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Closed-loop XPS production from TechnoNicol

TechnoNicol was founded in November 1992 and currently operates in the heat, water and sound insulation industries throughout much of Europe. Its main thermal insulation products are extruded polystyrene (XPS) and stone wool. *Global Insulation* visited the XPS TechnoPlex plant in Ryazan, Russia. Here Vasily Tkachev, the XPS divisional operating head, outlines the plant's production process and discusses the XPS market in Russia and the CIS.

Background

TechnoNicol first considered launching an extruded polystyrene (XPS) insulation division in 2006. At the time, Vasily Tkachev worked in the sales division, which bought XPS insulation from Russia's only XPS producer, Penoplex, to sell to TechnoNicol's customers. In 2006 Penoplex did not produce enough XPS for TechnoNicol's customers and the company shareholders decided to start their own XPS division.

TechnoNicol opened its first two XPS plants in 2007. The TechnoPlex plant was the first, built in the Ryazan region, initially with one production line. The second XPS plant was opened in the Urals region later in 2007. Other plants have since been opened in a wide range of locations to achieve an effective geographic presence. TechnoNicol constructs at least one new XPS plant or line each year: In 2014, it opened a new XPS plant in St Petersburg, in 2015 a new line will be commissioned at the Siberian plant and in 2016 a greenfield XPS plant will be completed in Kazakhstan. As XPS is a lightweight product, its final price depends heavily on transportation costs. This is one of the reasons why TechnoNicol has XPS plants well-spread throughout Russia.

The TechnoPlex plant currently has 800,000m^3/yr of XPS production capacity as new lines were installed in 2008 and 2013. It is now TechnoNicol's largest XPS plant and produces boards that range from 20-120mm thick. In all of the Commonwealth of Independent States (CIS), TechnoNicol has 2.6Mm^3/yr of XPS insulation production capacity. In 2013 the TechnoPlex plant produced 650,000m^3 of XPS insulation, while TechnoNicol produced some 2Mm^3 at all of its plants in the CIS.

Products

TechnoNicol produces four types of XPS products:

- TechnoNicol XPS: For DIY applications;
- TechnoNicol Carbon: For professionals;
  - Carbon Eco: For small houses;
  - Carbon Professional: For large buildings;
  - Carbon Solid: For floors in refrigeration chambers, ice rinks, roofs, roads and railroads;
- TechnoNicol Sandwich: For windows;
- TechnoNicol Swedish board: For basements.

TechnoNicol Carbon makes up the largest proportion of XPS production and sales. There are many varieties, so it is used for many applications and by a multitude of users. TechnoNicol Sandwich makes up the smallest proportion of sales as its applications are limited: It has a PVC finish on both sides and is used to construct windows. TechnoNicol XPS sees moderate demand as it is an all-purpose product used mainly by DIYers.

TechnoNicol Carbon Solid is not frequently used or produced in Europe, but there's a lot of demand for it in Russia, where it's mainly used for road construction. Tkachev explained that for road construction, sand is used beneath other road-building materials to form a stable base. However, large parts of Russian roads are covered by permafrost and if a truck or heavy vehicle drives over it, the permafrost melts and the road is warped and partially sinks. Thermal insulation is used to protect the roads in such conditions. TechnoNicol Carbon Solid is used to replace

Company profile: TechnoNicol

Founded:	1992
Started XPS production:	2007
XPS production capacity at TechnoPlex plant:	800,000m^3/yr
Total XPS capacity in the CIS:	2.6Mm^3/yr

Far left - Figure 1: The GPPS is delivered to the TechnoPlex plant in 1t bags. The bags are cut open and emptied inside the chamber. Around 3.8t/hr of GPPS is used, depending on the products being manufactured.

Left - Figure 2: The flame retardants and other assorted additives are mixed in the dosing station prior to being combined with the GPPS.

most of the sand beneath the other materials, improving the condition of the roads. Replacing most of the sand reduces road construction costs significantly, as sand has to be transported large distances to where it is needed. Considering the large amount of road construction currently ongoing in Russia, sales of TechnoNicol Carbon Solid are high.

TechnoNicol recently launched a new XPS product called Swedish board. It is used for the thermal and water insulation of basements. When a new building is being constructed, the Swedish board is placed below the foundations to completely isolate the structure from the ground. It is produced at all of the company's plants. While its market share is small at the moment, significant marketing efforts are being made to increase its demand. According to Tkachev, the Swedish board has a lot of potential.

Raw materials

TechnoNicol sources most of its raw materials in Russia and most arrives at its plants by truck. A small quantity arrives by railway. General purpose polystyrene (GPPS) makes up 85% of the raw materials at the XPS plants, 10% is blowing agents and 5% is additives. Different products require different blowing agents. The additives include different materials for higher mechanical and insulation properties.

The blowing agents are all sourced in Russia, as are most of the additives, although some are imported. GPPS is mainly sourced in Russia, but there are only two plants that produce it within the country. As such, GPPS has to be imported for some of TechnoNicol's remote XPS plants: The XPS plant in the Far East imports GPPS from Korea or other Asian countries, while the southern plants import from Iran, Pakistan and other Middle Eastern countries. It is prohibitively expensive to transport GPPS from the European part of Russia to the remote plants.

The GPPS supply chain has changed a lot in recent years; When the St Petersburg plant was first built, TechnoNicol planned to import GPPS from Sweden. However, as the Ruble exchange rate has become increasingly poor, this is no longer viable. Similarly, originally the XPS plant in Ukraine used GPPS from Russia, but due to the political tensions, it is now importing GPPS from Europe.

One of TechnoNicol's ongoing improvements relates to raw materials. Originally around 6-8% of Freon was used at the TechnoPlex plant for XPS production, but now its use is almost zero. It is only used to produce very thick panels and special orders only for the Russian market, as a suitable substitute has not been found that produces the same quality product.

Process and production

During *Global Insulation*'s visit, Tkachev demonstrated the TechnoPlex plant's production process on Line 3, the newest. As the line is so new, it can be operated and monitored by a single worker.

GPPS is delivered to the site in 1t bags (Figure 1), which are cut, opened and emptied into the feeding chamber. Around 3.8t/hr of GPPS is used at the TechnoPlex plant. Daily consumption depends upon the products being manufactured by each line, but around 91t/day is typically used.

The dosing station mixes the flame retardants and other additives (Figure 2), which vary according to the XPS product. The GPPS and additives enter the first extruder and are heated to 100-200°C, where the materials melt into an homogeneous mixture. The melt travel time though the extruder depends on the quantity of raw materials inside. The melt leaves the extruder and is filtered to remove any undissolved additives. At this point the CO_2 and blowing agents

are added and the pressure increases to 200bar.

The material enters a second, larger, extruder (Figure 3), which measures 8m long and has an internal temperature of 70°C. The material is extruded through a 1mm head at 94bar to form the XPS sheet (Figure 4). A calibrator monitors the board thickness. Rollers transport the product 100m down the 0.75m wide line, where the board is stamped by the 'tongue' (Figure 5). The edges are then cut flat (Figure 6) and the board is cut into lengths with the 'flying knife.' The boards are then stacked and cooled on a space-efficient paternoster (Figure 7).

Once an appropriate temperature has been reached, the boards are shaped as required. In some cases an L-groove is embedded in the boards. The boards are separated into stacks and packed with an automatic packing machine. The machine wraps the board stacks with thermal film, which is sealed inside the thermotunnel as it shrinks when it is heated (Figure 8). The packages are then cooled, stacked, wrapped and stored ready for dispatch. Around two months worth of production is stored on-site at all of TechnoNicol's plants.

The production lines at the TechnoPlex plant operate continually, halting for 2-3 weeks of major maintenance each winter and 24 hours once a month for minor works. During the major maintenance it takes several days to deconstruct all of the lines to check and replace the moving parts, bearings, screws and bolts, where needed. Usually professionals from the equipment suppliers visit to perform the annual maintenance. New equipment is also installed during this time: In the winter of 2013-2014, a new extruder was installed by Krauss Maffei. The monthly basic maintenance consists of cleaning and minor repairs.

As for much of Russia's industry, XPS production is highly seasonal. The TechnoPlex plant operates at 90% capacity in the summer and 35% in the winter. Sales in January are six times lower than in August. "No one builds in the snow," explained Tkachev. This is extreme compared to most of Europe, where sales are around three times higher in the summer than in the winter.

Quality control

Quality control is very important to TechnoNicol's operations. The lab tests the XPS insulation for density, size, thermal conductivity, moisture absorbance and load-bearing properties.

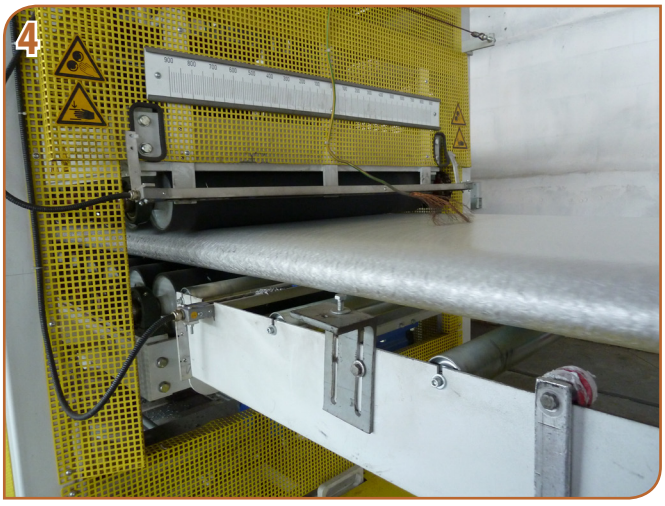
For load-bearing, the test identifies how much weight the board can withstand before it breaks. Both short- and long-term moisture tests determine the

Figure 3: The GPPS melt, blowing agents and additives are transported at 70°C through the second extruder, which was made by Krauss Maffei, one of Europe's top producers, according to Tkachev.

Figure 4: The melt is extruded through a 1mm hole at 94bar to create the XPS board on the forming table.

Figure 5: The board is stamped with the product identity using the 'tongue.'

Figure 6: The edges of the cooling XPS board are cut flat. The discarded edges are recycled.



Far left - Figure 7: The near-finished XPS insulation boards are stacked and cooled on the space-efficient paternoster in the production plant.

Left - Figure 8: The XPS board stacks, loosely wrapped in thermal plastic, enter the thermotunnel. Here, the plastic shrinks from the heat and the boards are then stacked ready for dispatch.

moisture absorbance of the boards. The short-term test sees an XPS board sample of known weight immersed in water and weighed after 24 hours. For the long-term test, the sample is immersed for 28 days. Global averages in weight variations are 0.7%, while TechnoNicol's is 0.4%. As thermal conductivity is the most important property of the XPS insulation, a sample is taken from each line every hour.

Operating efficiency

Tkachev explained that TechnoNicol doesn't use standard capacity utilisation rates. Instead, the company prefers to calculate the overall equipment effectiveness (OEE), which is more accurate and depends on three factors:

$$OEE = K_1 \times K_2 \times K_3$$

- K_1 - Product quality;
- K_2 - Line operation time;
- K_3 - Labour productivity.

K_1, the product quality factor, considers the waste generated by the production of sub-standard XPS. The low-quality product is recycled back into the production stream, but for every low-quality batch produced, efficiency falls. The more often the thickness of the product is changed on each line, the higher the defect rate becomes, reducing K_1.

K_2, line operation time, is the most complex factor. It is affected by seasonality, a predictable near-constant, as well as product specifics. The production efficiency of different board thicknesses varies from line-to-line: Detailed statistics have shown exactly which product thicknesses are the most efficient to produce on each line, at all of TechnoNicol's XPS plants. Efficiency can be improved by acting on this data. Additionally, efficiency is reduced every time the product thickness on a line is changed as production time is lost during the changeover. As TechnoNicol produces XPS ranging from 20mm to 120mm thicknesses, at 10mm intervals, changing between different products can be required frequently.

K_3, the labour productivity factor, is calculated by line and by product. Significant variations in labour efficiencies at different lines are observed. K_3 is lower at newly-opened XPS plants or lines, where the technology may be different to what workers are used to.

According to Tkachev, the average OEE of all of TechnoNicol's XPS plants is 70-80%. This value accounts for product quality and how much XPS could have been produced if operations were more efficient. Line 3 at the TechnoPlex plant is the most efficient of TechnoNicol's XPS plants, operating at 80% OEE.

Environmental concerns

TechnoNicol uses electricity for 100% of its energy needs. Water is re-used multiple times for cooling and is kept clean by the use of high-quality steel cooling equipment in the plant. The TechnoPlex plant uses a waste heat recovery (WHR) system; heat generated from the production process is used to heat the office buildings. Tkachev explained that the emergency heating is only occasionally needed. In the winter of 2013-2014, its Siberian XPS plant reached temperatures of -40°C, which the WHR system could not combat.

The TechnoPlex plant landfills 0% of its waste. Even the wooden pallets that are used for raw material deliveries are reused to store TechnoNicol's products or are sold back to the companies. The packaging that the GPPS is delivered in is made of fully-recyclable polymers and is sold to specialist recycling companies.

Right - Figure 9: When production changes between different board thicknesses, defective boards are manufactured more frequently. The low-quality XPS is processed in an Untha shredder for reuse.

Right - Figure 10: After shredding, the waste XPS is heated to an homogeneous melt at around 190°C and is passed through tiny holes under pressure to make new GPPS granules. The resulting recycled GPPS is black instead of white and is recycled back into the XPS production process.

Right - Figure 11: Additives are stored in small containers, as their consumption does not exceed 5%.

Low-quality or defective XPS is produced from time to time, most often when the line changes between different board thicknesses. There is also waste XPS that is cut off the edges of the boards during the finishing process. All of the waste XPS is processed in an Untha shredder (Figure 9) before being heated to around 190°C to form an homogeneous melt. The liquid is forced through tiny holes under pressure in order to form new GPPS granules (Figure 10), which are cooled with water. The recycled granules are black instead of white and are stored in a 100m^3 silo outside the plant. From there they are returned to the start of the XPS production process.

TechnoNicol is proud of its environmentally-friendly plants. Tkachev highlighted the XPS plant in the Stavropol region, which is situated within the town walls of Минеральные Воды (translates directly as Mineral Waters). The town is a popular destination for health-conscious tourists and has a variety of spas based on its pure natural water. The plant is inspected and tested frequently to ensure that it complies with the strictest environmental regulations and so far, there have been no problems reported.

In the future, TechnoNicol plans to install automatic windows and new ventilation systems. In the summer it can get very hot inside the TechnoPlex plant and the new systems would improve conditions for the workers.

TechnoNicol strives to continually improve in all areas, including energy-efficiency, environmental-friendliness, social responsibilities and process optimisations. The company has a unique system, wherein suggestions for improvements from employees are encouraged. The suggestions are analysed by a special team and every suggestion, of which there are around 600/yr, is granted a token reward. Around 50-70% of the suggestions are implemented and the best suggestions receive a bigger reward.

Market and distribution

Around 90% of TechnoNicol's XPS insulation is sold to Russia, Ukraine, Kazakhstan and Belarus. The remaining 10% is sold on the export markets. The TechnoPlex plant supplies XPS to central Russia and Belarus. Most of TechnoNicol's insulation is shipped by truck, although a small quantity travels via railway. TechnoNicol currently has 30-40% of the XPS market share in the CIS countries and aims to increase this further.

The XPS market in Russia is markedly different from Europe and the US. More XPS is used in Russia because large quantities are used for road construction. In Russia, XPS has around 11-12% of the thermal insulation market. In Europe and the US, where glass and mineral wool is more popular, XPS has around 6% and 3-4% of the thermal insulation market share respectively.

The XPS market in Russia is growing: Even though TechnoNicol installs at least one new XPS line each year, market demand catches up with the new capacity within twelve months. This is partly due to the market layout. While Russia has two major XPS producers, TechnoNicol and Penoplex, there are no major EPS producers. According to Tkachev, EPS is losing market share in Russia to XPS due to the poor quality of the EPS board and the low entry barrier in this market.