M €. Considering that the assembly/disassembly cost are equal to 10% of the original value of the entire system [4], equivalent to approximately 4.7 M€, the final value of the dismantled plant would be reduced to about 8.7 M€. By subtracting the cost of the raw materials for the startup and testing (approximately 2-5 M€), the total estimated value would be equal to 3.7-6.7 M€.

In the case the absence of documented and regular maintenance interventions had significantly compromised the functionality of the system itself (a test that would require, as mentioned above, an investment of approximately 2-5 M€), its residual value might simply reduce to the value of its scraps.

The residual value of the CP3 plant as scrap can be determined on the basis of the estimated scrap value of the CP1 and CP2 plants (see Answer to Question n°2), and by accounting for the different plant capacities. The capacity of the CP3 plant is about 5-6 times larger than CP1+CP2, and hence the CP3 value as scrap can be estimated to be in the range 0.8-1.3 M€. Now, in view of the fact that the investment costs for the SSP section amount to 15%, the scraps of the whole plant (CP3 + SSP) are estimated to have a value in the range 1.0-1.5 M€.

Answer to question n°3

Based on the discussion reported in the previous section, it can be concluded that the estimated value of the CP3 and SSP plants of Simpe Spa is in the range 9-12 M€.

If potential buyers are interested in using the plants in another area, the plant value drops down to 3.7-6.7 M€ (with disassembly and transport costs to be covered by the buyer).

We also estimated the minimum value that the plant would have if it were sold as scrap. This value is estimated to be in the range 1.0-1.5 M€.

Bibliography

1) Modern Polyesters: chemistry and technology of polyesters and copolyesters, edited by J. Scheirs and T. E. Long, Johm Wiley & Sons Ltd, The Atrium, Sothern Gate, Chichester, West Sussex, England 2003.

2) Mueller, M., SSP processes for capacities up to 600 t/d, presentation given at the Buhler Forum Protech, Buhler A. G, Uzwil, Switzerland, 10-11 June 1999.

3) Pellegrino G, Relazione Peritale di Stima per il TRIBUNALE CIVILE DI BRESCIA SEZIONE FALLIMENTARE, Fallimento n° 87/2012.

4) Happel J., Jordan D. G., *Chemical Process Economics*, 2nd edition, Marcel Dekker Inc., New York 1975