DR. THIELE POLYESTER TECHNOLOGY

FUTURE SCENARIO IN POLYESTER FIBER AND FILAMENT PRODUCTION

Technology change from melt to fiber back to pellet to fiber by applying a new technology approach?

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Ladies and Gentlemen,

Before I am coming to my presentation titled "FUTURE SCENARIO IN POLYESTER FIBER AND FILAMENT PRODUCTION" I like to give you a very brief background of our business. Now, after more than ten years of successful operation round the globe the *Dr. Thiele Polyester Technology* consulting service is mainly active in five areas which are:

- Long term technical and scientific company support based on flat rate consulting
- Customized projects, seminars and sales support
- Conferences in PET-Recycling – the "Polyester Recycling Forum" PRF and publications
- Web site "Chemical Engineering – Polyester Information Platform" under www.ce-pip.com
- Support in patent filing and patent litigation

Some examples out of the 10 years reference list with more than 100 companies are names like Advansa, Barmag-Oerlikon, Brueckner, CCFEI, DOW, EPC-Group, Freudenberg, Gneuss, M&G Group, Neumag-Oerlikon, Nestlé, PIC, Poddar Pigments, Rieter-Automotive, Reliance, Sabic, Shantou Ocean Enterprise, Sukano, TITK, Uhde-Ems-Inventa, UOP LLC, VPI, Welspun, Yuhuapet.

More information you can find under www.polyester-technology.com and www.ce-pip.com

DR. THIELE POLYESTER TECHNOLOGY

Often new ideas are like
hot air balloons
in the clear sky of the Alps

- nice wishful thinking -

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1. Preface

Today polyethylene terephthalate ranges with its production size of about 50 Mio t/a and a market share of about 18% at the third place among all polymer materials produced world wide, behind polypropylene (19,5%) at second place and polyethylene (33.5%) at first place.

Polyester fiber and filament production is about 35 Mio t/a and approximately 20 Mio t/a are produced in China at an operational rate between 75 and 80%.

Large fiber and filament producers in the world and especially in China are changing to direct spinning processes.

Direct spinning seems to be the only economical way to produce textile intermediates.

This might be applicable for the east cost of China, the Mumbai or Calcutta area in India, Mexico City, Sao Paulo and some places in Fare East where the dense population is absorbing cheap textiles like a dry sponge.

But what about the rest of the world?
Will China become finally our major textile supplier?
Will the world become dependent on China´s textile export?
What about the textile industry in Europe, USA, Middle East, Africa and the rest of the World?
Will we become dependent on weal and woe of China´s textile industry?

To investigate for answers to this questions it might be useful to have a quick look at the situation of our major bulk polymers – the polyolefin polypropylene PP and polyethylene PE

Besides chemistry - what are the main differences between polyolefin and polyester production?

- Production capacity per single PP or PE unit is huge and in such a magnitude that an investor who likes to erect substantial polymer capacity must build a new cracker at first and after this a new poly plant, CONSEQUENCE: poly plants are always downstream integrated to raw materials like oil or LPG.

- The process chemistry of polyolefin reaches from raw material (OIL/LPG) to PE/PP polymers at one single site mainly.

- By nature of PE/PP process technologies the high and low pressure polyolefin *are not* useful *at all* to be connected to a direct processing like spinning or film casting caused by *process hurdles* and *capacity mismatches*

- PE/PP polymer production ends at the stage of pelletizing / compounding

Chemistry (reaction of polymer production) and **Physics** (mechanic of polymer processing) are **strictly separated –** so far some about the polyolefin situation

2. Textile polyester production today

Let us have a deeper look at the current situation of polyester fiber and filament production.

Different to polyolefin chemistry *the polyester chemistry is simple, well understood and easy to perform* within a very wide range of products and processes from smallest lab scale of 20 g/batch till largest industrial scale up to more than thousand tons per day.

✦**Chips spinning - Chips from discontinuous and continuous poly lines**

Chips spinning was the first approach in the 40th to 60th of the last century. At that time the polycondensation process was mainly discontinuous. Today only few large continuous poly plants are producing pellets for further spinning (about 10% of total filament/fiber production), large textile pellet producer are for instance Invista in Europe or Zhuhai Polyester in China

✦**Direct spinning – melt to fiber or filament (M2F)**

The step to continuous polymer production flattened the way to the connection of melt phase poly and spinning, first direct spinning plants in 1965-70, based on DMT and PTA, at capacity of 20 – 60 t/d

Today direct spinning of POY, FDY and SF is the mainstream technology. SF in single fiber lines up to 300 t/d and POY/FDY direct spinning up to 700 t/d, potential to 1000 t/d by densification of production space (under discussion more ends per spinning position), optimized plant lay out to minimize melt residence time

3. Where are the limits of direct spinning ?

The limits of capacity growth of textile polyester are in different sections of the process.

- **Melt distribution and melt residence time at its limits today**

maximum now about 60…90 min, optimum at about 30 min, capacity growth is always increasing residence time caused by oligomer increase, COOH increase, AA increase and IV decrease and b colour increase

- **Melt distribution systems of high complexity**

booster pumps, distribution valves, long distant pipes, melt cooler, and static mixer consuming high amounts of energy and causing thermal and mechanic-chemical degradation, shut down and maintenance are increasingly cost consuming, a 600 t/d direct spinning POY/FDY plant is operating with 10 – 20 spinning lines depending on titer program and plant layout

- **Decreased flexibility with capacity growth**

The long process chain from paste preparation to spinning die and winding/doffing is decreasing the flexibility by further increased capacity, high losses in case of process failures, plant shut down caused by mechanical problems, market problems like the current crisis situation

...limits for direct spinning ?

- **Limited flexibility of titer and fiber/filament type program**

Innovation in textile fibre production boosted by vogue and textile processing hardware development will be thwarted by direct spinning ponderosity

- **At the moment 700 t/d are the upper capacity limit,** 1000 t/d direct POY/FDY spinning is said to be manageable

- **Increasing logistic and transport costs** in case of central POY/SF production, POY/SF transport packed in boxes or bales of about 400 kg/m³ against 800 kg/m³ in case of pellets

- **Limited shelf live of POY,** different to cotton shelf live of POY is limited to about 6 months at normal environmental conditions, high storage temperatures are of disadvantage

4. Vertical integration from PX to polyester, current status

- Polyester bottle resin is still on the way to be produced in huge capacities at integrated production sites where also PTA and MEG are produced (SABIC, RELIANCE, SINOPEC, EASTMAN, M&G, MITSUBISHI, TEIJIN)

- Large textile PET producers like RELIANCE, SINOPEC, INDORAMA or NAN YA are integrated at one single site from PX to POY/FDY or SF, but in the most cases PTA/MEG intermediate transport is required to feed the direct spinning plants

- Polyester bottle resin production in one single melt phase (MP) line starting with lower melt IV of 0,45 – 0,50 dl/g of 1000 till 2000 t/day and subsequent SSP to 0,75 – 0,85 dl/g is proven technology today

- To produce textile polyester pellets of required IV of 0,65 dl/; especially size/weight/volume of finishers to produce 2000 t/d and more of textile IV 0,64 – 0,66 dl/g is a technical hurdle

- The traditional chips rout is providing amorphous pellets which must be crystallized and dried prior melt preparation for spinning, especially crystallization is consuming high amounts of energy

How to overcome technical obstacles?

5. Future scenarios for textile polyester production

5.1 Capacity growth of currently available melt to fiber (M2F) direct spinning technology

- polycondensation capacity currently at the limits
- melt distribution currently at the limits
- transport logistics of POY and SF are causing increased transport costs

Based on traditional direct spinning technology there are currently no revolutionary technology Changes in sight which will further simplify the path of textile polyester production. Direct spinning is getting more and more a dinosaur syndrome : clumsy, inflexible , high entrance barrier for investors and matured

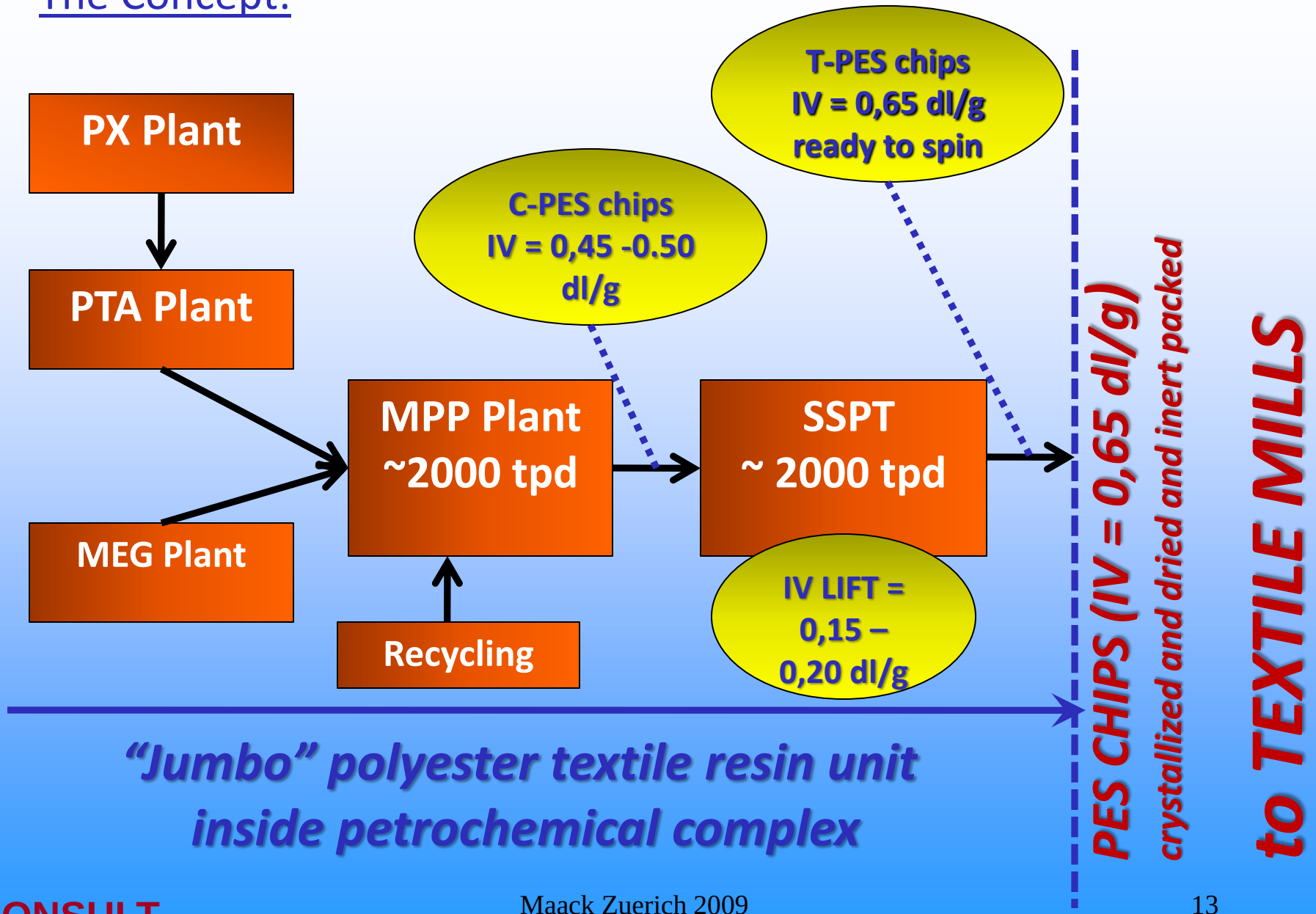
THE WAY OUT?

5.2 Modified jumbo SSP technology transferred to textile PET pellet production

The process principles:

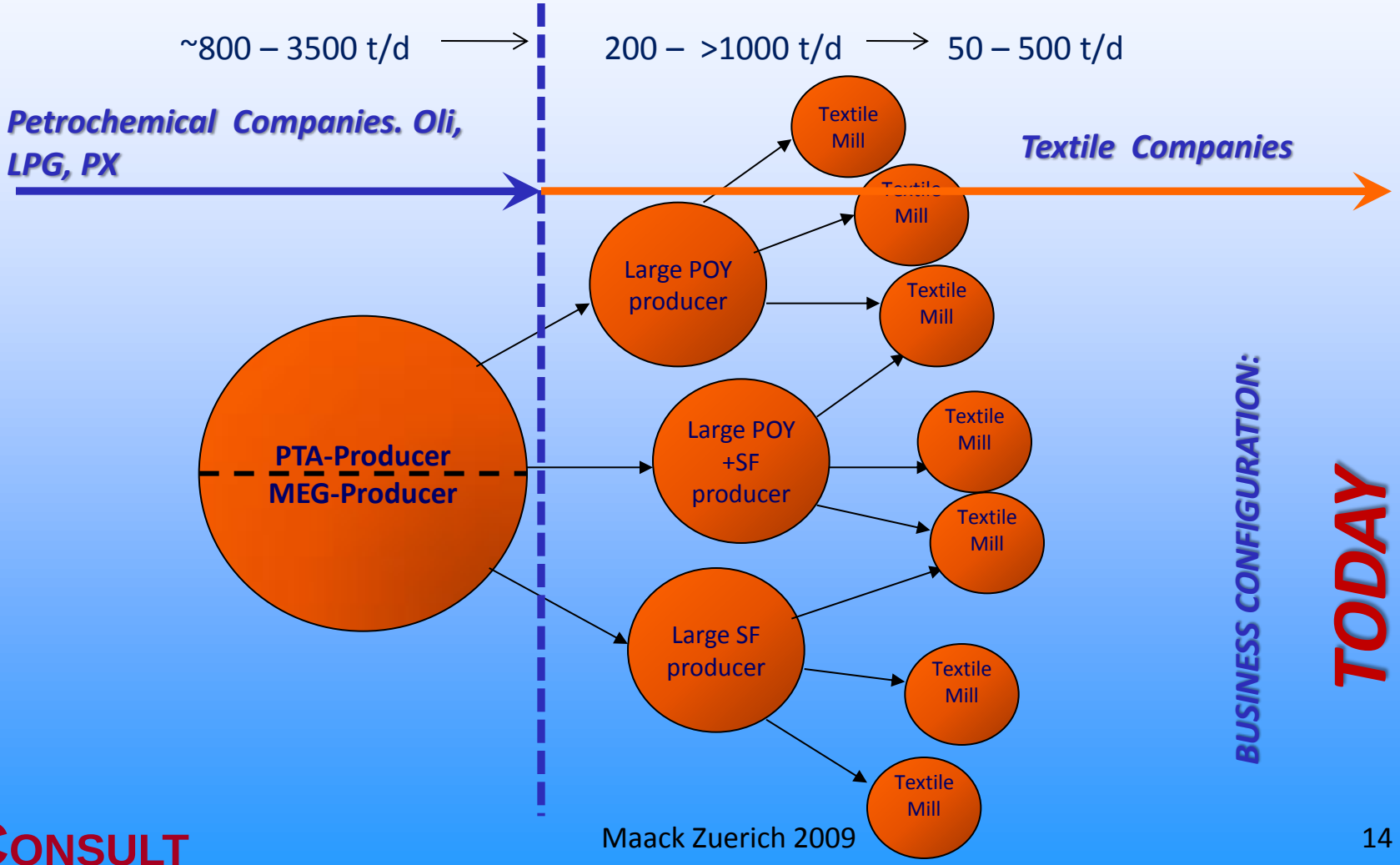
- Melt phase poly (MP) up to IV of 0,42…0,52 dl/g (including TiO2 addition and fine filtration)
- Chips cutting applying direct-crystallization to save energy cost
- Melt phase plant capacity of 2000 t/d and higher at IV of 0,42…0,52 dl/g for the known vendors like UIF, CHEMTEX, LURGI, EPC, AQUAFIL, CTIEI, no technical problem
- Low IV-upgrading SSP let us call this process SSP-Textile or **SSPT** from 0,45 to 0,6…..0,64 dl/g ,cooling and dry packing under dry atmosphere using proven technology (analogue PA6)
- Currently available SSP processes like HCIRR of M&G (> 1600t/d) and BUEHLER (about 1000 t/d) units for bottle resin IV 0,45….0,52 dl/g to 0,80 – 0,85 dl/g providing a comfortable platform for the new **SSPT** approach
- **SSPT** will allow tremendous capacity boost by reducing the IV-lift to 40% of bottle grade lift up which is ending up in SSP throughputs of 1600 t/d (BUEHLER) - 2500 t/d (M&G) using the known equipment, know how and technology (modified to the high throughput)

The Concept:


PX Plant
PTA Plant
MEG Plant
Recycling
MPP Plant
~2000 tpd
C-PES chips
IV = 0,45 -0.50
dl/g
T-PES chips
IV = 0,65 dl/g
ready to spin
SSPT
~ 2000 tpd
IV LIFT =
0,15 –
0,20 dl/g
PES CHIPS (IV = 0,65 dl/g)
crystallized and dried and inert packed
to TEXTILE MILLS
"Jumbo" polyester textile resin unit
inside petrochemical complex

The Idea – current situatiuon:

Change the production path of textile yarn and staple fiber from three steps of today's CAPACITY SCALE

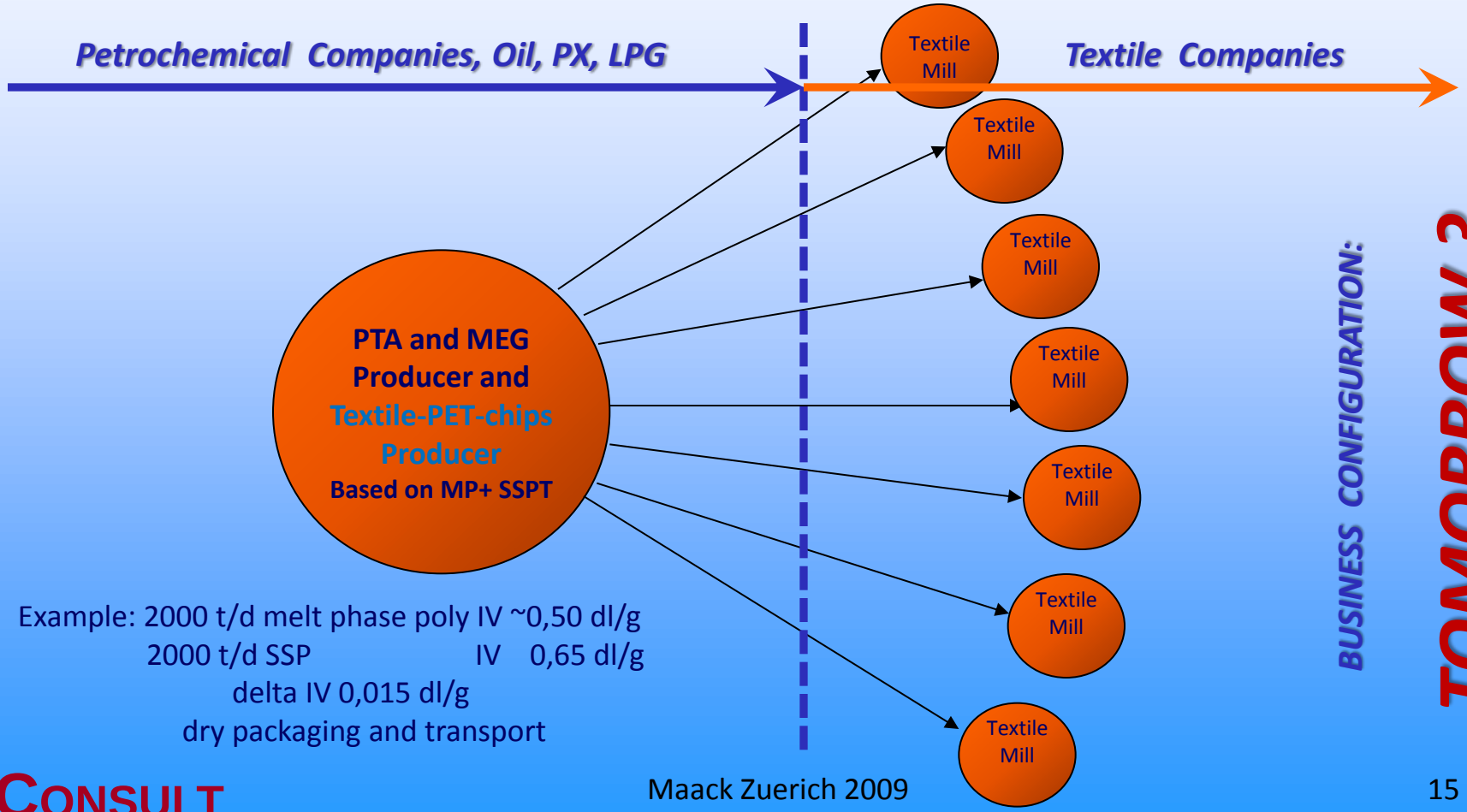


The Idea – future scenario

To two steps of tomorrow's CAPACITY SCALE

~1500 – 3500 t/d

> 50 t/d up to any capacity POY or SF



Example: 2000 t/d melt phase poly IV ~0,50 dl/g
2000 t/d SSP IV 0,65 dl/g
delta IV 0,015 dl/g
dry packaging and transport

BUSINESS CONFIGURATION: TOMORROW ?

SUMMARY Direct Spinning versus SSPT

Direct spinning of POY, FDY and SF is reaching capacity limits

- Capacity growth reaches the limit (600 t/d max 800 t/d)
- Melt distribution and melt residence time at the upper limits
- Currently 1hour melt residence time maximum
- Increased inflexibility with growing capacity
- Increased logistics, storage and transport costs in cause of central POY/SF production
- Limited shelf live of POY

New path applying MP+SSPT is generating

- Reduction of material consumption
- Separation of polymer chemistry and polymer processing (equivalent to polyolefin situation)
- Reduction of energy consumption
- Reduction of transportation cost
- High polymer quality (low thermal treatment, fine filtration, low oligomers)
- High production flexibility in spinning
- Storage time dry 6 month, otherwise > 2 years

6. Advantages of a new SSPT technology path (1)

- Substantial savings of overall energy costs, today are minimum four large poly lines and in average eight poly lines requested to produce the amount of 2200 t/d polymer and subsequently filaments or fiber
- Significant reduced material losses and operational costs
- Clear separation of chemistry (polymer production) from physics (fiber and yarn spinning and refining, garment production) is realized
- Melt phase residence time substantially reduced, moderate process temperatures are resulting in reduced thermal stress and high resin quality potential
- Short residence time of SSP results in better resin quality
- Because of low melt viscosity fine filtration of precursor (< 10 µm) is practicable, which improves polymer quality also
- Flexibility of spinning lines increase
- Spinning lines are moving to upstream processing sites
- The total transport costs are less because POY and SF transport becomes reduced

today: PX transport to PTA transport to Polymer/POY/SF transport to DTY/text. processing;
SSPT: PX/PTA/Polymer transport to POY/SF/text. Processing :
saving potential between 5 and10 Euro/t

Advantages (2)

- The polymer contains lower amounts of oligomer which will further improve spinning and mechanical properties, there is a potential to reach the same textile properties with less material consumption
- Insertion of new antimony free catalysts (Ti) is uncomplicated; results are improved spinning performance, more environmentally friendly textiles
- Pellets are dry after SSP and being transported under inert conditions, the crystallization process prior spinning is becoming obsolete
- Chemical recycling of all kind of PET waste could be performed in a central chemical recycling plant integrated into the poly
- The idea of textile recycling to raw material becomes more realistic under such conditions

In my opinion SSPT technology is one interesting possibility to overcome any capacity barrier in direct textile production at further capacity growth at one side and diversification of fiber types and increased flexibility at the other side

Sooner or later polyester might change over to the same production paths like PE, PP or PVC where first step is chemistry till polymer pellets, than transport and distribution, and second step is processing in more or less upstream integrated units; this means textile polyester will finally enter the production path of common bulk polymers.

7. Challenges of SSPT technology

- The heating energy to prepare melt out of the pellets is consumed additionally.
- A new generation of sufficient extrusion equipment to prepare up to 12 – 15 t/h of good spinning ability polyester melt is requested because currently available small extrusion lines are inefficient and costly
- Jumbo cutter of capacity > 20 t/h are requested to reduce poly investment costs
- Complete mind change of the very traditional people of textile production is required but also large future textile resin producer of petro chemistry are getting the burden of textile application research.
- Going apart from this, simple polymer conversion might be easier for spinning and textile people than further downstream integration of chemistry to textile-, yarn- and fiber production

8. Potential players

Like in PE and PP production the potential future players in SSPT are the chemical giants like for example BP, BASF, RELIANCE, SABIC, PETROCHINA, SINOPEC, SAMSUNG, MITSUBISHI, MITSUI, EASTMAN

9. Conclusions

- SSPT technology to produce textile grade polyester is providing the potential to produce textile PET pellets at an economical scale which is making a turn back from direct melt spinning to pellet spinning feasible and thinkable
- An important step towards a conversion of currently applied direct spinning to new chips spinning would be an economical study using investment- and conversion cost calculations based on proven running MP and SSP technology in bottle PET.
- Today, experienced engineering companies and equipment producers in the field of polyester are possessing all necessary design and engineering know how for planning and execution of high capacity MP and SSPT
- Even in China the time might come when flexibility and specialization will outstrip the simple bulk production of POY and PSF and optimization of transport costs becomes decisive
- The presented process study is providing a first frame to be filled with the necessary details to develop SSPT as an alternative solution to direct spinning

It might take time to become realized but a change will be necessary in future.

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THANKS FOR YOUR ATTENTION!
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