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NORNER NEWS 2018

Material Development for Demanding Applications

New Projects for a Circular Economy

norner™
The Polymer Explorers

Leader

3@Norner

Sven Arve Halvorsen

Hi, I am expert in plastic processing and applications and have special expertise in the rotomoulding materials and processing.

Thor Kamfjord

Hi, I am business director for infrastructure and circular economy and excited about how Norner can and will contribute to new and better solutions.

Irene Helland

Hi, as a researcher and a polymer expert, I am working in projects with packaging and barrier performance.

I have just taken over the chair after Tine Rørvik as new CEO, and enjoy working with my highly competent Norner colleagues, and with all our interesting projects and customers.

Dear reader

Norner is created on a vision:

The global market leader of Industrial R&D services in Polymers by exploring opportunities and discover sustainable solutions.

I have just taken over the chair after Tine Rørvik as new CEO in Norner, and can assure that this vision is more alive than ever.

Sustainable Solutions is one of the big global megatrend in our society, among our customers, and in everyday life. Together with digitalization, this is where the drivers for future businesses will be, for our customers, and for Norner. Digitalization brings us the speed of change, and the speed of innovations has never been so high, and will never be so slow again, either.

We are convinced that **we are near a tipping point when it will no longer be possible to run a company in an unsustainable way.** If you are not part of the transitioning, it will be harder to sell your products, it will be harder to recruit talents and no one will want to invest in your company. Based on the recent focus on plastic waste handling, microplastics and marine littering, the plastics industry is near this tipping point. We now see how fast the plastics industry are able to turn around and start to act which give us good reasons to believe that we will find good solutions, and turn this into new opportunities for the plastics industry, together.

We started off last year by announcing our plans to invest in a brand new, world leading Polymer Exploration center in Norway. This will be a unique facility for advancing developments and testing for polymers in the world's first Powerhouse, which also will include laboratories. These plans are now moving fast forward and have been approved by our owners, the SCG board recently. We will see the detailed planning and construction work starting soon.

The Powerhouse concept was a natural selection for us due to its unique qualities of being an energy-positive building. This is aligned with our vision to design sustainable material for the future – for Norner this is to Walk the Talk.

To further prepare for the future we will also invest considerably in new, state-of-the art machinery and assets, that will make Norner a preferred future partner. Along with these ambitious plans, we will continue to strengthen the team and secure future competence with recruitment of new talents. Our people are, and will be our most important asset.

2018 will be the start to prepare for the future. We look forward to work with our customers to explore sustainable solutions, together.

Enjoy the reading!

- Kjetil

Highlights

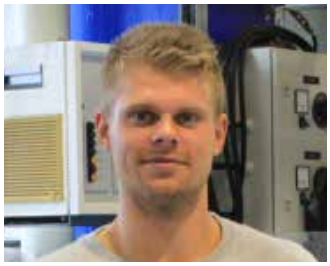
Kjetil Larsen - new Norner CEO

It is a pleasure for Norner to welcome Kjetil Larsen as our new CEO.

Kjetil holds a PhD in polymer technology, has over 25 years of people and technology leadership in major international companies. He recently came from the position as Head of Energy Management in Skagerak Kraft AS. Prior to this he has a broad background from innovation and business positions in the polymer value chain such as Protan, Amiantit/Flowtite and Borealis.

Both the board of directors, our owners and the employees in Norner regard Kjetil as a valuable addition for the continued success of and growth of Norner in the coming years. He brings broad international experience and technical competence in plastics and composites. I have been looking forward to this and am now finally here at Norner. The results they have achieved is an inspiration and I know this is due to their very competent employees", says CEO Kjetil Larsen.

New employees



We are happy to welcome new employees in our technology centre.

Our team is continuously expanding and we are happy to welcome new clever and motivated people in the near future.

Anita Thoner is certified within process and laboratory technology with experience from Noretyl, Biotek and Jotun with responsibility for development, documentation and certification. Anita has started in Performance Laboratory. She will be working in the coating team and material laboratory.

Tom Arne Henriksen is BSc in Machinery Design and a certified industrial mechanic. He has long experience from mechanical industry and production at REC, Bilfinger and EFD Induction. Tom Arne will strengthen our team in the Application Hall and work with compounding, plastic processing and application testing.

Robert Olsen is BSc in Machinery Design and a certified plastic mechanic. He comes from Bilfinger where he has good experience with plastics. Robert will strengthen our team in the Application Hall and work with plastic processing like film extrusion and application testing.

A new role for Tine Rørvik

SCG Chemical announces the ambitions to strengthen the footprint in Europe to boost the sustainable innovations of new products and has appointed Dr. Tine Rorvik in the role as Innovation and Technology Director in Europe.

To better serve customers' requirements, SCG Chemicals assigns prime importance to the development of new technology and innovation for the creation of high value-added products (HVA) and service solutions. SCG Chemicals already invested strongly in R&D facilities and competences in Asia and has today also presence in Europe through Norner owner ship and Oxford Center of Excellence.

Smarter additivation

Morten Lundquist
morten.lundquist@norner.no

Adding additives in the reactor instead of adding it during the compounding step opens for a manifold of advantages.

This has been described by leading polyolefin companies in conference presentations, brochures and in literature. In Norner we call it "In-Situ Additivation".

The effect of in-situ technology will depend on the catalyst used, the grades produced and the process selected. In Norner, in-situ technologies have been developed during a decade both with respect to practical implementation in plant, the effect on operational cost and properties of the final polymer type and product. Norner's experience covers PE and PP in situ- additivation and PP in-situ nucleation.

In this article we will further discuss PP in-situ nucleation. However several of the operational benefits will also be valid for e.g. in-situ antioxidant systems.

Addition of nucleating agent into isotactic polypropylene (i-PP) powder before compounding to produce a nucleated PP compound has been a general way to promote i-PP crystallization. This is a well established method to improve such polymer properties as stiffness and transparency in addition to processing properties as e.g. cycle time reduction by injection moulding.

Norner has explored various possible methods for in-reactor additivation and nucleation including alpha-nucleating agents, polymeric nucleating agents and the nucleation by Adeka's T-186. In-situ additivation aim to overcome the many shortcomings associated with the traditional melt-mixing methodology. That is; dispersion of nucleation agent in i-PP matrix and energy consumption during melt-mixing.

Typically, an in-situ technology will be a very moderate plant investment with a good ROI. Norner can ofer a low-cost development route using our advanced bench scale reactors, analytical and mechanical evaluation and small scale conversion pilots.

Norner can provide a full support package for companies who consider to install in-situ technology. This covers:

- FTO studies on selected technologies
- Tuning/optimisation of catalyst and nucleation systems
- Cost comparisons to clients existing (traditional) nucleation systems
- Design and engineering of modified feed/dosing systems
- Optimised recipes/formulations
- Polymer grade performance testing
- Mapping of benefits for the polymer converter

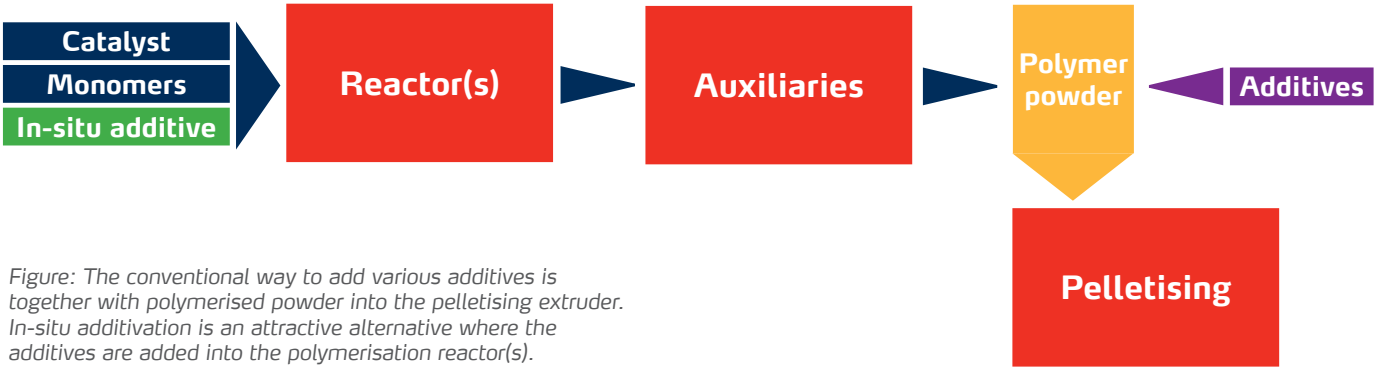
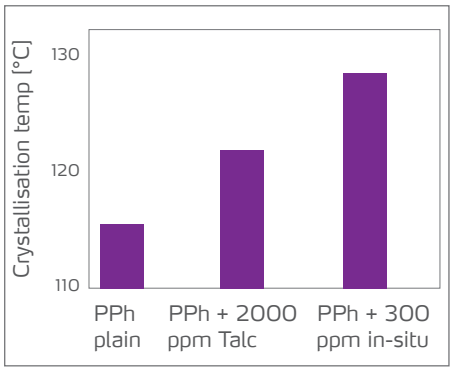
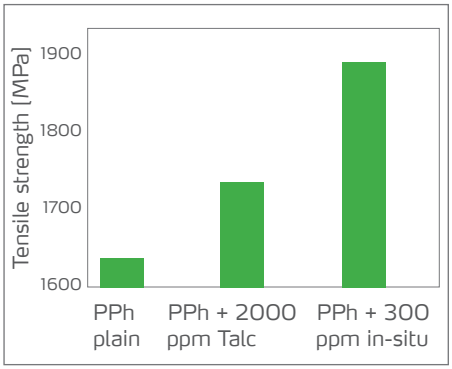


Figure: The conventional way to add various additives is together with polymerised powder into the pelletising extruder. In-situ additivation is an attractive alternative where the additives are added into the polymerisation reactor(s).

In-situ technology will first of all need less amounts of additives. This will reduce cost and improve organoleptic performance and purity. Secondly, it will be more evenly distributed in the polymer matrix. This will result in better homogeneity and mechanical properties. Furthermore in-situ nucleation will lead to better mechanical properties, increased stiffness and lowered haze which creates better products. Last but not least it will provide improved productivity at the converter through a better flow and processability, reduced cycle time and a lowered carbon footprint.

A comparison of crystallization temperature and stiffness for conventionally compounded and one selected in-situ nucleated technology with virgin PP homopolymer is shown in figures to the right. All results are Norner internal.





The concept of changing the point of adding the plastic additives from the pelletising extruder to the polymerisation reactors will represent a paradigm shift in operation, cost, quality and performance.

The market for nucleated PP is large. In Europe, for example, the market for a cost effective in-situ technology will be attractive for > 3,0 million tons per year. In South-east Asia the corresponding figure is currently about 1,5 million tons.

The strive for improved products where in-situ nucleation will have advantages will be within a variety of applications as seen in below figure.

Segment	Application	Benefits	In-situ opportunity
Thermoforming	Food packaging Catering	High stiffness	(+) PPH, PPR
Blow moulding	Transparent bottles Food and sauces	Mechanical properties	(+) PPR, ICP
Transport packaging	Foldable Containers Crates Boxes	High stiffness and Impact Dimensional consistency Reduce cycle time	(+++) ICP
Thin wall packaging	Pails food/non food Consumer food products Non-food and cosmetics	High stiffness and impact Improved organoleptics Reduce cycle time	(+++) PPH, PPR, ICP
Caps & Closures	Sport caps Wide mouth caps Covers/lids	Low Shrinkage High stiffness and Impact Improved organoleptics	(++) PPH, PPR, ICP
Houseware	Kitchen & Storage Horticulture Stationary	Mechanical properties	(++) PPH, PPR, ICP
Automotive	Compounds Technical parts	Mechanical properties	(+) PPH, PPR, ICP
Appliances	Small appliances	High stiffness and Impact Dimensional consistency	(+) ICP

Beach Cleaning Day 18' - mission completed!

Ole Jan Myhre
olejan.myhre@norner.no

Norner believes that we all can be a part of the solution to stop marine littering. Our beach cleaning actions is one of our ways to demonstrate this.

During the first week of May, more than 100.000 Norwegians went to the shores for cleaning litter off our beaches in a huge voluntary campaign.

Norner organised the largest campaign in our region with 90 employees, children, friends and customers. We managed to clean a coastline of 3 km for about 0,5 tons (!) of litter.

Plastics represents the most significant marine litter challenge and we are convinced that with our unique plastic experience, and competence we can play a significant role in research and development to find good solutions to this challenge.

The coastline of Norway is among the longest in the world when considering the fjords. Due to the major currents like the Gulf Stream and others, there are massive amounts of marine litter landing on our shores. This comes in addition to a wide range of domestic sources of litter.

National and international media have covered the problem of marine and plastic litter in depth during the past few years and this have, together with a high attention from the authorities, created the high awareness in the public. Norwegians are nature-loving and it gives us a practical meaning of doing something useful when we participate in solving one of the fastest growing environmental issues we have internationally. It's a huge task to reverse the situation with 8 million tons of plastic ending up in the sea every year.

Plastic and other items generally enter the environment as a result of irresponsible behavior or a lack of appropriate infrastructure. However, we must provide people with the opportunity to do the right thing – we need developed waste infrastructures that are easily available.

On May 3rd, we gathered at the beach of the beautiful Eidangerfjord in Telemark County.

We spread our troops over a beachfront of 3-4km equipped with sacks and gloves and a scuba diving team went subsurface to remove marine debris. During the next couple of hours approximately 150 bags and a total of almost 0,5 ton was brought back to our point of litter collection. You can see for yourself on the picture the amounts collected.

This action was also covered by the national broadcasting, NRK.

Pictures
Top left: Norner CEO, Kjetil Larsen wish welcome.
Top right: Employees and children working together.
Bottom - Norner team with customers, students and children behind the mountain of litter found in the action.

When the litter collecting was done, we enjoyed the sunny evening with a barbecue on the beach and nice time together. In this way we combined a social event with employees and customers with this very useful campaign.

The litter collected can be categorised as follows:

- rigid packaging (50 kg)
- various rigid plastics (70 kg)
- plastic films and bags (60 kg)
- expanded foams (10 kg)
- rope and twines (75 kg)
- glass/bottles (40 kg)
- metal boxes (20 kg)
- various metal scrap (60 kg)
- paper/wood (40 kg)
- clothes/shoes (15 kg)
- all together this is 440 kg.

In the fractions of rigid plastics, we found most of those typical small and larger items like nurdles/pellets, Q-tip sticks, scrubber pall rings, syringes, caps, pails to large cannister, a chair and plastic pipe.

Norner will actively work with the industry to develop and implement solutions, and continue to increase awareness and competence to impact consumer behavior.

We hope our results can inspire all of our customers to also organise similar actions in your local communities.

Plastics industry must take actions in several ways for improved awareness and developing better solutions.

Arctic expedition for microplastic research

Thor Kamfjord
thor.kamfjord@norner.no

We can all contribute to fight marine littering. Norner supports and cooperates with S/Y Fairwinds on «Arctic Expedition 2018»

Norner supports and cooperate with S/Y Fairwinds on «Arctic Expedition 2018» sailing from the Bahamas to Bermuda - Nova Scotia – Newfoundland - Labrador – Greenland - Iceland and back to Norway. The Arctic Expedition will trawl for macro- and microplastics over a distance of more than 5000 nautical miles.

The start of the expedition is in the North Atlantic Gyre, where high accumulation of plastic debris previously has been reported. Marine litter contamination in coastal waters and large stretches of Open Ocean has been investigated intensively, but there are still many blind spots. These are mostly open ocean and remote regions, where access is seasonally restricted and research is expensive and challenging, such as the Polar Regions. S/Y Fairwinds will therefore explore the Arctic waters, which is significantly less investigated, but also known to be contaminated by plastic pollution and microplastics.

The region is highly important for domestic and international fishing industry. We have recently seen investigations showing significant amounts of microplastics trapped inside the sea ice floating in the Arctic. It is therefore of high relevance to extend the fact base and knowledge of macro- and microplastics in the seas where the Gulfstream transports water into to the polar region.

S/Y Fairwinds is a 53 feet steel ketch, originally built for the German Naval Academy and offshore sailing. The owner and captain of Fairwinds is Fredrik Molin, who has been sailing full time on the oceans around the world the last 5 years.

On board this expedition participates Simen Wingrei, who had his apprenticeship and Journeyman's Certificate at Norner. He will be responsible for the trawling of macro and microplastics, which will be done systematically and after methods developed by the 5Gyres Institute. The collected samples will be analysed by Norner after the expedition.

The main objective for Norner with this expedition is to contribute to the quality of documentation of marine littering and thereby an increased understanding, awareness, and how we can deal with the issue of pollution of plastics in our precious sea.

Norner has cutting-edge knowledge within plastics and polymers and is highly engaged in serious issues of marine littering. Arctic Expedition is one of our actions to increase the effort and contribution to solve the challenges the world is facing due to plastics being resources astray.

Norner will have a special focus on plastic granules, also being called «nurdles» or «mermaid's tears», where pellet loss at plastic processing facilities currently only has been vaguely estimated.

The plastic pellets are small (3-4 mm, ~30 mg) and look similar to organisms that marine animals and birds are eating. If they are not passed through or repelled by the digestive system, they, like other litter items, may accumulate and cause malnutrition and starvation.

While consumers are responsible for the proper disposal of used products, the plastics industry must ensure containment of the products it handles, namely the plastic pellets.

About Operation Clean Sweep

Operation Clean Sweep® is an international programme designed to prevent the loss of plastic granules (pellets) during handling at the various entities in the plastics industry and their release into the aquatic environment. Today, not all plastic companies participate in the program. Results from the Arctic Expedition may encourage more companies to join. Norner wants to contribute to this increase in corporate stewardship.

Pictures
Page 8; Fairwind is trawling for litter.
Page 9; Top - life on board.
Bottom - Norner team with Kjetil Larsen (CEO), Simen Wingrei (on Fairwinds) and Thor Kamfjord

FuturePack targets improved recycling

Siw Fredriksen
siw.fredriksen@norner.no

EU has defined new and ambitious targets for circular economy and recycling of materials. This includes packaging materials. The FuturePack project develops know-how on technologies and requirements to reach these targets for plastics.

After the project kick off in 2017, all work packages and institutes are now activated and post doc's students have been employed.

The "Packaging Design for Recycling" work package deals with technology to enable increased recycling through material simplification and quality improvement of recycled materials.

At Norner we have made extensive lab work related to the quality of recycled materials. This includes studies by our own team as well as a Post-doc who had additional support from BSc students and an MSc thesis. We would like to highlight some interesting findings from this work.

RECYCLING STUDY

In a recent study at Norner, we collected all rigid plastic packaging waste from all Norner employees for seven weeks. The collected packaging was sorted into relevant fractions of material and quality. The collected materials fractions were; 17% PE, 37% PP, 23% PET, 8% PS and 15% other, a distribution which is in line with the statistics of Green Dot Norway. The rigid PE fraction included 87% bottles and 13% caps & closures. The PP fraction included 68% injection moulded cups/trays, 19% thermoformed cups/trays, 7% caps & closures and 6% bottles.

The PE and PP fractions were washed, compounded and thoroughly tested in order to identify critical factors for improving the quality of recycled plastics. Some key findings are:

- The majority of HDPE bottles are transparent or white and can be recycled to a high-quality product.
- Good sorting and quality control is important for stress crack performance in HDPE recycling.
- Coloured materials create more quality issues for both PE and PP.
- PP has more differentiated material performances and new technology for better separation is required for optimised specifications.

MIGRATION STUDY

Another study analysed the leaching of chemical substances from commercially available recycled materials. Recycled materials can be used for various applications ranging from less critical products like flower pots to critical products like food packaging. Several applications need to have a high purity and very low amount of leaching chemicals.

Packaging materials like PE and PP contain some but very low amounts of food approved additives in order to increase their functionality and durability. Additional chemicals will be included in the packaging from pigments and inks, laminating adhesives or labels - including pressure sensitive adhesives.

Chemical migration was tested according to guidelines of the EU food contact regulation (EU 10/2011) and both overall and specific migration were evaluated as well as non-intentionally added substances (NIAS). Key findings were:

- The overall migration was on a low or moderate level and within the requirement of the regulations.
- Additives and monomers were in line with the regulations.
- Several well-known NIAS from additive degradation were found.
- Some recyclates contained phthalates which is potentially carcinogenic.

The project continues to the end of 2020 with more information to come.

Challenging Greenhouse Conditions for Lankhorst

Svein Jamtvedt
svein.jamtvedt@norner.no

Polyolefins (PE and PP) will have an accelerated degradation if exposed to UV light, as several other plastics. Stabiliser additives are available but these also need to be designed for another challenging condition.

In greenhouses it is important to eliminate or control fungal diseases to avoid damage of plants, vegetables, berries and fruit. Evaporated sulphur is a well-known and efficient pesticide that protect the greenhouse crops from fungal disease and the spread of greenhouse pests.

Polyolefins used for greenhouse purposes need addition of UV stabilisers to get the desired lifetime either to be used as a greenhouse film or to be used inside a greenhouse as twine/yarn for binding up plants like tomato or cucumber. A huge challenge is that the most common UV-stabilisers based on Hindered Amine Light Stabilisers (HALS) are alkaline of nature while pesticides, including evaporated sulphur, are acidic of nature.

This means that the UV-system has to be carefully selected to avoid negative interaction (antagonism) with the pesticide used. Worst case is that the UV-system will not work at all due to protonation of HALS (see figure).

Lankhorst, our customer, is producing twine to be used in greenhouses. The twine is polyolefin based and the oriented film has a thickness of 35 µm.

They contacted Norner to develop a suitable UV-stabiliser recipe for twine and for testing of such recipe in accelerated weathering in a Weather-O-Meter (WOM). A new test procedure had to be specified because prior to weathering the twine samples should be treated with evaporated sulphur corresponding to 0.75 g S/m^2 of greenhouse area.

A Hotbox Sulfume sulphur vaporiser, see picture, was used for sulphur treatment weekly (ca. 0.15 g S/m^2 per week).

The sulphur treatment was done in a plastic tent with ca. 10 m^2 area, where the samples were located at a fixed distance to the sulphur vaporiser.

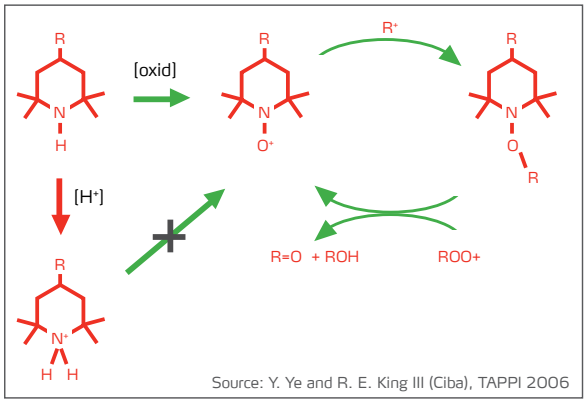
The developed UV recipe had 63% retained elongation at break after 1150 hours WOM exposure (ISO 4892-2). This corresponds to ca. 100 kLy which gives about 1 year lifetime outdoor in Central Europe.

If the twine would have been unstabilised it would have only lasted 2-3 months before it would be brittle.

If the UV stabiliser would not be resistant to the acidic conditions it would also fail. This reason for this failure is chemically illustrated in the below figure.

Figure left: The sulphur vapouriser from HotBox.

Figure right: The functionality of UV stabilisers is the ability to neutralise oxidation reactions - as shown in the horisontal chain of reactions. This figure is of a first version of HALS type of stabiliser. When this molecule is exposed to acid the active centre protonate which disable the UV stabilisation.



Source: Y. Ye and R. E. King III (Ciba), TAPPI 2006

Palsgaard®

Heart working people

Venturing new markets

Lars Evensen
lars.evensen@norner.no

Palsgaard – a world leading producer of food ingredients had been on the radar of Norner for some time, but why?
Because their emulsifiers products could have interesting potentials within the polymer industry.

Back in 2009 Palsgaard and Norner met for the first time at the Palsgaard estate in Juelsminde, Denmark. A strong team from Palsgaard covering Sales & Marketing, R&D, Business and Product management met with Norner experts in additives and polyolefin industry.

During this first meeting, Norner introduced the idea to diversify Palsgaard business into a new market segment – the polyolefin Industry.
Palsgaard was established in 1908 by Einar Viggo Schou who had a special vision for his business. Einar laid down a set of corporate and social values for Palsgaard which the company has continued to follow ever since. Owned by a foundation, Palsgaard has the freedom to think long term without the everyday pressure from shareholders.

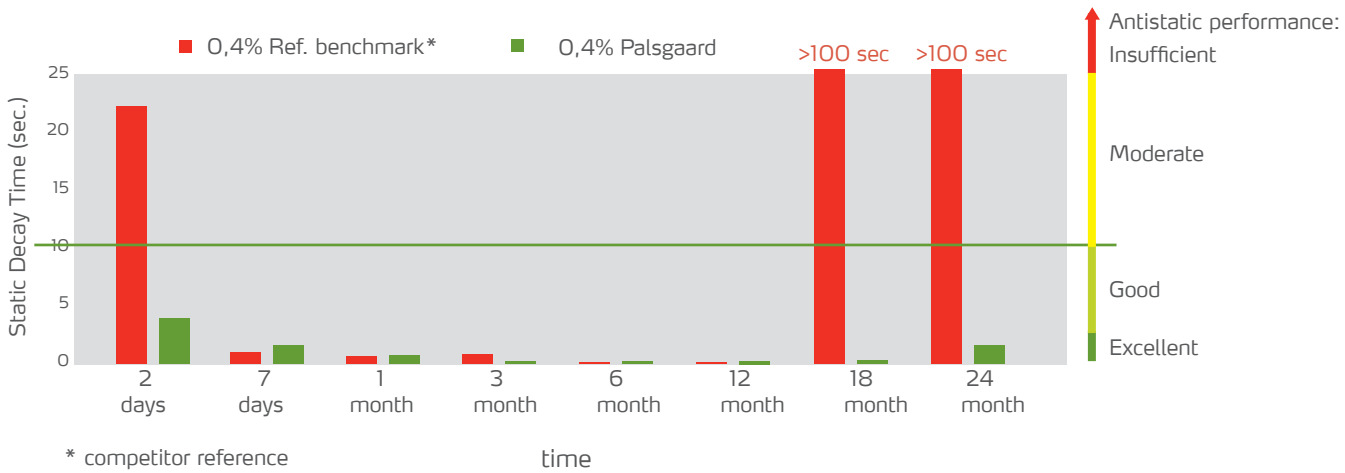
Their sustainable product philosophy and knowledge in the food industry was a good platform to enter the additives to food packaging with 100% vegetable based products. Combined with Norner's advanced laboratories and expert knowledge in the polyolefin (PO) industry and its requirements, the opportunity was up for grab.

Through several workshops, Palsgaard and Norner analysed and worked out;

- The PO market & technologies
- Emulsifier based additives, their applications in plastics and the requirements
- Value Proposition
- Market Plans
- Roadmap

This work was followed by projects were Palsgaard's existing products were analysed and tested against benchmark from market leaders to enable Palsgaard management making a qualified decision whether to expand their business into the polyolefin (PO) industry.

Figure: Comparative study of antistatic performance. The antistatic effect is measured as static decay time.



The test results confirmed that Palsgaard's emulsifiers excellent performance as anti-fogging agents in PE and antistatic agents in PP with properties even exceeding the benchmark.

"Palsgaard decided to go for the leap into a new market for their products"

Palsgaard decided to take the next steps and started the development of new tailor-made products for specific PE and PP applications supported by Norner application testing and feedback.

To prepare their organisation for the new business, Palsgaard sent 25 key employees to Norner for a 1-week tailor-made training program. The training covered all aspects of plastics and the PO industry, market requirements, testing & characterisation, PO procurement strategies and even included role-plays, making Palsgaard ready to interact with the PO industry in a professional way.

Palsgaard, who since long have had a sophisticated R&D branch (Nexus) supporting their activities in the food sector, gradually developed their own capabilities in product characterisation and application testing for the non-food area.

In 2017 they invested in their own dedicated Development Centre for functional agents to polymer application, hiring a highly skilled staff headed by Bjarne Nielsen, a well know capacity from the additive business.

In 2016 Palsgaard launched their new product range for PO applications under the brand name Einar® - honouring their founder Einar Viggo Schou and closing the circle.

Sustainability is vital for the "Heart working people" at Palsgaard, and they have established a blog called "Emulsifiers for Good"; www.emulsifiersforgood.com

The purpose of Emulsifiers for Good is to educate on the use of emulsifiers in food and in non-food applications and to advocate that these emulsifiers be produced in a sustainable manner, to help achieve the UN's 17 Sustainable Development Goals.

Posts on the blog are written not just by Palsgaard staff but also by other experts within the food and non-food industries or by sustainability focused NGOs. If you are an expert in the use of emulsifiers in polymers, we are sure Palsgaard would like to invite you to contribute to the blog as well.

We would like to thank Palsgaard for an excellent and exiting cooperation and wish them all the best in the PO industry.

_____

Top Picture: Paalsgaard additives can be used as antifogging additives.
Courtesy of Paalsgard

Mezonic

Challenge in a bin

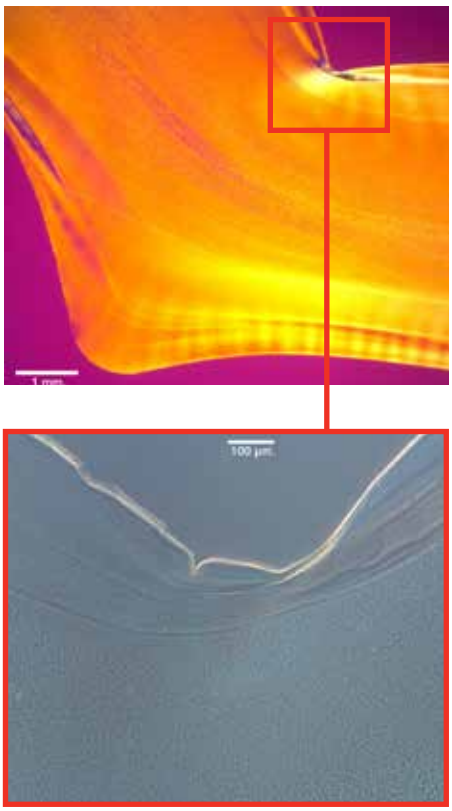
Jørgen Nyhus
jorgen.nyhus@norner.no

Development of a new wastebin sounds like an easy task. It's not! At least when it should be used for dangerous waste. Add functional design and it gets even worse.

Mezonic have developed a full plastic, patent pending, combined storage and transportation container for solid and liquid waste. All parts of the CC container are produced from injection moulded high-density polyethylene. This eliminates corrosion problems and adds durability. It is designed for high strength with shock absorbing ribs on the lid and at the bottom of the container. The design also makes the bin stackable which enable efficient in transportation.

Norner was engaged by Mezonic during their development of the, so far, world's largest UN-certified injection moulded container for dangerous goods. Our expertise was needed in material selection, mould improvements and optimization of processing conditions. In this article we share some of the many lessons learned during this challenging and, in the end, very successful project.

The Challenges
Mezonic aimed to make the World's largest UN-certified injection moulded container for dangerous goods. To overcome this challenge, the best material had to be selected, processing of the thick-walled big container optimised and certification test requirements overcome (e.g. drop tests and pressure tests).



Right figure: Sharp corner radiuses caused parts to crack. Example from study of an early mould design requiring improvements.

Mezonic had selected a multi-modal PE, based on data sheets and supplier information. But this was not successful. Mezonic then came to Norner for help due to our competences and detailed understanding of PE materials, processing conditions of injection moulding as well as root cause analysis by microscopy.

The first task was to investigate material morphology differences after moulding with a selection of the most promising PE grades which concluded with a recommendation of a material which worked well.

Norner helped Mezonic further in several optimisation stages of mould design and IM process parameters. Microscopy and analytical evaluations in this work could explain and identify preventive actions for;

- delamination problems
- impurity sources
- notch sensitivity

After each stage, new prototypes were undergoing UN-testing followed by new investigations and improvements until the container passed the certification.

Containers are delivered in several colours and some pigment types and masterbatches have been more challenging than others. Mezonic experienced problems of dispersion and distribution of pigments, impurities and that different pigments influenced nucleation and thereby morphology and physical performance.

With the assistance from our microscopy team, all of these issues could be identified, understood and properly addressed. Each of them got solved.

The below pictures are some examples of microscopy investigations during this product development.

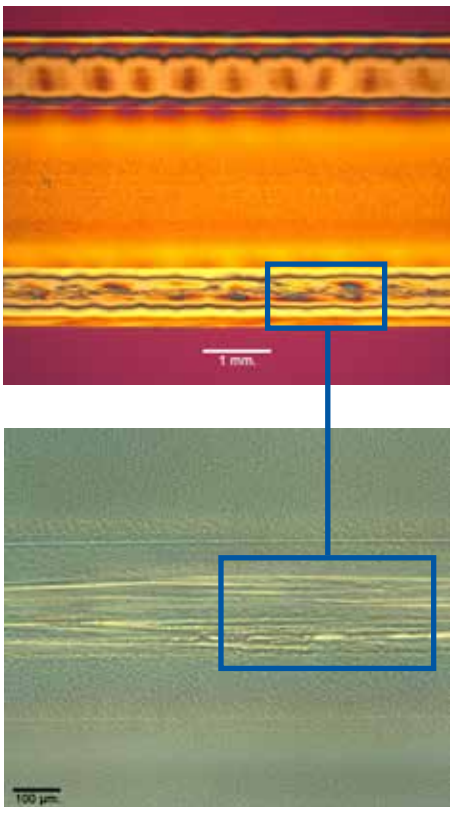
Mezonic and Norner learned many lessons in this challenging development. Our best advice is to always include more detailed testing and microscopy investigations in the design- and process set-up phases. This reduces risks of failure, delays and saves significant costs long term.

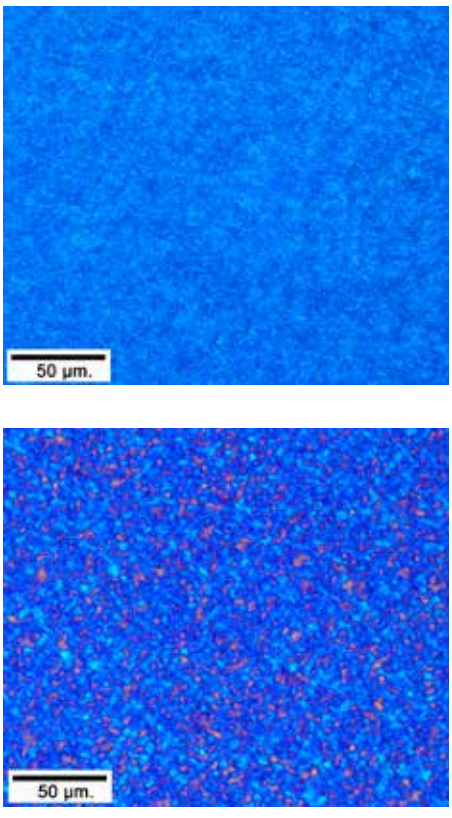
For Mezonic it's extremely important to have strong confidence in their products and this product is now well founded on deep insight and documentation.

Left figure: Laminar layer in the shear zone (cold orientation), which in worst cases may lead to delamination.

Middle figure: Delamination challenges at an early development stage. Better material selection and improving moulding conditions removed these problems.

Right figure: Morphology differences caused by two different pigments.





Vikothe th

TRELLEBORG

Henning Baann
henning.baann@norner.no

Trelleborg is a leader in thermal insulation for subsea installations in the Oil & Gas sector. They earned this position through innovation and product leadership. Norner is now engaged in a new exciting project.

Thermal insulation is necessary to avoid formation of hydrate plugs and wax build-up in subsea structures. The build-up begins when the oil or gas composition temperature is not maintained and begins to cool. Without thermal insulation the cold seawater rapidly cools down the oil, forming hydrate or wax blockages making it impossible for a safe flow.

The target of this new project is to develop a monolithic subsea thermal insulation material which vulcanises at temperatures below 50 °C and a low thermal conductivity of maximum 0.15Wm-1K-1. It also shall have unlimited water depth and high temperature operational capability.

There are many materials that can be considered for this purpose. However, the raw material cost and ease and speed of application must be borne in mind. The material development programme started with a wide material focus and have looked at liquid systems such as methacrylate's and also derivatisation of other commercially existing products to give new material possibilities. These considerations have led to the choice of rubber based systems as the main avenue of development. This also gives a very good fit to Trelleborg's long experience with rubber based systems for commercial use.

The development of a commercial product, also requires the development of suitable QC methods to allow inspection of the system during production. A wide range of non-destructive test methods have been investigated with a view to monitor the curing process on-line.

The development of a rubber based product requires attention to both the resin and vulcanisation package. Several materials will cope with the temperature requirement, but not the requirements for low temperature vulcanisation or low thermal conductivity. Thus, considerable effort has been invested in the development of novel vulcanisation chemistries which are stable and which give the desired reaction at the required temperature.

The situation is particularly challenging in as much as the ambient temperature where the material is to be applied is often close to the vulcanisation temperature and the applicator needs a certain minimum time to apply.

erm R3 - Next generation hermal insulation material

The delivery of material to the point of use is also a consideration as the system must be stable for a long period of time from manufacture and through shipping to distant lands. Preferably without the need for refrigeration. Finally, the method of producing the material must be such that during work at site, using simple and robust equipment must be possible.

Over the past two and a half years, the development has given us:

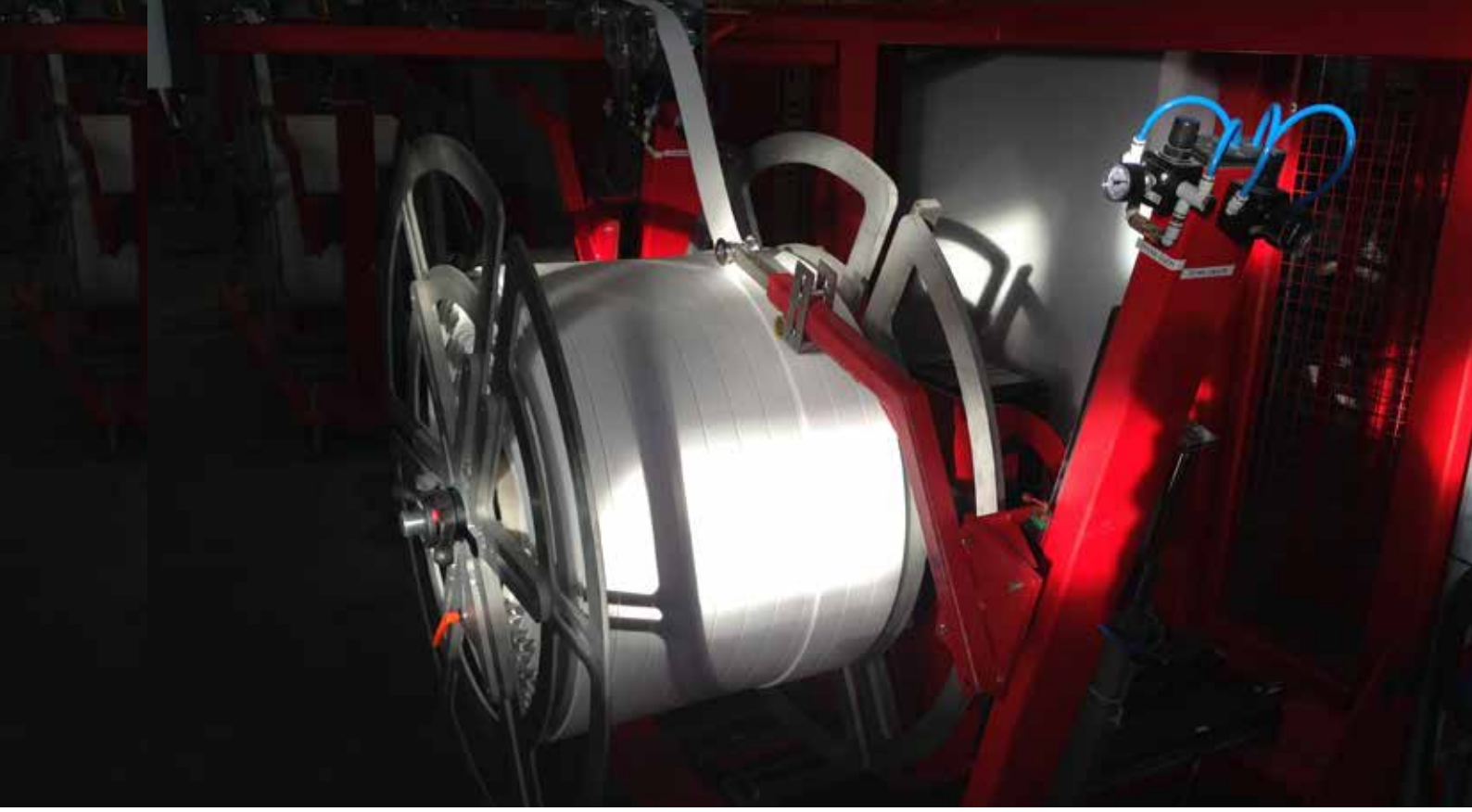
- A clear decision as to which materials are suitable for this application
- A developed formulation for a vulcanisable rubber system which fulfils the thermal and mechanical requirements.
- A 2-component system that is stable for transport.
- A self-agglomerating material, with excellent properties for application.
- A material that can be produced using relatively simple equipment.
- A good overview of relevant inspection techniques together with their readiness for use.

The current status is that the project is moving toward full-scale trials on production scale equipment in which the material will be produced and applied under conditions in keeping with typical production conditions. This will provide test items that can be subjected to full scale simulated service testing and material ageing and characterisation studies. This, with a view to releasing the application of this material as a robust service to the offshore oil and gas industry.

Norner was selected as a partner due to our capacity in material development, polymer and polymer stabilisation competence backed up with a unique and advanced test facility. Our autoclave test house is fully utilised in this project to secure service life design in harsh environment as high temperature and pressure.

Norner will further contribute with material characterization, develop non-destructive test methods (NDT), on-line curing methods and testing of the selected rubber material(s). NDT will be used for process and product quality control and verification. Novel destructive and non-destructive test methods are being developed in the project.

This project increase Norner's rubber material expertise, strengthen our competitiveness as a research institute and broaden our service offering as a material expert for the Energy Sector.



Calora Subsea - a decade of R&D collaboration

Jørgen Nyhus
jorgen.nyhus@norner.no

Calora Subsea is a key partner for material innovations with Norner and our first major customer. Norner has been a key success factor for this profitable company and vice versa.

Norner had its 10 years anniversary in the fall 2017. Interestingly we shared this anniversary with our very first "real" customer, Calora Subsea (CSU). It is interesting to share some moments from the story of CSU and the very fruitful partnership with Norner.

CSU started out as a good idea at the right time. Entering a business within an expanding field of flexible pipelines for Oil & Gas, teaming up with a strong customer and the ambition to make market leading products. The company offers design, development, production and sales of polymer based products for subsea use. Their first and foremost product has been syntactic PP insulation tapes with extreme dimensional and thermal stability.

CSU knocked on Norner's door back in 2007 and is still one of our most frequent guests. In the start, the relationship focused on Norner providing QC services as part of CSU requirements to supply material certificates with product deliveries. Furthermore, this relationship has been expanded into close R&D collaboration on various projects. The business collaboration passes a 10-year milestone in 2018.

calora subsea as

CSU is a very innovative company, with a strong industrial basis. CSU is a demanding customer in the good sense, and together with Norner many stretched targets have been reached.

We have worked on product and material understanding from first principles, tested materials and products under tough and accelerated conditions, developed new recipes and verified product performance of new and commercial products. CSU has utilized a broad range of Norner's areas of expertise, such as polyolefin compounding and extrusion, material and analytical testing, compatibility testing, microscopy and failure analyses, to mention just a few.

CSU has with its strong customer relations and high-quality focus gone through the recent oil market crisis incredibly balanced. We wish CSU the best for 10 new years and look forward for new and exciting collaboration.

ISO 17025 Accredited testing of protective coatings

Henriette Skarpeid
henriette.skarpeid@norner.no

We strive to continuously increase our service offering and maintain high quality. Therefore, our testing services of protective coatings are now in the last phase to obtain a ISO 17025 accreditation.

Pre-qualification testing of protective coatings in accordance with Norsok M-501 and ISO 20340 consist of various test methods depending on the area of application.

It is essential to have good procedures and routines for the testing and Norner has therefore decided to apply for ISO 17025 accreditation within protective coating testing area.

Our intention is to fulfil the intention given in "Joint ISO-ILAC-IAF Communique – General Requirements for the testing and calibration laboratories":
"A laboratory's fulfilment of the requirement of ISO/IEC 17025 means the laboratory meets both the technical competence requirements and managing systems requirements that are necessary for it to consistently deliver technically valid tests and calibrations. The management systems requirements in ISO/IEC are written in language relevant to laboratory operation and operate generally in accordance with the principles of ISO 9001".

Advantages for our customers will be:

- Our equipment and instruments are regular checked by accredited and independent third party.
- Our test methods are according to latest versions of international standards.
- Accurate traceability throughout the complete testing.
- Overview over uncertainty budget related to testing.
- Skilled and approved personnel in all functions.
- Accredited management systems.
- Accredited reports.

ISO 17025 accreditation is a demanding and time-consuming process, but has increased our knowledge in all functions throughout our organization. We are certain that this breakthrough in quality improvement will improve quality in the whole value chain within the coating industry.

Failures in Rotomoulding

Sven Arve Halvorsen
sven.halvorsen@norner.no

Kristen Kjeldsen
kristen.kjeldsen@norner.no

During our 25+ years of experience in Rotomoulding applications, we have been faced with a lot of problems.

Even if the machines, materials and operators are getting better and better, problems will still occur. At the same time the requirements and demands of the product are increasing. This will be challenging for us working within this industry.

The problems we have been confronted with have various casualties and often they are composed of several problems. it can be problems related to the production of the resin, compounding or pigmentation of the material, grinding of material and, finally, processing issues.
Norner has long experience in examination of problems within rotomoulding. We also have broad background from other plastic applications like injection moulding. Failure and root cause analysis of plastics is a key competence.

Rotomoulding struggle with such problems and this article is the first of two parts which is a summary of some key problems, their cause and solutions.

SWIRLING

Swirling is defined as darker stripes or areas within a pigmented part. This is caused by a higher pigment concentration in the darker areas and is a problem for dry-blended recipes. The reason is that during the dry mixing of pigment into the natural powder, there will be a static build-up of the polymer powder particles.

Static electricity is a well-known problem in rotomoulding. Smaller particles will first be statically charged and relatively more pigment will adhere to these particles, because the pigment particles are smaller in size compared to the powder particles.

When the rotomoulding process starts, the smaller particles will attract to the mould surface, due to the static charge, and create these darker areas /stripes.

How to solve it?

- Use a fully compounded material but this will increase the cost
- Add antistatic agent direct into the mould. A small amount of mineral oil or water can also help.
- Try to avoid too much fines in your powder. Check the supplier specification for Powder Size Distribution.
- Increase the relative humidity level in the processing area
- Additive suppliers are also working to find new and better solutions to avoid static build up.

MATERIAL DISTRIBUTION

It is highly important to keep even wall thickness when making a plastic product. The rotomulding process itself creates relatively even material distribution despite of the specification from the designer. Sill it is a challenge to control the wall thickness and tolerances are often in the 10 -20% range. Too high variation can give problems of warpage, stress and failures in the product.

How to solve it?

- Change the rotation speed and ratio.
- Optimal mounting of the mould on the arm to avoid parts of the mould are shielded from heat.
- Check the dry flow behaviour of the powder to ensure it flows well in all parts of the mould.

Written in collaboration with Ronny Ervik, Ultra Polymers

MOULD VENTING ISSUES

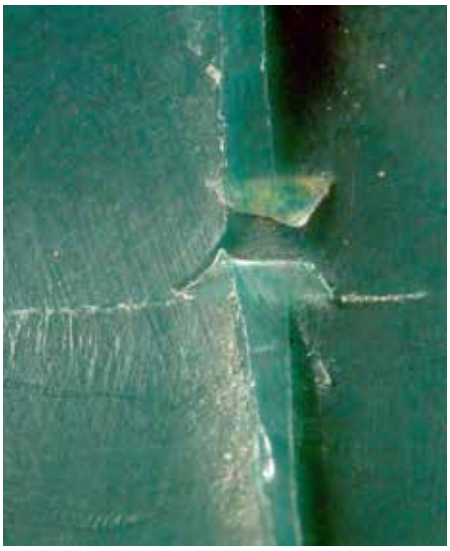
The moulds normally have a vent pipe from the interior to the exterior. This ensures that the inside always remains at atmospheric pressure.

Heating: If the vent pipe is blocked during the heating stage, there will be a build-up of pressure inside the mould. This tend to force the plastic out at the parting line, creating bubbles at the outside of the product which again gives product failures.

Cooling: If the vent pipe is blocked during the cooling stage, it can create a vacuum. This can pull the part away from the mould wall and create a distorted product. Also bubbles or pores can occur in the parting line at the inside of the product, resulting in product failures.

How to solve it?

- Always secure that the vent pipe is pen and the size fits to the mould size.
- Place a Teflon tube with glass fibre or steel wool through the vent pipe to avoid polymer powder escaping from the mould and to keep the equilibrium of the pressure between inside and outside of the mould.
- Make sure parting line and flanges are designed and located to facilitate damping.
- Maintain and clean the parting line frequently in order to prevent powder exiting during the heat cycle and water — entering during cooling.



NOTCH SENSITIVITY

Polyethylene is very sensitive to notch. This requires special attention when demoulding and trimming products especially if tools or a knife is used. Products having inward corners and products where other parts will be mounted on to the end products need special attention.

Notches should be avoided because these are starting point for failures. Air bubbles occurring in the parting line, can also be starting points for failures. This is illustrated in the figure.

How to solve it?

- Avoid sharp edges when mounting spare parts on products, which can make notches in the product during movements or loading when in service.
- Inspection and maintenance of the parting lines. If it is a bad parting line, material will come out between the two halves, hence, more difficult to trim the products.
- Knifes can make a notch and notches have to be avoided. Do not use Stanley knives or other sharp knives for removing excess material. Special equipment is available in tooling shops.

DESIGN

Plastic products are cost effective with high performance. When adding attractive properties such as chemical resistance, toughness, durability and easy processing of complex parts, the use of plastics will continue to grow. We need to ensure the quality through good design procedures.

The image shows a problem caused by wrong design. Bridging has occurred in parts of the product. This is not favourable, because it often gives product failure during service. We will not go in depth on how to design for rotomoulding here. There are good literature which describes the design process but here are some important aspects to consider:

Stiffness: An advantage of rotomulding is that we can make products with thin walls relatively to the size of the product. Introducing ribs and kiss-offs will provide higher stiffness and load support in rotomoulded products; especially when using materials with relatively low stiffness and strength like PE.

Corner radii: A rotomoulded product will have stress concentrations in its corners. Sharp corners will amplify this. By introducing radii's, the corners get smoother from a better flow and more even thickness. The stress Will be distributed over a bigger area and the result will be a tougher product.

Tolerances: This depend on the type of material used and the design. Wall thickness, size, complexity will influence the tolerances together with processing parameters. All these factors need to be monitored to produce a narrow tolerance product.

Improved gas barrier simulations for food packaging

Irene Helland
irene.helland@norner.no

Norner's barrier calculator has become a popular tool among professionals in the packaging industry. We have now made major upgrades of the calculation possibilities.

Barrier properties of packaging materials are important requirements to consider when selecting and developing optimal packaging systems. Packaging materials could prevent ingress of oxygen and/ or moisture, they could keep desired balance of oxygen and carbon dioxide (CO_2) and they could prevent loss or ingress of flavours and solvents.

Our web based calculator for barrier properties was developed by a team of Norner experts and is a tool for making simulations in the packaging design phase. By using this calculator, the developer can investigate changes in design and layer structures without expensive testing in a screening phase. It will also be possible to reduce instrumented testing of permeability and actual testing of shelf life in the development phase.

The simulation model estimates the oxygen transmission rate (OTR) and water vapour transmission rate (WVTR) of packages by most plastic materials like PE, PP, PET, PA and EVOH. Barrier properties of co-injection or co-extruded multilayer and in-mould-label solutions can be studied and evaluated for cups, bottles, films and square containers.

The flexibility of geometrical options, permeability properties and environmental conditions provides a useful tool for design, development and application of plastic packaging.

The shelf life of a food product is the period between the manufacture and the retail purchase, during which time the product is of satisfactory quality in terms of nutritional value, flavour, texture, appearance and safety.

The shelf life of a food product is depending on the "activity" of the product, the environment in the value chain and distribution, especially the temperature as well as the properties of the packaging system, especially the permeability.

NEW FEATURES

Norner has now upgraded this web based calculator with CO_2 transmission rate calculators. Two new models have been developed for calculation; one is for a constant CO_2 concentration on one side and the other is for a declining CO_2 concentration (as in MAP).

A second upgrade is the possibility to calculate the permeability for a sequence of different conditions, i.e. a dynamic simulation of the packaging. This allows the user to simulate the variations in conditions in the value chain.

The dashboard and web interphase is also redesigned and the calculators are available both in a full version, which is payable, and a free simplified version.

A wider selection of materials, unlimited number of layers for extruded films and blown articles, unlimited number of layers for cup and square boxes as well as IML and an unlimited number of conditions calculated in a sequence is available in the payable version.

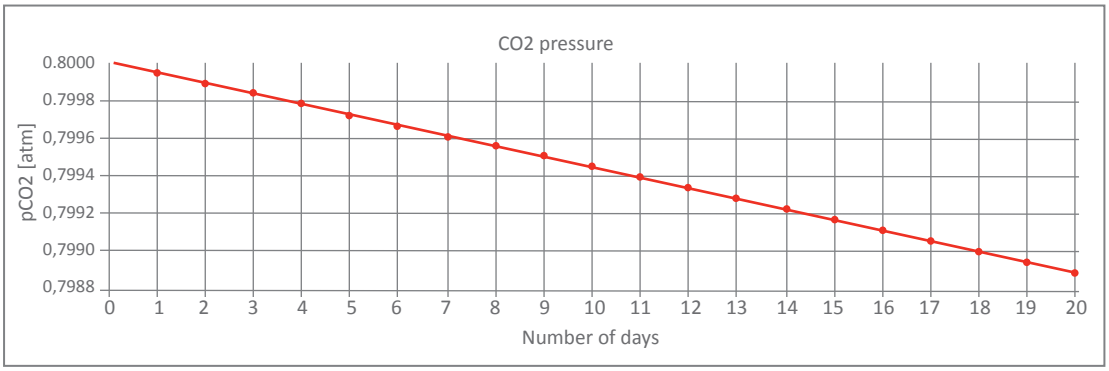


Fig 1: Example 1 - Loss of CO_2 pressure in a MAP tray made from 100µm plain PP with initial concetration of 80% CO_2.

EXAMPLES

1 - Modified Atmosphere Packaging

Modified atmosphere is the practice of modifying the gas composition of the internal atmosphere of a package (MAP) to improve shelf life. For instance, the use of gas mixtures with relatively high levels of CO_2 can double the shelf life of raw poultry.

In this example, poultry is MAP-packed with 80% CO_2 in a thermoformed tray (20x10x5 cm) with a lidding film consisting of decorated aluminium foil. Since the logistics is cold and low permeation can be expected, a plain 100 µm PP tray was tested versus a barrier tray consisting of 40µmPE /4µmTIE/5µmPA6/3µmEVOH32/5 µmPA6/4µmTIE/40µmPE. Loss of CO2 pressure in the plain PP tray as a function of time is illustrated in the figure on previous page.

The figure show only a minor loss of CO_2 in the plain PP tray. For the barrier tray the loss of CO_2 is insignificant and the MAP atmosphere is constant during the 20 days we selected for these calculations. At the same time, the barrier towards oxygen was calculated using the OTR calculator. The results show that the plain PP tray has total transmission of 30 ml versus 0,13 ml for the barrier tray.

The balance of MAP gases and oxygen transmission is the key to keep the food fresh and it can be expected that the plain PP in this example is sufficient to retain the CO_2/MAP gas, but insufficient to keep the oxygen transmission sufficiently low.

2 - Packed meat

The quality of meat is affected by the presence of oxygen. This effect is further influenced by temperature and temperature is known to vary through the logistic chain from producer via retailer to consumer.

This example describes a logistic chain comprising storage at producer, transportation to retailer, storage at retailer, transportation to consumer and storage at consumer. We have assumed that temperatures alter between 4 and 20°C. An oxygen limit of 1 ml is further defined. It is interesting to compare the barrier performance of a multilayer and a monolayer film.

We have defined a costly a but common 7-layer PE/PA/EVOH film structure with the following composition; [40µ mPE/4µmTIE/5µmPA6/3µmEVOH32/ 5µmPA6/4µmTIE/40µmPE].

As a cheaper alternative solution, a thermoformed monolayer PET tray, 200 microns, is defined. The oxygen transmissions during the logistic chain over a period of 22 days is calculated and given in the figures below.

These examples illustrate that an acceptable shelf life for the defined oxygen limit is achieved for the 7-layer PE/PA/EVOH film structure, while for the monolayer thermoformed PET is insufficient since the oxygen limit is reached already at the producer.

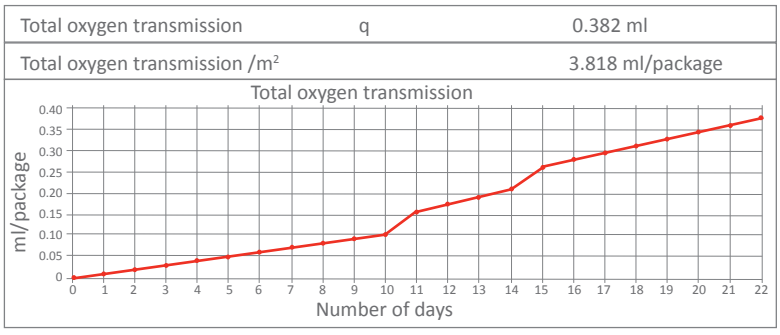


Fig 2 / Example 2 - Oxygen transmission for a 7-layer PE/PA/EVOH film structure

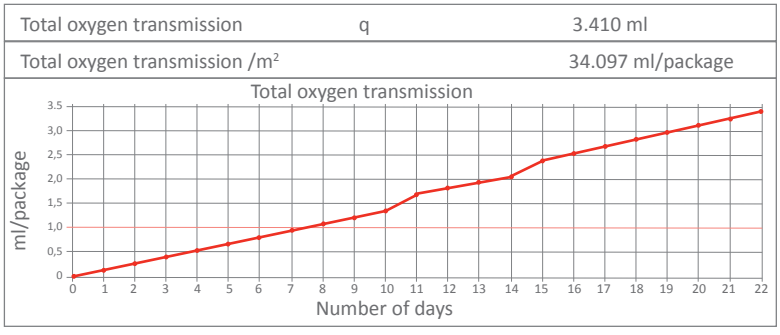


Fig 3 / Example 2 - Oxygen transmission for a mono layer PET thermoformed structure

Return address: Norner AS, Asdalstrand 291, NO-3962 Stathelle, Norway

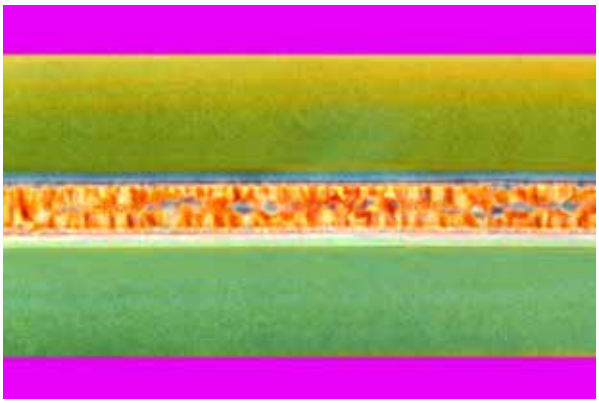
At the back

Norner has leading expertise in microscopy, microstructure and material analysis for investigation of failures and material composition. This is an example of how multilayer material structures for flexible and rigid packaging are analysed.

A key competence area of Norner is our advanced packaging development centre including film extrusion lines, MDO line, injection moulding and EBM machinery and a flexible and rigid packaging test centre with physical and analytical services. This is led by a dedicated expert team in plastics and packaging.

In order to analyse the structure and composition of multilayer moulded, laminated or extruded film structures it is necessary to involve several techniques. Each will provide valuable information regarding the polymer composition of the film/sheet/bottle/cup/tray, the number and thickness of its layers and their polymers. Detailed analysis with photographic documentation will be provided for the structure as can be seen in the illustration below. Photo documentation can also be provided for sealing areas, perforations or scoring, delamination problems or other critical details.

The analysis may include several methods which enable analysis down to even a very detailed level. These are useful to split into a range of analytical services of basic investigations and more advanced analysis. Our alternatives and procedures in structure and polymer analysis can be listed as follows:



- Basic microscopy analysis for documenting the number and thickness of layers.
- Basic polymer analysis by FTIR and DSC for identification of all polymers contained in the structure.
- Advanced microscopy analysis for investigation of the melting behaviour of each layer and contrasts with different light filters.
- FTIR analysis of each layer under microscope for detailed identification of polymers in the layers.
- Scanning electron microscopy for investigation of scoring and perforations or inorganic components like catalysts.
- Further analyses like GPC/SEC, NMR, MFR and density will give more detailed and valuable information in some cases.

We recommend carrying out such analysis in the same sequence as presented above.

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You can access these earlier editions of Norner News through our homepage www.norner.no or read them at http://issuu.com/norner

NORNER**NEWS**

Norner AS
Asdalstrand 291
NO-3962 Stathelle
Norway

Tel: +47 35578000
Fax: +47 35578124
Web: www.norner.no
Mail: post@norner.no

norner™
The Polymer Explorers

Photo by Tom Riis, Torkel Bach, Kristen Kjeldsen, Istockphoto and Norner