Polyester plant design and engineering today and tomorrow

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Summarizing the consulting experiences of the recent years, the essence of important polyester conferences like the yearly Polyester World Congress in Zurich/Switzerland and fairs like ACHEMA and ITMA, the description of current status of polyester plant design and engineering business provides an interesting picture. One proven fact is the significant decline of new polyester projects in Western Europe and America and the sharp increase of projects especially in China and Eastern Europe (see pages 40-46 of this issue). At the same time the number of companies fighting for market shares of polyester plant engineering has surprisingly increased.

Polyester engineering on the move

As little as five years ago the market of large continuous polyester plants, even in China, was completely dominated by the leading engineering companies like Chemtex using DuPont technology, Zimmer AG, Inventa-Fischer, Kanebo and Hitachi whereupon large producer like Nanya, Hyosung, Eastman (Voridian), Mitsubishi, Mitsui, Toray or Tuntex took planning, design and erection of new plants into their own hands.

Today, even with the smaller market shares of new investments in Europe and America the number of companies which are fighting for this market and which are able to deliver world scale polyester plants has increased remarkably. Newcomers and developers in Europe like NOYVallesina Engineering, EPC-industrial-engineering or AQUAFIL Engineering and in China companies and design institutes like Huitong Polyester [1], CTIEI/CTCEC [2] and CTA/SINOPEC [3] are increasing the competition potential enormously. Especially the market in China changed drastically. When the above mentioned leading traditional engineering companies covered about 80 % of the market share in China six years ago, this share has shrunk currently to less than 40%, and this process is rapidly ongoing. The latest bank loan policy of the Chinese government especially, where instead of 10% now about 50% net equity is necessary for new projects, will force Chinese investors to turn to domestic engineering companies which are able to strongly undercut the import prices.

Capability to build world scale plants

Looking at the results of the recent years expressed in erected and running polyester lines, the capabilities to build "World Scale" and competitive continuous polyester melt phase plants is presented in Table 1.

The reported numbers of plants and the related melt phase capacities might be different from source to source, but the message is clear. Besides, China is the leading country in polyester with a production capacity of nearly 14 million tons/year. The Chinese engineering capability to build world scale melt phase plants also has to be considered. It should also be mentioned that SSP technology for bottle polyester in China is on the way to becoming independent soon. At the end of 2004 Yizheng will start up its first homemade solid state polycondensation plant with a capacity of 275 tons/day based on a joint development with CTIEI.

Plant capacity development

How conservatively capacity development was seen only 8 years ago is demonstrated in the comparison Fig.

The limitation of maximum plant capacity differs significantly between PET resin for bottle applications and textile chips on the one hand and direct conversion of melt to textile fibers and filament yarns at the other hand. For chip production there is, besides mechanical limits of vessel sizes and vessel transport logistics, no real upper limit, and plant capacities of up to 1500 tons/day and higher will be realistic in the near future. The best example for this development is the new Altamira line of M&G which was originally designed for 750 tons/day, which has reached an output of 1000 tons/day and which is under further capacity optimization. This process route is becoming more and more comparable to the huge bulk production lines of polyolefines.

As opposed to this, the direct conversion of polyester melt to textile fibers and filament yarns might capacity wise be saturated at about 600 tons/day. The latter process is limited in the residence time of PET melt which should, for reasonable spinning results, not exceed 30-40 minutes depending on melt temperature.

The rapidly ongoing capacity growth might also have a positive consequence for technology owning engineering companies in future. Different to the past, where large production companies had the reliance in their in-house engineering to erect polyester plants using home made, licensed or copied technology, it will be hardly probable in the future that an engineering department which erects a new plant every now and then will take risk and responsibility for such large capacity and investment projects. Here again, the cooperation between polyester producer and engineering might be the most successful model.

Process simplification and optimization

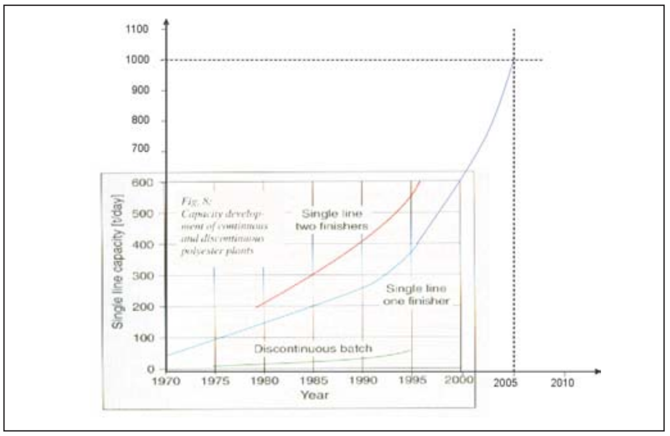
Besides the steadily increasing plant capacity, one can recognize the clear trend toward the reduction in process steps. The three step process of esterification, pre-polycondensation and polycondensation as applied for many years by the DuPont/Chemtex technology, is becoming more and more common nowadays. Companies such as NOY Vallesina Engineering or CTA/SINOPEC are designing their plants based on this process philosophy.

Significant further progress is made by Inventa-Fischer with their new two step process applying a tower reactor containing esterification and pre-polycondensation as well in one housing as a first reactor, and polycondensation as a second reactor. The compact design allows savings in conversion cost of up to 21 %, which means a reduction of total production costs by 3.5-4.0 %. Having the small profit margins of the PET business in mind, this development might attract future investors. The patented "ESPREE" technology [4] has already been introduced to industrial size and executed in four polyester projects with current largest capacity of 250 tons/day. The scale up is on the way.

Another new polyester process technology called NG3 proprietary to DuPont, which was introduced to the public during the 1990s, raised high expectations regarding savings in investment costs

Table 1

Established engineering companies:	
Chemtex/DuPont + M&G:	800 tons/day, 3-stage-process: bottle grade, in operation at about 1000 tons/day in Altamira/Mexico, further output increase is in preparation
Chemtex/DuPont:	More than 15 lines over 500 tons/day
Chemtex/DuPont (NG3)	2 lines 600 tons/day
Inventa-Fischer:	10 lines 500 - 600 tons/day including challenging projects such as direct processing of BOPET
Zimmer AG:	3 lines 600 tons/day, 7 lines 300 - 500 tons/day
New companies in China:	
CTIEI/CTCIC:	20 lines 500-600 tons/day, 10 lines > 300 tons/day
CTA/SINOPEC:	1 line250 tons/day, 1 line 400 tons/day
Huitong Polyester:	1 line 250 tons/day, 1 line 300 tons/day



Development of capacity: figure published in 1996 [4] and the current situation

and quality improvements. Here, the traditional melt polycondensation under vacuum is completely replaced by the SSP which reduces the chemical part of the plant to a two reactor process. There might be unexpected problems or hurdles during the first industrial start up of the new process as there is no official statement on the status of the projects currently available.

Saving costs and cutting process steps on a somewhat smaller scale is also the background of the recently announced combination of under water pelletizing and crystallization by Kreyenborg [6]. Keeping sufficient heat in the pellets during the cooling period by heating up the cooling medium to a range where the polyester chips will remain at temperatures between 160-110 °C provides a quick crystallization in the presence of water. The resulting chips have a degree of crystallization in a range of 40 % according to Kreyenborg, which is enough for a safe and lump formation free drying step without crystallization. This technology will especially interest those processors who aim for PET applications in packaging and engineering plastics.

Another path to satisfy the growth of polyester production, besides the erecting of new plants, is the substantial capacity boost of existing continuous lines. By understanding process kinetics, heat management and internal flow conditions in detail, it is possible to increase the plant output of existing plants up to the double name plate capacity by replacing the bottlenecks and redesigning important single parts such as finisher internals, scraper condensers, process columns or heat transfer equipment. This field, for instance, is the special domain of EPC industrial engineering which offers expertise and process knowledge to fill this market niche.

Besides reduction of process steps or number of reactors or equipment parts, the whole production chain has to be x-rayed to cut production costs and to simplify technology or distribution logistics. Because savings in transport and warehouse costs are becoming increasingly important with declining margins, there is still space for development for those companies which are fully integrated with the raw materials PTA and EG. Here, the physically closer coupling of PTA and EG production with the conversion to polyester might provide further cost saving potential.

Direct conversion processes

Having had the good luck to have started up a new process development nearly a decade ago as co-inventor, it is now satisfying to notice that this technology is on the way to its first roll out soon. Meant is the direct performing or melt to preform process which today, is investigated and developed by Inventa-Fischer [7] and Zimmer AG [8] in pilot scale condition. Both companies presented their experimental concept in pilot scale together with the melt to preform machinery to the interested public. Some details e.g. how to reduce the AA-content to the demanded low AA-level for water packaging without spoiling the polymer by adding high amounts of AA-scavengers, or how to manage the seasonable and fashion driven flexibility of preform designs, are still under question. Yet like 35 years ago the step from extrusion spinning to direct spinning, which was driven by enormous cost savings, the melt to preform process will become reality in the near future. It would be recommendable for those who are producing preforms now and who are still skeptical about the future development of their business to have a deeper look at continuous direct spinning- and fully-automated POY plants as they are newly installed at large textile yarn producer around the world.

The direct preforming plant capacity might start at an output range of about 100-200 tons/day which means at likewise low melt phase capacity. The well known correlation between plant capacity and conversion cost where the largest melt phase capacity secures the lowest cost might raise the question of the economy of scale for this new direct preforming process. Yet as shown in the previous passage there is new design for a two reactor compact melt phase polycondensation of 200 tons/day already available on the market. Finally, one has to puzzle the currently present best technologies together, and of course one must take the comparable high risk to become the first user of direct preforming technology

At this point the largest direct conversion film project must be mentioned. Out of a melt phase finisher of a capacity of 600 tons/day polyester melt 400 tons/day thereof will be directly converted to biaxial oriented film in a thickness range of 12-36 µm in four parallel lines of a capacity of 100 tons/day each. The remaining 200 tons/day polyester melt are converted to film granulate. This project is under construction in China. The melt phase plant which provides the film polymer to the BOPET lines including the melt distribution to the single film lines is designed and executed by Inventa-Fischer.

Future prospects

In summary it can be said that polyester plant design and related engineering businesses are under increasing competition pressure whereas the serial erection of standard type polyester plants in China at sizes up to 600 tons/day is on the move to Chinese engineering companies. As a consequence, one could expect Chinese engineering activities outside of China after the Chinese market is saturated. To sustain and even grow in this business thus needs a straight-forward and long term research and development commitment in order to serve customers with high quality and cost saving polyester production and conversion technology. Besides further substantial capacity increases, there are process simplifications and further integration to raw material production, direct conversion melt to preform or melt to film, as well as intelligent plant optimization and the revamp of important fields to be distinguished from me too engineering. Not forgetting the myriads of the existing discontinuous and low capacity continuous lines. To survive in the market they will need to produce highly specialized polyester products, which is another field of know-how developing engineering companies.

Literature

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