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Editor's Note

We are now at the start of 2017, and I hope that all of our readers had a pleasant New Year's. Looking back over the past year, the Japanese converting industry seems to have been primarily supported by two industries, namely flexible packaging and lithium-ion batteries.

One reason for the popularity of Japanese made printing equipment is that these machines will function for 20 or 30 years if provided with proper maintenance. Although this means decades will sometimes pass before a customer will purchase a new machine, printing equipment manufacturers are starting to see replacement orders for machines built more than 20 years ago that are now coming to the end of their usable life.

As you are aware, packaging is essential for shipping goods to market, but it is also becoming increasingly important as an on the shelf marketing tool. Because of the diverse range of demands from this marketing aspect, we have been seeing an increasing number of options for flexible packaging printing, from conventional gravure and flexo, to newer inkjet, digital, and offset machines. This competition of printing methods has also been a driver of new machine sales, particularly because the right machine for the right application is essential to the success of converters now.

Meanwhile, applications for lithium-ion batteries have expanded from electronic devices to automobiles and airplanes, and are expected to find demand in an even greater number of fields in the future. As such, the demand for battery separators, particularly in East Asia, has been driving the growth of slitting and coating equipment. Likewise, the rapid growth in China’s lithium-ion battery production capacity has also been placing pressure on Japanese coater and slitter manufacturers to produce the related equipment.

As the automobile industry shifts to electric vehicles, we will see further growth in the lithium-ion battery industry. Despite the fact that hybrid vehicles and fuel cell vehicles are better able to meet the non-stop long-distance requirements demanded by customers, for example the 600 km distance between Tokyo and Osaka in Japan, electric vehicles are finding a niche in shorter distance city driving, which only requires a range of 150 km.

In either case, given the issues of industrial maturity, societal changes, and market value shifts faced by Japanese industry, innovative businesses are growing. As we head towards the 2020 Tokyo Olympics, which will be a major showcase for Japanese technology as a whole, we look forward to introducing the next-generation of manufacturing from Japan.
Exhibition Preview
Converting Technology Exhibition 2017

ICE Europe 2017

ICE USA 2017

The FN405E, a Cutting-edge NS Slitter Model Developed for Flexible Packaging
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Theoretical Approach to Winding Defects
Toshimitsu Kanda, Process Technology Section, Product Research Department, Research Center, LINTEC Corporation

PSA Fundamentals and Evaluation
Toshio Sugizaki, Research Planning Section, R&D Strategy Dept. LINTEC Corporation

Targeting a WVTR of Less Than 0.000001 With a Roll-to-roll Organic Catalytic CVD System
Professor Hiroshi Nakayama, Graduate School of Engineering, Osaka City University Shinji Wakura, CEO, Asahi Electronics Laboratory Co., Ltd.

Pursuing Table Die Coater Technology to Meet the Needs of Customers
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Together with Converting S.p.A., an Italian flexible packaging converting equipment manufacturer, Eastman Kodak Company (Kodak) unveiled the XGV (Extended Gamut + Varnish) hybrid printing system for flexible packaging and labels at drupa 2016. During a press conference in Japan last November to announce the world's fastest full-color inkjet press, the PROSPER 6000 S, which Kodak newly developed for paper carton and architectural material printing, Will Mansfield, director of Marketing, Inkjet Printing Solutions, commented that they expect to release XGV to the world in the summer of 2017. Meanwhile, in March 2015, Kodak announced it would sell off its inkjet business, including PROSPER, which throws this announcement into a new light.

PROSPER 6000 S Hybrid and Stand-alone Systems

With 550 patents related to inkjet printing, 2017 marks Kodak's 50th year in the inkjet business. Using Kodak's continuous inkjet nozzle technology, PROSPER heads are able to deposit proprietary water-based nanoparticle pigment inks at a speed of 20 m/s. First unveiled at drupa 2008, PROSPER utilizes Stream Inkjet technology to precisely control the micro-ink droplets, dividing a continuous stream of ink into droplets that are deposited on the substrate and recycling the unused ink.

Last November, the company introduced the PROSPER 6000 S press, a one-sided four-color inkjet printing machine based on the design of the PROSPER 6000 C double-sided eight-color (4+4 color) printing press. Whereas the PROSPER 6000 C is designed for commercial printing applications that require high ink coverage, the 6000 S comes in two variations—a stand-alone printing system and hybrid version. The stand-alone unit includes an unwinding and rewinding unit, and can be used for offline variable printing after offset printing. Some product examples include direct mail, retail outlet fliers, greeting cards, labels, paper cartons, and architectural materials. The hybrid version is designed to be integrated into a flexo or rotary offset printing machine, and thus does not have its own unwinding and rewinding units. In this way, the integrated printing line itself is able to print single-sided variable data on direct mail, newspapers, and paper cartons, for example.

The PROSPER 6000 S offers a maximum printing width of 620 mm on media ranging in width from 204–647 mm, a repeat length of 76–1,372 mm, a media paper weight (paper, paperboard) of 42–270 g/m², and a media thickness of 3–12 point (approx. 1.0542–4.2168 mm). Although having a repeat length might seem odd for an inkjet printer, this limit is a result of the maximum printing data processing capability of the machine. In February 2017, however, the company will announce a newly developed digital front end (DFE) for seamless printing. Meanwhile, the maximum printing speed of the stand-alone system is limited by the post-processing units, whereas that of the hybrid system is limited by the other printing units with which it is integrated. The machine itself has a maximum speed of 300 mpm at a dpi of 600 x 600. Some applications require higher speeds, so the company is also working to handle these.

Mr. Mansfield explains that PROSPER uses water-based pigment inks, and the machines can be used for applications that do not directly contact food. In addition, the inks are cheaper than those of their competitors, so the machine is advantageous when printing the entire substrate surface, such as with packaging. Another target is paper cups, for which Kodak is investigating the market for variable printing of advertisements and coupons on paper cups.
used at local events. Mr. Mansfield explains that they are looking to digitally print cups conventionally printed with flexo and gravure.

In December 2016, the first hybrid PROSPER 6000 S was integrated into a narrow width flexo printing machine at a US printing company. In this case, the paper drinking cups are first printed in the flexo unit and then printed with the variable promotional information in the PROSPER 6000 S unit all in one line.

**UTECO Sapphire**

Kodak is currently developing a digital varnish ink that can be used with the XGV water-based hybrid inkjet printing system when equipped with PROSPER S series heads. In this case, the XGV will print the varnish in the desired pattern. Kodak plans to complete development in the first or second quarter of 2017, while UTECO, Kodak’s PROSPER OEM partner, will integrate the XGV system with a web handling system and drying unit. Kodak plans to announce a commercial version this summer. They have yet to develop a white ink, however.

At an event in April just before drupa 2016, UTECO unveiled the XGV system under the name Sapphire at their Italian headquarters. The seven-color machine equipped with water-based inkjet pigment inks and water-based varnish is able to print on paper and films at a width of 400 mm, a resolution of 600 × 600 dpi, and a speed of 300 mpm.
Every year, business offices print and copy huge amounts of documents. At times, these documents can also contain confidential or personal information, disposal of which requires care. In this light, Seiko Epson Corporation (Epson) developed its dry PaperLab concept, the world’s first office system able to produce recycled paper and business cards using printed and copied documents as raw material. In a positive sense, this development, originally announced in December 2015, was a wake-up call to converting related companies focused on environmental responsiveness. Following this announcement, Epson made multiple inquiries into the needs of those companies with a strong interest in becoming PaperLab premium partners, and eventually began deliveries of PaperLab A-8000 to these premium partners in December 2016. Epson plans to begin deliveries to other companies at the start of fall 2017. Including sales in countries with limited water resources, over the next three years Epson aims to post sales revenues of ¥1 billion from its PaperLab related business.

Completely Erasing Text

The raw material for PaperLab A-8000 is the standard used copy paper (A3 or A4 in size) found in offices. This paper, which can be colored and printed on both sides, is fed into the machine using a specialized feeder, after which the company’s proprietary Dry Fiber Technology shreds and beats the paper into long, thin fibers. This process completely destroys the printed information. A binder called PaperPlus (a powder for which the details, including size and composition, have not been disclosed) is then added to the fibers, which are then heated and bound together. The bound fibers are then pressed with a roller to produce new sheets of paper. After the paper is produced, it is completely free of any printed information or confidential data.
PET Laminated Japanese Paper
Creates a New Sense of Texture in "HAKUUNSHI"

Kyoto Art, a paper converter and developer of the PET laminated Japanese paper called HAKUUNSHI, exhibited this unique product at the 2016 Printing Technology + α Exhibition, held in Osaka, Japan, this past August. Praised for its Japanese expressiveness provided by the see-through nature of Japanese paper, HAKUUNSHI is increasingly being used for Japanese gift food packaging. Although Kyoto Art was originally founded as a paper converter, more recently the company has seen growing sales from its packaging business, which the company hopes to expand by promoting applications for HAKUUNSHI. We spoke to Makoto Ogihara, sales manager at Kyoto Art, about this move.

**Paper Converting for Tourist Post Cards**

Founded in 1962, Kyoto Art’s main business was originally paper converting, including applying glossy coats to postcards made from photographs of tourist destinations. These paper postcards are first coated with resin, after which a mirror-finish stainless steel plate is hot-pressed against the surface to produce a glossy appearance. This method, called the press-coating method, creates a finished paper surface with a high gloss and attractiveness. This method is also used to produce magazine covers, photo pages in graduation albums, and packages.

Mr. Ogihara explains that although the company started out by converting postcard surfaces, it eventually moved on to make the boxes used to hold postcard, for which they installed the necessary paper cutting equipment, Thomson die-cutters, and sheathing machines. As the company expanded its business, it also acquired the skills for hot foil stamping to give the surface a luxurious quality and other related techniques.

**Making Proposals From the Design Stage**

Currently, the company has all of the necessary techniques in place to produce the finished product, including various coating techniques applied to printed surfaces, die-cutting, and box making. In addition to book and magazine cover converting, more recently the company is seeing an increase in the ratio of paper packaging converting, which has led to work with intricately designed packaging, such as that for Japanese sweets.

Mr. Ogihara explains that Kyoto is home to many Japanese sweets makers, who tend to request designs that are slightly different from those of their competitors. Until recently, he continues, trading companies and design offices would typically place the orders, for which they would design the packaging using CAD and covert the paper accordingly. As such, they would occasionally come across cases where the requested design was not suited to the converting process. In such cases, they would propose changes to the design that would ease converting and increase yield, which has more recently led them to see an increase in operations on the upstream side, closer to the package design stage.
These materials produce attractive packages as a result of the Japanese paper texture and as a result of the transparency that allows the contents to be faintly seen through the paper. These packages thus provide a sense of luxury to the product, which has led HAKUUNSHI to be adopted for packaging Japanese gift foods and nail care products. The company is also considering offering HAKUUNSHI for use in stationary products, such as clear file folders. They can also print (UV offset, screen) images onto the Japanese paper side or apply hot foil stamping.

Compared with paper and PET lamination, however, these approaches require an extra two or three steps, so necessarily increase the cost. In this respect, Mr. Oghihara says they work to reduce the raw material costs during acquisition of the Japanese paper, but when converted into a package, the material clearly shows its value. Mr. Oghihara closes by saying that although it is difficult to propose the use of specific materials, they hope to expand applications for HAKUUNSHI by focusing on the final product.
Functionalizing Amphiphilic Polymer Nanosheets Made Using the LB Method

Mitsuishi Group, Polymer Hybrid Nanomaterials, PHyM IMRAM, Tohoku University

www.tagen.tohoku.ac.jp/lab/mitsuishi

The PHyM IMRAM Polymer Hybrid Nanomaterials Mitsuishi Group at Tohoku University in Sendai, Japan, has developed a previously unseen functional nanosheet by forming an ultra-thin film out of an amphiphilic polymer and combining this film with various materials, including metal nanoparticles. Although development of practical applications is still in the wings, the research group has high expectations for a wide range of fields based on their success in using the nanosheets to enhance luminescent material light emissions and based on their work using the nanosheets to form SiO$_2$ ultra-thin-films under normal conditions. They are also considering larger micrometer and millimeter size applications, such as selectively functionalizing the surface of microfluidic devices.

**LB Method Monolayer Lamination**

In 2012, Tokuji Miyashita, professor emeritus at Tohoku University, received the Purple Ribbon Medal of Honor in Japan for his many years of work in the field of polymer chemistry. Much of his success in this field stems from his research into ultra-thin polymer films with nanometer thicknesses. Today, his research into nanometer thick films is being continued by Masaya Mitsuishi, a professor in the PHyM IMRAM Polymer Hybrid Nanomaterials Mitsuishi Group at Tohoku University. Dr. Mitsuishi is currently working on functionalizing these types of films through hybridization with various organic and inorganic compounds.

One of the subjects of his research is polymer nanosheets produced through the Langmuir-Blodgett (LB) method (see figure). In this method, amphiphilic molecules—molecules with both hydrophilic and hydrophobic groups—are dissolved in an organic solvent and dripped gently onto the surface of pure water in a Langmuir trough so that the solution spreads out over the surface. After the organic solvent evaporates, a barrier is used to push the molecules on the water surface in one direction.

**Functionalizing Amphiphilic Polymer Nanosheets Made Using the LB Method**

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**Langmuir Trough**

An LB Film Forming Device at Dr. Mitsuishi’s Laboratory. The Barrier Is Made of Fluorine Resin so That the Amphiphilic Polymer Does Not Adsorb to the Barrier. Modifications Were Also Made so That Vibrations During Operation Do Not Reach the Water Surface
Established in 1912 as a seller of chemicals, paints, and dyes, OMURATORYO CO., LTD. a Tottori Prefecture, Japan, based coatings producer, is utilizing its more than 100 years of accumulated technology to develop new adhesive and coating products from chitin nanofiber (NF). Together with Tottori University and Kyoto University, the company has already acquired a patent for the production process of chitin nanofiber (chitin NF). In addition, they have also been working with Osaka based Sharp Chemical Ind. Co., Ltd., a producer of sealants and adhesives, to develop and improve the adhesion strength of chitin NF adhesives.

OMURATORYO CO., LTD.

www.omuratoryo.co.jp

Developing Chitosan Paints

The grandfather of Yoshihiko Omura, the current president of OMURATORYO, established the company after leaving the family-run Omura Pharmacy. Historically, this pharmacy was the chemical seller for the Tottori Domain during the Edo period, giving OMURATORYO roots going back to Japan’s medieval period.

After working as a researcher, Mr. Omura was appointed president of OMURATORYO in 1983. Ever since, the company has developed and sold a unique range of functional coatings, including chitosan coatings and inorganic coatings used to prevent graffiti.

The company first began focusing on chitosan after participating in a project with Tottori Prefecture in 1989. Along with the Faculty of Agriculture at Tottori University, the Industrial Research Institute, Tottori Prefecture (currently, Tottori Institute of Industrial Technology), and a local furniture manufacturer, this project aimed to develop a furniture coating using chitosan. Mr. Omura explains that during the project they used the capability of chitosan to dissolve in a weak acidic solution to develop a variety of functional coatings.

One of the results was OS CHITO #100, a pretreatment for wood-use electrostat-
Increasing Tensile Strength

Results of their tensile shear tests (JISK6850: Testing methods for the tensile shear strength of adhesives) have shown the effects of adding chitin NF to vinyl acetate resin type emulsion adhesives. For example, chitin NF made using the new microbubble fibrillation method have a significantly higher tensile strength (adhesive strength) than conventional chitin NF and Cellulose Nano Fiber (Fig. 1). In this case, the tensile strength of chitin NF by additive weight shows a rapid increase up to an additive weight of 1.0%, with a more gradual increase beyond (Fig. 2).

Mr. Omura explains that they achieved a higher than expected tensile strength, which they assume is a result of the longer chitin NF fibers produced by the microbubble fibrilla-
Recent research has shown that chitin nanofibers (chitin NF)—obtained by fibrillating the chitin contained in crab and shrimp shells—have the ability to moisturize skin, heal wounds, and vitalize immunity. A leader in chitin NF research, Associate Professor Shinsuke Ifuku of the Graduate School of Engineering, Tottori University, established Marine Nano-fiber Co., Ltd. in April 2016 to further develop applications for these capabilities of chitin NF. Dr. Ifuku also serves as president of this spin-off from Tottori University, which is currently building a plant in Tottori City to produce and sell chitin NF as early as FY 2017. Although standard chitin has been used as the raw material for chitosan and glucosamine, one obstacle to the expansion of standard chitin’s industrial use is the difficulty of dissolving the material in most solvents. In contrast, chitin NF disperses easily in water, which provides it with the potential to see a rapid growth in applications. We spoke to Dr. Ifuku about his latest chitin NF research.

Removing Proteins, Calcium, and Pigments from Crab Shells

Sakaiminato, a port town in Tottori Prefecture, is well-known for its crab catch, particularly snow crab and red crab. Unfortunately, once the crab catch is processed into canned crab, a huge amount of crab shell waste is left over, from which Dr. Ifuku got the idea of using this waste as a regional resource in some way, namely as chitin NF.

Because chitin accounts for only 20–30% of crab shell material, preparing chitin NF requires the shells to be stripped off their other components, including proteins, calcium carbonate, and pigments. The shells are then pulverized into powdered chitin, which is fibrillated in a grinder along with a high volume of water. This produces a whitish gel-like water dispersion containing 10–20 nm wide chitin NF.

Dr. Ifuku explains that fibrillating the chitin NF is like tearing dried squid into shreds. Insufficient grinding will leave behind fuzzy fibers, just like partially torn dried squid. When the raw chitin is fibrillated to an extreme, however, the nanofibers will have a uniform width.
causes light to undergo diffuse reflection. These chitin NF films can then be impregnated with an acrylic resin, which can then be polymerized with UV exposure to produce transparent sheets. In this case, replacing the air with a transparent resin having a similar refractive index as chitin NF prevents diffuse reflection and turns the film transparent. Dr. Ifuku says that he foresees such films as having medical applications in devices that apply wound healing films.

The results of the rice tests hint at the possibility of mitigating human immune disorders and inflammatory diseases. Likewise, Dr. Ifuku says that if it is possible to appropriately control the immune function by applying or administrating chitin NF, it might be possible to heal diseases using an immune reaction.

Because chitin NF is a water dispersion, it can also be formed into sheets and transparent films, or added to provide functionality to coatings and paints. Sheets can be formed by dehydrating chitin NF dispersions with suction filtration or filling the dispersion into a dish and drying. The initial films appear white because the high volume of air contained in the sheet causes light to undergo diffuse reflection. These chitin NF films can then be impregnated with an acrylic resin, which can then be polymerized with UV exposure to produce transparent sheets. In this case, replacing the air with a transparent resin having a similar refractive index as chitin NF prevents diffuse reflection and turns the film transparent. Dr. Ifuku says that he foresees such films as having medical applications in devices that apply wound healing films.
Research and development of printed electronics has seen significant advancement over the past few years, with regular announcements being made for new technologies. Although fully printed organic thin-film transistors (OTFT) are now possible, aside from membrane switches and a few other existing applications, there has been little development of new business markets in the field. Despite this situation, AgIC Inc., founded in 2014, has high hopes for the ability to manufacture flexible printed circuits (FPC) using inkjet printers. The company is currently developing the technology necessary for printing flat flexible cables (FFC), but as it overcomes problems with circuit anchorage and resistance levels, AgIC is steadily closing in on its goal of inkjet printed FPC. 

AgIC is also seeing an increase in demand of FFC, and expects to build a new production site over the next year.

An Initially Naive Outlook

AgIC is well-known as the maker of pens that can be used to draw conductive circuits by hand. Although the impact of this pen brought the company broad recognition, Shinya Shimizu, president of AgIC, says that their ultimate goal is to use inkjet printers and film substrates to produce FPC durable enough for application in industrial equipment.

After graduating from the Graduate School of Information Science and Technology at the University of Tokyo with a master’s degree in engineering in 2012, Mr. Shimizu entered US-based McKinsey & Company as a consultant for the manufacturing industry. During this time, he began gathering information with an eye on starting his own company in the future. His work also afforded him the opportunity to meet with Associate Professor Yoshihiro Kawahara of the Graduate School of Information Science and Technology at the University of Tokyo and a visiting professor at the MIT Media Lab in Boston. Associate Professor Kawahara’s novel research into using inkjet printed electronic circuits was Mr. Shimizu’s first deep introduction to the world of printed electronics. Already having a wealth of experience in circuit design, including designing a 4 bit CPU during his second year of high school, Mr. Shimizu knew that manufacturing electronic circuits requires a complex photolithographic process, even for simple patterns, so immediately saw the revolutionary potential of printing electronic circuits with an inkjet printer. After leaving McKinsey & Company, he immediately founded AgIC in January 2014 with Associate Professor Kawahara as an adviser.

From the outset, the company’s goal was the manufacture
der for the costs of related materials, including silver nano-ink, to come down. Mr. Shimizu says he feels this is a major obstacle, particularly because they are one of the only companies pursuing this business at the moment. Although AgIC’s ability to produce inkjet printers in-house is a strength, put another way, Mr. Shimizu says he doubts they could have entered this business without this capability. In addition to solving the problems mentioned thus far, many different skills are required, including electronic circuit design know-how; optimization of equipment and materials, such as inkjet printers, inks, and film; and new application development. In this light, Mr. Shimizu explains that he established their offices near the University of Tokyo in part to secure the talented staff, including part-time student workers, to handle these challenges.

In terms of the future of printed electronics, Mr. Shimizu says he is paying close attention to venture companies outside of Japan. He says that even though Japan is capable of developing the fundamental technology for new manufacturing techniques, deployment of most of these techniques is led by the US. One recent example is 3D printers. Moreover, Mr. Shimizu says he feels it will be venture companies that will open new markets for printed electronics applications, after which large companies will enter when there is a positive outlook for success. For example, in 2015, it was announced that together with the US government, private industry would invest a total of approximately US$171 million dollars over five years to FlexTech Alliance, a Silicon Valley based research and development consortium for next-generation flexible electronics. In this way, however, there is no guarantee that the required printing technologies for flexible electronic circuits will come from Japan as the technology spreads throughout the world. As such, Mr. Shimizu says AgIC is dedicated to ensuring that Japan will not play second fiddle.

Mr. Shimizu goes on to say, however, that there are few inkjet printer manufacturers in the US, so in this regard Japan is at an advantage. Given the interest that many of the major printer manufacturers have shown in printed electronics, Mr. Shimizu says it is his goal to expand the potential for this industry.

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East hall 3, Booth 3J-02
Some of the technologies that were originally developed for and regularly used in the converting industry are finding broader use as they are transferred to other fields. Although the medical field offers a potential market for the further use of these technologies, there are difficult obstacles to overcome in terms of health and safety. In this light, Mitsubishi Plastics, Inc., (MPI) exhibited a new porous film, applications for diamond-like carbon, and a sky-blue adhesive film as developmental products for the medical field during the 29th INTERPHEX Japan, held this past summer in Tokyo.

MPI’s new multilayer olefin porous film is made using the company’s coextrusion film forming technology and can contain porous layers with different pore diameters or combinations of nonporous and porous layers, allowing for some unique characteristics. The film also eliminates the need for fillers.

Conventionally, porous films are made by biaxially stretching films containing resins and fillers. Stretching causes the two components to separate at the interface, which generates overlapping voids that form continuous holes. In contrast, MPI’s new film eliminates the need for fillers. Specifically, the new method applies a physical force to the film to produce micro-fractures inside the film. When this micro-fractured film is stretched, these micro-fractures grow into pores of various shapes and sizes. The stretching ratio can be controlled to 1.1–4.0 times, and the pore diameters can be controlled to micrometer and millimeter sizes. The pores can also consist of independent holes that penetrate from the top to the bottom of the film, or consist of overlapping continuous pores. This approach has less of an environmental impact than the conventional approach because there are no fillers to produce ash (residue) during incineration.

According to the representative, the porous film can be designed to be selectively permeable to gas or water vapor, and can be designed to separate out specific substances. Specifically, by combining layers with small and large pores, the film can be used as a wound dressing that reduces skin maceration, as a cell culture sheet, and as a filter for selectively separating out blood components. Another benefit is the cushioning property and soft-feel of porous films.

Diamond-like carbon (DLC) films are seeing a greater demand from industrial applications, such as coatings for web handling rollers, and from beverage applications, such as barrier coatings for the inside of plastic bottles. MPI is also working to apply DLC films to various resin products used in medical related fields, including films and molded medicine bottles. According to the representative, DLC films provide a variety of features in addition to a gas barrier property. Some of these include adsorption resistance, slipperiness, chemical stability, and smoothness. In this way, MPI has been developing a film forming method with an eye on applying these characteristics to medical containers, such as plastic syringes and vials, and to analysis equipment components.

MPI also exhibited a coextruded olefin food wrapping film that contains a middle layer doped with additives that give the film a light blue color (DIAWRAP Blue Colored Film). This color makes it easier to find the film if by chance a piece tears off and becomes mixed in with the food. They have also developed a sky-blue adhesive film version for application in the medical field. With a total thickness of less than 10 μm, the film has a self-adhesive property, so sticks and conforms to the shape of the area to which it is adhered. According to the representative, MPI is considering the film’s application as a protective film for medical equipment and as a contamination prevention film for dental equipment.
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Precision Equipment Shipping Film Provides Both Transparency and a High Barrier Property

E-pack Corporation, an Osaka, Japan, based manufacturer of industrial packing materials, uses its 4,000 mm wide extrusion lamination facilities to supply wide width packing materials for a variety of industrial applications. During its exhibition at TOKYO PACK 2016, the company featured its latest grade from their E-Barrier Series of barrier shipping films, the “Transparent MI-Barrier” film. In addition to allowing the packed contents to be visible, this barrier film has a higher water vapor barrier than aluminum metalized PET film. When used with an LLDPE sealant film, Transparent MI-Barrier can also meet the needs of applications that require a strong seal property. In this light, the company is proposing use of the film for seaborne transport of precision equipment, including semiconductor production devices.

When transporting precision equipment by ship, barrier films made of aluminum foil or aluminum metalized film are used to pack the equipment in order to reduce the impact of water vapor and gas. The packing process can be complicated. Specifically, a barrier film is first placed on a pallet, after which the equipment is set on top. The equipment is then wrapped in stretch film to protect the surface, and a second barrier film placed over the top of the wrapped equipment. Finally, the top and bottom barrier films are heat sealed together and the air contained therein evacuated. Ultimately, the entire item is placed inside a reinforced cardboard box and secured in place.

The structure of E-pack’s E Barrier standard grade packing film is aluminum metalized PET/PE laminate/aluminum metalized PET/PE laminate/PE cloth/PE laminate. The two layers of aluminum metalized film provide the barrier property and the PE cloth layer provides strength. The representative explains that although their standard grade of E-Barrier has both an excellent barrier property and strength, it is opaque, so the contents within cannot be seen. This can cause problems when the contents are checked during transport. In some cases, for example, the packing will be roughly opened and the barrier film torn, which breaks the vacuum generated during the above packing process. As such, there are many cases that require a transparent barrier film.

Previously, the company responded to such demands with “Transparent E-Barrier,” a grade made using a transparent barrier film. Unlike E-Barrier, which has a water vapor transmission rate (WVTR) of 0.1 g/m² per day, however, Transparent E-Barrier has a WVTR of 0.6 g/m² per day, so there was a need to increase the water vapor barrier property. Given this, in 2013 the company developed Transparent MI-Barrier. The structure consists of transparent high barrier film/PE laminate/PE cloth/PE laminate/LLDPE film and realizes a WVTR of under 0.1 g/m² per day, which exceeds that of the standard E-Barrier grade. Moreover, using LLDPE sealant allows the film to meet the needs of applications that require a tighter seal property. This high barrier film is made of PET (or Ny) that has been coated with an inorganic deposition barrier layer of alumina or silica. This layer is then wet coated with a barrier coating to produce a three-ply structure. During selection of the film at the time of development, the company focused on the barrier property of the film as well as the ability to supply the film in wide widths, the strength of the company.

In fact, the company is able to supply all of their barrier films, including Transparent MI-Barrier, at a maximum width of 4,400 mm. In this way, depending on the size of the device, E-pack is able to offer butt-seam structures in which a single sheet is used to cover the entire device so that only one side of the film needs to be heat sealed.
The semiconductor chips used in servers and power devices (semiconductor elements for power control) today radiate more heat than in the past, which increases the risk of degraded performance and failure, and has also been a shackles on improving performance. Heat radiation relies on a high-performance thermal interface material (TIM) to efficiently conduct the heat from the chip to a heat sink, for example. Although grease-type TIM are commonly used today, sheet-type TIM are easier to apply. Balancing thermal conduction in the thickness direction with the flexibility required for anchorage of the sheet to the chip, however, has been a problem. In 2015, Zeon Corporation began mass producing (super growth method) single-walled carbon nanotubes (SWCNT), which they are now compounding with fluorine rubber and graphite to develop an advanced sheet-type TIM. In December 2016, the company completed its pilot plant at which it aims to establish the mass-production technology for this new TIM.

The super growth (SG) method injects a tiny amount of water into the CNT synthesis atmosphere to significantly improve the lifetime and activity level of the synthesis catalyst. The resulting SWCNT are called SGCNT, which Zeon Corporation is commercializing under the name ZEONANO SG101. One of the applications for ZEONANO the company is currently focused on developing is a sheet-type TIM made by mixing ZEONANO at a 1% ratio with fluorine rubber and bulky graphite. Specifically, this TIM is being developed to handle the higher temperatures generated by the more advanced, higher functioning semiconductor chips used to process the greater amounts of information handled by today’s servers and power devices.

The heat generated by the chips themselves degrades performance and risks failure, so managing this heat effectively is essential to further improving computing performance. One typical heat dissipation device is the heat sink. In this case, a TIM is sandwiched between the chip and the heat sink to reduce the thermal resistance at the interface. TIMs come in sheet types and grease types. Although sheet types are limited to general applications that only require an interfacial thermal resistance of 0.4°C/W or more, they are easy to work with and can be applied by simply placing them on top of the chip. Meanwhile, applications that require a low interfacial thermal resistance of 0.2°C/W, such as servers, use grease types. Grease-type TIMs are made by mixing a good thermal conductive filler, such as silver nanoparticles, with grease. Grease types are more difficult to work with because they need to be uniformly coated and the grease can drip. Despite this situation and the demand from the market for higher performance sheet-type TIMs, it has been difficult to balance a high thermal conductivity in the thickness direction with the flexibility required to anchor the TIM to the chip.

Unlike other sheet-type TIMs, the new sheet-type TIM achieves a thermal resistance of 0.05°C/W, which is twice that of grease-type TIMs (0.10°C/W). The new TIM also has excellent flexibility and achieves good anchorage with the chip at a low pressure of 0.1 MPA. In this case, Zeon Corporation used fluorine rubber to ensure the TIM is incombustible, but they can also utilize other materials depending on the application.

One of the factors that makes the new TIM possible is that the length of ZEONANO ranges from a few hundred micrometers to a few millimeters, which is far longer than the maximum length of standard CNT at a few tens of micrometers. The longer ZEONANO will easily intertwine with each other to form a mesh structure, which is used as a framework to support the bulky graphite that forms the thermal conductive pass over the surface.

According to the company, the cost of advanced TIM that can satisfy the need for a thermal resistance of 0.2°C/W or less is approximately ¥80–90 thousand per square meter, so they expect the new TIM to offer cost benefits as well. In December 2016, they completed a pilot plant on the site of the ZEON KASEI Co., Ltd. Ibaraki plant, a subsidy of Zeon Corporation, which they plan to put into operation by April 30, 2017.
ROLL GUIDER PGMW-15

It is high output, high-rigidity Roll Guider although being compact

Outline

- PGMW-15 is the small roll guider developed for the purpose of having the user who has PG-50, 80, 100, 110 and 800 of the conventional model used transpose to G series, without changing the present installation state greatly.
- It applies to a web width of 600 mm or less, and is the optimal as the web meandering correction device of a packaging machine or a hygiene products machine.

Features

- The maintenance-free brushless DC motor was adopted
  The ball screw type micro actuator is built in and it can be made to circle in a roll frame powerfully without rattle.
- The revolution torque of a roll frame will be 3 or more times compared with the thing of the conventional gear type.
- The roll frame is low backlash (1/10 or less of the conventional machine), and since it is supported three points in a pivot axis and two cam followers, it is high rigidity roll frame.
- Wiring work is easy in order to connect with a PEM type controller or a PSM type sensor only by a connector.
MIKATA Co., Ltd., an Osaka based die-cutting converter, has developed a technology called “Miracle Core” to reduce the extent of step marks at the start of film rewinding. In this new approach, a plastic core is wrapped in a soft polyurethane foam sheet, which absorbs the step created by the first layer during rewinding and reduces the length of the web affected by step defects to one-sixth that of conventional cores. They have already begun providing samples to converters, and are rushing to expand production with the introduction of a machine this past November that wraps the foam sheets on the cores. The move to produce cores is a step away from their main business of die-cutting, but as Yoshihide Inoue, president of MIKATA, states: “Some things are possible precisely because you are unfamiliar with them.” We spoke with the highly inquisitive Mr. Inoue about the secret to this development.

**Development Background**

MIKATA has had a long history of success with die-cutting optical films and double-sided tapes. During a recent hearing of their customers, including converters, printers, and slitter manufacturers, they found that many companies are troubled by problems that occur during film rewinding, namely step marks and roll tightening.

Step marks are caused when the edge of the film at the start of rewinding leaves a mark in the following layers of film as they are rewound. Step marks can require the first several tens of meters to be discarded, but the typically high unit price of films that undergone multiple processes makes such loss unacceptable. The tendency for step marks to occur is particularly strong with hard plastic cores.

In response to customers wanting to reduce such loss, MIKATA began developing Miracle Core. Although other companies already provide cores that reduce the extent of step marks, Mr. Inoue states that he wanted to go further and eliminate the marks entirely.

The second problem, roll tightening, occurs when the outer layers of film in the roll squeeze the inner layers, which causes wrinkles to occur inside the roll. These wrinkles are only discovered when the film is used, so are a major problem for converters. Mr. Inoue explains that with some types of film, roll tightening can even cause tiny bits of debris to leave dents in the layers as if they were stuck with a needle. This is a particularly urgent problem for optical film converters.
The “Converting Technology Exhibition” combines six specialized exhibitions to present all of the converting technologies, materials, and equipment required to process webs and sheets such as film, foil, paper, and non-woven fabric.

The Converting Technology Exhibition is proud to present the strengths of the industry—in terms of both process technology and materials—that the pioneers of the field have developed over the years.

For this reason, the exhibition offers all visitors the potential to find that extra something essential to realizing innovations and solutions.

**Convertech JAPAN:** Originally held in 1987 under the name CMM JAPAN, Convertech JAPAN is a top-quality converting equipment exhibition with a focus on sophisticated coating, laminating, slitting, printing, and peripheral equipment.

**neo functional material:** This exhibition was initiated in 2004 to focus on converting materials, including advanced films, paper, nonwoven, and foil. Many and various functional materials made in Japan continue to be used in different types of high-value products around the world.

**Printable Electronics:** Specialized in next-generation manufacturing technologies, including flexible and elastic electronics devices such as flexible sensors.

**3D Surface Decoration Technology Exhibition:** Specialized in the decoration technologies now replacing coating with decorative films.

**Advanced Printing technology Exhibition:** Focused on special printing technologies.

**Prototype and Contracted Manufacturing Exhibition:** Focused on outsourcing of converting services, including coating, laminating, slitting, and printing.

**Organizer**
Converting Technical Institute

**Co-organizer**
JTB Communication Design, Inc.

**Dates**
February 15 (Wed.) - 17 (Fri.), 2017

**Time**
10:00 - 17:00

**Venue**
Tokyo Big Sight East Hall 2-3

**Participants**
60,000 visitors expected (including concurrent events)

**Admission fee**
3,000 (JPY) *Free admission with online registration

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**Exhibitors List**

KINYOCHA
Masroll Systems / Masuda Seisakusho
OSG SYSTEM PRODUCTS
H.IKEUCHI
HEISHIN
Techno Smart
HIRAI INDUSTRY
PNEUMATIC INDUSTRIES
PAIONIA FURYOKUKI
NISHIMURA MFG
HELL Gravure Japan
Sunrise Chemical

Hakuto
Inspec
FUJI KIKAI KOGYO
ALTECH
OKAZAKI MACHINE INDUSTRY
UNIONTECH
MUSASHINO KIKAI
Heraeus
THINK LABORATORY
PS Company
Nihon S & H
SAKURA SEIKI
HIRANO TECSEED
KASUGA
MEC (Chiba)
Praxair Surface Technologies

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Exhibition Preview

OSADA CORPORATION
NEGISHI MFG.
PROTEC MACHINERY
MEC (Kanagawa)
KATSURA ROLLER MFG.
SHINKO
Mitsubishi Electric
Tokuden
TOYO MACHINERY / Mahlo
Mahlo
WAKAMIZUGIKEN CO., LTD.
ROLLTECH / POLYWEST JAPAN
OTEC
YOKOYAMA ENGINEERING
Hitachi High-Technologies
KURABO INDUSTRIES, Advanced Technology Division
Ritech Japan
RISHO KOGYO
HALLYS
ASAHI SOKKI
Techno Support
HIMECS
Kanken Techno
YASUI SEIKI
Tokyo Seisakusho
RAYON INDUSTRIAL
NDC Spray Coating System Fabricating
SOFTAL Corona & Plasma Japan Branch
Audio-Technica
TANKEN SEAL SEIKO
YAMABUN ELECTRONICS
Wedge
OMRON
Kataoka Machine
KANSEN EXPANDER INDUSTRIAL
ONO SOKKI
NIRECO
ROBOT INDUSTRIAL
SUMITOMO HEAVY INDUSTRIES
Erhardt+Leimer Japan
NIKKA
NISHI INDUSTRY
Nippon Avionics
DAC ENGINEERING
SAWA CORPORATION
New IWASHO
NIHON DENGÍ
TOYOX
MASHINTEX
T. FUKASE & CO., LTD.

MIYAKAWA ROLLER
Uni-Ram Japan
UNION TOOL
Takei Electric Industries
TAIYO ELECTRIC INDUSTRY
TECHNO ROLL / fuso
fuso
BELLMATIC
Spectris NDC Technologies Japan
JUNG CHANG MACHINERY
SOBU Machinery
Iwatani Materials
Ube Information Systems
Tsujikawa
SHIBASAKI Inc.
Shin-Nihon
NORITAKE
AIKEI / EF ENGINEERING
MEIWA RUBBER
ITOCHU MACHINE-TECHNOS
Riken Keiki
THERMAL ENGINEERING & DEVELOPMENT
MEISEI
ORIENT SOGYO
Nissio Gravure
TSUKATANI HAMONO MFG
Yamaha Fine Technologies
CORTEC

Converting Technology Exhibition
January / February 2017     Convertech International

neo functional material

DAIEI SANGYO
KJ Specialty Paper
NIPPON SODA
Dainichiseika Color&Chemicals Mfg
SHIKOKU CHEMICALS
Osaka Municipal Technical Research Institute
Shikoku Industry & Technology Promotion Center
ASUKA
SHIHEN TECHNICAL
TAKECHI
Fujiko
Heiwagenshi
Nanao kogyo
meiko industrial
NAGAMINE MANUFACTURING
NIPPON SHOKUBAI
3M Japan
TAIMEI CHEMICALS
Daicel
YAMAKIDENKI
Taki Chemical
CCS
Hamamatsu Photonics
Toyama Denki Building
POWDERTECH
Yamagata University, Hirose Laboratory
AZmax
AGC COAT-TECH
MITSUBISHI MATERIALS / Mitsubishi Materials Electronic Chemicals
ARAKAWA CHEMICAL INDUSTRIES
High Performance Paper society, japan
M.I.C
KRI
Research Society for Biotemplate Technology
TECHNO FLOW ONE
TOSOH
YOSHIZAWA LIME INDUSTRY
WATANABE GOSANDO
NODA SCREEN
Oji Holdingus
MATSUO SANGYO
MUROMACHI CHEMICALS
Kanai Juyo Kogyo
FUTAMURA CHEMICAL CO., LTD
Research Institute of Advanced Industrial Science and Technology Clayteam
Forestry and Forest Products Research Institute
Oasa Electronics
TENDO
JAPAN MATEX
KUNIMINE INDUSTRIES
MIYAGI KASEI
TOHOKU KOGEI
Aster
SIP-Lignin
ICHINEN CHEMICALS
NUCLEAR TECHNOLOGY
SUMITOMO SEIKA CHEMICALS
CHUGOKU KOGYO
Kyushu Institute of Technology
Japan Aerospace Exploration Agency
Fujitsu Quality Laboratory
Kochi Industrial Promotion Center
Kochi Kidata Kogyo
Sanwa Seishi
Hidaka Washi
Hirose Seishi
Labo
GSI Creos
Soken Chemical & Engineering
Corbion Japan
INCUBATION ALLIANCE
Kochi University of Technology Yamamoto Laboratory
Kochi University of Technology Kobiro laboratory / Ujiden Chemical Industry
DAICEN MEMBRANE SYSTEMS
JX Nippon Oil & Energy
NBC Meshtec
PaPaLaB
All Nippon Nonwoves Association
CLARIANT JAPAN
AITEC SYSTEM
NIPPA
Quark Technology
CHIKAMI MILTEC
J.T.S
Kansai Converting
IOX
PANAC
NEOS
GOO CHEMICAL
IS SLITTER
MITSUWA FRONTECH
KONICA MINOLTA JAPAN
TEIJIN
Sunhayato
KURARAY
NIPPON PAPER INDUSTRIES
TOIN
Kyoto Institute of Technology
Ai-Carbon
Fluke Process Instruments
SAKURAI
Jisedai Monodsukuri Zone
Hohsen / STT
Advanced Softmaterials
ECT
KAWAI LIME INDUSTRY
MT TECH
FASSE
Society for Specialty Film
MEDIKEN
UNITIKA
EIWA KAKO
KURABO INDUSTRIES Chemical Products Division
MINO GROUP
Exhibition Preview

Materion Brush Japan
HARIMA Chemicals
Luci
TOKYO PRINTING INK MFG
TOYO INK

Disposable Electronics

Nihon Denshi Seiki
DAICEL
ISHII HYOKI
Yamagata University Innovation Center for Organic Electronics
Yamagata University Research Center for Organic Electronics (ROEL) Tokito Laboratory
Y Drive
3M Japan
AGFA Materials Japan
Kanagawa University, Faculty of Science, Department of Chemistry, Yamaguchi Laboratory
Novacentrix/Shoko
HARIMA CHEMICALS
Future Ink
Advanced Printed Electronics Consortium
Oki Communication Systems
SK-Electronics
Japan Aviation Electronics Industry
MINO GROUP
USHIO
NOF
MITANI MICRONICS KYUSHU
TOYOBO
BASF New Business
FUK
PRECEED
Toray Engineering
FUJIFILM Global Graphic Systems
Organic and Printed Electronics Association (OE-A)
Coatema Coating Machinery
PRINTED ELECTRONICS
Genes’ Ink
Sumitomo Chemical
C-INK
SK-Electronics
Arkema
National Institute of Advanced Industrial Science and Technology, Flexible Electronics Research Center
The Institute of Scientific and Industrial Research, Osaka University
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YAMAGATA RESEARCH INSTITUTE OF TECHNOLOGY
Industrial Technology Center, Gifu Prefectural Government
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ARISTOTELE UNIVERSITY - NANO TECHNOLOGY LAB LTFN
ORGANIC ELECTRONIC TECHNOLOGIES
MAGNETAR

3Decotech Expo

Illumination
Fu-se Vacuum Forming
MEIBISHA
Teikoku Printing Inks Mfg
ASANO LABORATORIES
NAVITAS
YAMATO Jushi
Alent Japan
DAI-ICHI JITSUGYO
Idemitsu Unitech
SANRYU
Murata-Kimpaku Group
WBMTRADING
M’s Systems
katani
SPACE SYSTEMS
Kayoh Techno Plaza

Advanced Printing Technology Exhibition

SCREEN Holdings
TOKYO KEIKI
MIYAKO ROLLER INDUSTRIAL
SANKI MACHINERY
Roland DG
FUJI SHOKO
HP Japan

Prototype and Contracted Manufacturing Exhibition

Ebisu Kako
Die-Gate
ITOROKU
Sunny Sealing / Mitsui Kinzoku Instrumentations Technology
Mitsui Kinzoku Instrumentations Technology
Global Facility Center, Hokkaido University
Tokyo Cellolabel
FUJI FILM
ICE Europe 2017

The 2017 show will focus on the diversification of converting techniques in the context of progress in automation and digitisation as well as on the efficient and sustainable converting of high-class flexible materials.

Venue: Munich Trade Fair Centre (Germany)

Opening Hours

- Tuesday 21 March 2017 09:00 – 18:00
- Wednesday 22 March 2017 09:00 – 18:00
- Thursday 23 March 2017 09:00 – 16:00

Entrance Tickets

To benefit from favourable prices and quick admission to the halls on-site you can purchase your entry ticket online ahead of the show. Tickets are available via the Online Ticket Shop from January 2017 onwards. Alternatively, you can purchase your ticket on-site.

Exhibitors Expectation

About 400 exhibitors (as of Jan. 4, 2017) from 25 countries

Main Exhibitors from outside of Europe

- Japan
  *HAGIHARA INDUSTRIES INC.(Japan)
- Korea
  *SAM (SUNG AN MACHINERY CO., LTD.)
  *NICELY MACHINERY
  *YICHEEN TECHNOLOGY CO., LTD.
- Taiwan
  *NICELY MACHINERY
  *YICHEEN TECHNOLOGY CO., LTD.
- China
  *BEIJING ZODNGOC AUTOMATIC TECHNOLOGY CO., LTD.
  *CHANGZHOU COATING MACHINE CO., LTD.
  *DEQING TIDE MACHINERY CO. LTD
  *LABTHINK INSTRUMENTS CO., LTD
  *SUZHOU CHUANRI PRECISION MACHINERY CO., LTD
- USA
  *AIMCAL - ASSOCIATION OF INTERNATIONAL METALLIZERS, COATERS AND LAMINATORS
  *BETA LASERMIKE (AN NDC TECHNOLOGIES BRAND)
  *CLOEREN INCORPORATED
  *COAST CONTROLS, INC.
  *CONVERTING QUARTERLY MAGAZINE
  *DELTA MODTECH
  *FLEXO CONCEPTS
  *NORDSON PREMIER COATING DIVISION
  *ROLLGUARD EU
  *SPECMETRIX SYSTEMS (SENSORY ANALYTICS)
  *STRATIS PLASTIC PALLETS, A BRAND OF SNYDER INDUSTRIES
  *VALCO MELTON
### Main Exhibitors from Europe

**Germany**

- 3F GMBH KLEBE- UND KASCHIERTECHNIK
- ACHENBACH BUSCHHÜTTEN GMBH & CO. KG
- AFS GMBH
- AHAUSER GUMMIWALZEN LAMMERS GMBH & CO. KG
- AHLBRANDT SYSTEM GMBH
- AIRMAT TECHNOLOGY
- AMS - GRAPHICTEAM GMBH
- ANKE GMBH & CO. KG OBERFLÄCHENTECHNIK
- APPLIED MATERIALS WEB COATING GMBH
- AR WALZEN GMBH
- ARCTEC GMBH
- AST BESCHICHTUNGSTECHNIK GMBH
- BAAL, VAN GMBH
- BÄUMER GMBH CONVERTING MACHINES
- BAKA - D. BADER SÖHNE GMBH & CO. KG
- BAUMER INSPECTION GMBH
- BAUMÜLLER NÜRNBERG GMBH
- BEARDOW ADAMS GROUP, KLEBSTOFFWERKE COLLODIN GMBH
- BILSTEIN, WILHELM GMBH & CO. KG
- BLOCK & MOHR GMBH
- BN TAPES & LABELS GMBH
- BOLZ PRODUCTION GMBH
- BOSCHERT GMBH & CO. KG
- LEONHARD BREITENBACH GMBH
- ADOLF BRODECK MASCHINENBAU
- BST ELTRATOM INTERNATIONAL GMBH
- BST PROCONTROL GMBH
- BÜHLER ALZENAU GMBH
- BW PAPERSYSTEMS
- COATEMA COATING MACHINERY GMBH
- DR. COLLIN GMBH
- DALMEC GMBH
- DAVIS-STANDARD, LLC
- DERICHS GMBH
- DEUROTECH GROUP GMBH
- DEUTSCHER FACHVERLAG GMBH
- DIENES WERKE GMBH & CO. KG
- DIETZE + SCHELL MASCHINENFABRIK GMBH & CO. KG
- DOUBLE E INTERNATIONAL, LLC
- DOUBLE JU INTERNATIONAL LTD. - BARTHOLOMY REEL HANDLING UNITS / BARTHOLOMY ROLLENHANDLING PRODUKTE
- DR. SCHENK GMBH
- DRÄGERWERK AG & CO. KGAA
- DRECKSHAGE
- DRELOO ING. PAUL DREWELL GMBH & CO. KG
- DRUCKTECHNISCH BLOS GMBH
- DRYTEC TROCKNUNGS- UND BEFEUCHTUNGSTECHNIK GMBH & CO. KG
- DS DATENTECHNIK UND SOFTWAREENTWICKLUNG MÜFTAHI
- DÜRR SYSTEMS AG / CLEAN TECHNOLOGY SYSTEMS
- EIBENROTH KENNZEICHNUNGSSYSTEME GMBH
- ELKOM-ELEKTROHEIZPLATTEN-TECHNIK GMBH
- ELOVIS - LÄNGEN- U. GESCHWINDIGKEITSMESSTECHNIK GMBH
- ELTEX ELEKTROSTATIK GMBH
- EMTEC GRAFIX GMBH
- EMMENDINGER MASCHINENBAU GMBH
- ENTEX RUST & MITSCHKE GMBH
- ENULEC GMBH ELECTROSTATIC
- ERHARDT + LEIMER
- ESWE-FLEX WALZEN GMBH
- EXPERT STEPHAN HEUSER GMBH & CO. KG
- FELDBAUM + Vogt GMBH
- FGM FRITZ GRADERT MASCHINENBAU GMBH & CO. KG
- FINESTFOG GMBH
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Orange County Convention Center (North Hall A, Orlando, FL)

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The FN405E, a Cutting-edge NS Slitter Model Developed for Flexible Packaging

Kazuki Yoshimi
Sales Department
Nishimura Mfg. Co., LTD.
http://www.ns-slitter.co.jp/

1. Introduction

On occasion of our 60th year in business, Nishimura Manufacturing Company developed the FN405E, a general-purpose secondary slitter for standard flexible films. The new slitter was designed by thoroughly updating our existing general-purpose model both to meet the specifications required by today’s standard flexible film market and to be sold at a competitive price.

2. Technological Development Background

Founded in 1957, Nishimura Manufacturing Company recently entered its 60th year in business. Throughout our history, we have supplied equipment to a wide range of industries, and designed slitters that work with a broad variety of materials, including the latest materials of the times and those materials for which demand exists regardless of the era. Some examples include packaging film, optical film, paper, metal foil, lithium ion secondary battery electrodes, separator film, video tape, audio tape, x-ray film, nonwoven fabric, and adhesive tape. Among our slitters, one of our top-selling machine has been the FN Series, a general-purpose secondary slitter model for standard flexible films, including packaging materials. As of today, we have delivered more than 800 units.

The specifications of this model have been kept simple for good operability and a reasonable price that falls within the range of general-purpose machines. More importantly, although true for all of our slitters, we have given our FN Series models the durability to be continually used for 20 and 30 years. The design, which considers both the rationality and reliability of the equipment, represents our spirit of manufacturing.

On the other hand, we are faced with one problem particularly because these models are well-used for years on end. Specifically, the problem of “updating our general-purpose models”. Currently, the most basic of our FN Series models operates at a maximum speed of 250 mpm, and is not equipped with a roll unloading mechanism. Many of the model’s operators are long-time users, and in many cases will install a new machine with the same specifications as their existing machine. As such, until now these machines have changed very little in terms of appearance, ease of use, and basic machine specifications. In contrast, the primary demands common to all slitters in the standard flexible film market in Japan today are a speed exceeding 350 mpm, a standard equipped roll unloading mechanism, and a cost range on the level of general-purpose machines. Our models that meet these specifications are upgraded versions of our standard specification models. As such, a divide has occurred between our general-purpose models and the typical needs of today’s film market (primarily in Japan).

Although the need for slitters on the global market for standard flexible films, including packaging film, is extremely large, there are many competing manufacturers and price competition is severe. In this light, we have recently placed more importance on high-value equipment as films have become more advanced, so we cannot deny that our name recognition on the standard flexible film market has fallen. Therefore, we began developing a new general-purpose slitter for standard flexible films (Photo 1) and plan to demonstrate these machines in order to strengthen our presence on this market as well as increase the name recognition of the “NISHIMURA” brand on the global market.
3. Requirements for Slitters on the Flexible Packaging Market

Given the nature of standard flexible film applications, high-volume production must be low-cost and efficient. As such, slitters are required to operate at high speed, be easy to use, and be available in the cost range of general-purpose equipment. As mentioned in the previous section, the slitters that are widely sold throughout the world today operate at speeds exceeding 350 mpm and come equipped standard with a roll unloading unit.

During the development of the FN405E Slitter, our sales department took the lead in designing the machine to ensure the machine was equipped with only the minimum required specifications and to ensure the cost was kept low. We also placed particular attention on the ease of use.

For example, the touch screen and operations panel button displays are very different from those of our conventional general-purpose model. Specifically, we adopted graphics and charts for the touch screen display, and made modifications so that the layout provides organized information that is easy to understand at a glance (Photo 2). Moreover, we used icons for the operational button displays where possible, and replaced
the conventional word-type indicators with graphics and symbols that represent the specific operation (Photo 3). These improvements were not made simply to improve visibility, but were made so that the operational procedures could be understood as images in recognition of today’s globalizing world. In fact, slitter manufacturers in the US and Europe, regions populated by individuals with a variety of linguistic backgrounds, primarily use icon displays for most equipment operations today.

In terms of machine specifications, we increased the maximum speed from the original 250 mpm to 400 mpm, and the
The machine now comes equipped standard with coreless edge trim rewinding units and a semi-automatic roll unloading unit. The edge trim rewinding units are designed to solve problems found during higher speed operations. When operating flexible packaging slitters at high speed, the trimmed edges can break or become entangled, which often causes problems that halt production. In response, our edge trim rewinders have a structure that guides the trimmed edges immediately below either side of the rewinding shaft and rewinds these using motor torque control. Moreover, locating the trim rewinding units directly below the rewinding shaft allows product rewinding and edge trim rewinding to be observed at the same time from the same position (Photo 4). In addition, we included tracking contact rollers before rewinding and equipped the individual rewinding nip rollers with a contact pressure adjustment mechanism that stabilizes high-speed rewinding operations (Fig. 1, Photo 5).

We also adopted a semi-automatic system for unloading units with a high frequency of use. An air cylinder is used to dock the unit with the rewinding shafts, while the unit shafts are pivoted manually. Although a motor could have been used as the drive system, we chose this simple mechanism to increase the operability and durability. Moreover, there is no operational down-time during the manual steps, which shortens work times. The simple mechanism also improves the machine rigidity, reduces the frequency of breakdowns, and considers the long-term use by our customers. In addition, the unmotorized system ultimately helps to reduce the amount of maintenance (Photo 6).

We also improved the rewinding shaft. In this case, the rewinding shaft is composed of a main shaft and individual friction core holders (referred to as PX Holders). The PX Holders also have the unique ability of being able to transmit torque; engaging the pistons laterally prevents the holders from being affected by torque transmission variation during rewinding regardless of the weight of the rewound product. The torque transmission unit is also specially machined to reduce torque variation, which improves stability. The holder surfaces are embedded with ball bearings, which allow even heavy product rolls to be easily unloaded with a simple push of the hand (“Floating Sup-

![Photo 5 Individual Nip Roller Contact Pressure Adjustment Mechanism](image)

![Photo 6 Roll Unloading Unit](image)
port", Photo 7).

We also modified the design of the new slitter in terms of the appearance. For example, we adopted a two-tone color and made part of the cover translucent, giving the new machine a more sophisticated appearance than our conventional design (Photo 8). The neatly positioned internal wiring and piping can also be seen through the plastic cover. Although these areas typically remain hidden, we have given care to these areas of over the years (Photo 9).

As mentioned thus far, the design concept for our newly developed FN405E slitter maintains the functionality and durability of our conventional machines while upgrading the specifications to meet the needs of today’s market and reducing the cost to a level equal to similar machines generally sold in Japan.

4. Future Outlook

As described thus far, this year we newly developed the general-purpose FN405E slitter model for the standard flexible film markets, including packaging film. Over the past 20 years, we have mainly supplied slitters to markets that handle special materials, including lithium ion secondary battery materials (film, nonferrous metal foils) and advanced films (optical-use, electronic-use), which has increased the ratio of our international sales to 70% and brought the “NISHIMURA” name recognition throughout the industry. Even so, there is no guarantee that today’s market environment will continue into the future.

Existing structures change with the continuous development of new materials, while new companies, teams, and research centers come into being. As such, for us to continue the name “NISHIMURA” indefinitely, we must steadily work to increase our name recognition from where we stand now. For this reason, we hope to improve the standing of the “NISHIMURA” name globally by aggressively promoting ourselves through this machine, which is designed to be used widely in the standard flexible film market—a major market for slitters—and by having users experience our slitters through demonstrations of an actual machine.

We also offer thorough after-service, so we would also like to touch upon this point here. From our service departments located at our Kyoto headquarters and Tokyo branch offices, we cover both Japan and the globe. As such, users who are newly considering one of our slitters upon reading this article should not worry about this point.

For your information, this past September we began operating the newly developed slitter, and are currently accepting requests for tours and slitter tests. Our first step in promoting the machine outside of our company, will be a planned exhibition of an actual machine at Convertech JAPAN 2017, to be held from February 15 to February 17, 2017, at Tokyo Big Sight in Tokyo, Japan. As such, we look forward to seeing you at our booth when you visit the show and hope you take this opportunity to view our manufacturing spirit with its focus on functionality, general-purpose applicability, and durability.
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www.ns-slitter.co.jp

February 15 - 17, Tokyo Big Sight
East hall 2, Booth 2E-01
1. Introduction

Plastic film (film hereafter) is converted into products through a variety of secondary processes, including coating, printing, laminating, and sitting, but the final step in the converting process often winds the film into a roll. Defects in the wound roll can lead to other problems, such as lowering the value of the product and preventing the film from being fed into later processes. In short, it is no exaggeration to say that winding is the most important process affecting the final quality of the film.

Technologies that wind the web without issue have been developed based on experience acquired on the plant floor, and these empirical technologies have become very useful. Meanwhile, we have received comments expressing the difficulty with which companies are faced when establishing the winding conditions for films that require a very high level of quality, as well as when dealing with winding defects that occur during transport to later processes and storage.

One way of overcoming these problems is a theoretical approach to winding defects. In other words, the optimal winding conditions are determined based on a theoretical understanding of the mechanisms that cause these defects.

2. Fundamental Thinking

The degree of quality, productivity, and cost required for a film differs depending on the final product. As such, establishing the winding conditions (particularly tension, taper rate, and nip load) that satisfy these requirements has become an important

With one goal being the discovery of methods to prevent winding defects, research into winding theory has primarily been conducted by the Web Handling Research Center at Oklahoma State University in the US, and by the Hashimoto Laboratory at Tokai University in Japan. The results of this research have reached a practical level and have begun to be used effectively in the industrial world.

In this article, we will introduce the fundamental thinking behind these theoretical approaches to winding defects and provide several specific examples.
1. Introduction

Pressure-sensitive adhesive (PSA) products come in one-ply (Fig. 1a), two-ply (Fig. 2b), double-sided tape (Fig. 1c), and substrateless double-sided tape (Fig. 1d) structures. In general, one-ply products are made by coating a PSA onto the surface of the substrate and coating a long-chain alkyl release agent or alkyd release agent to the opposite side of the substrate. Two-ply products are made by coating the PSA to the substrate and coating a release agent, primarily a silicone type, to the surface of a second substrate used to protect the PSA surface.

In addition to the packaging and packing fields, these types of PSA product are increasingly being used in applications related to the construction, automotive, and electronics/electrical fields. These products also come in a broad range of types—from advanced high-tech sheets to simple, easy-to-use tapes—and can be provided with different functions. As such, PSA products are being seen in a broader range of applications in different fields, where some examples include PSA films that combine a UV/IR blocking function with an anti-glass-scatter function, outdoor-signage PSA sheets that improve visibility when exposed to UV light, automobile body and tire protection, automotive PSA tapes for interior applications, semiconductor related tapes that change their properties from PSA to adhesive, and liquid-crystal related PSA films that have the ability to relax the thermal shrinkage of substrate films.

2. PSA Mechanism

In general, solid surfaces are composed of microscopic roughness that forms voids (gaps) when two solids are brought to-
1. Introduction

Almost twenty years have passed since we thought it would be possible to achieve a water vapor transmission rate (WVTR) of $10^{-6}$ (g/m$^2$/day). It was only in 2015 and 2016, however, that this barrier technology finally took form. Although this may seem like a long time, it is a length of time we like to think of as “history”. However, the results are something that we should be able to say were “right beneath our noses”. In this article, we will introduce the approach we took towards perfecting this high barrier film.

2. Forming a Barrier Layer on Plastic

Figure 1 shows the gas barrier film categories and their relationship to each other as seen from the perspective of WVTR. From this, we can see that it took twenty years and three generations of barrier films (gas barrier plastic films, metal/inorganic coated barrier films, high barrier films) to reach a gas barrier property of $10^{-3}$ (g/m$^2$/day). Over these three generations, the authors formed individual barrier films one at a time by changing the substrate, density, and temperature. The first item is the substrate, for which we chose PEN. We used a source gas of SiH$_3$Me+$\text{H}_2$+$\text{O}_2$+$\text{N}_2$, but we did not utilize a SiH$_4$+$\text{CH}_4$+$\text{H}_2$+$\text{O}_2$+$\text{N}_2$ process. The barrier film is formed of individual layers with a thickness of approximately 100–200 nm.\(^1\) We formed films with compositions including SiCN (H), SiOCN (H), and SiCNF (H). Here, (H) represents hydrogen, but the volume of hydrogen in the film is not recorded by our instruments. Figure 2 shows the dispersion of gas from the top to the bottom of these films formed on a plastic surface. Because the number of molecules (for example CO$_2$) that reach the OLED (organic light emitting diode) layer is smaller by a degree of magnitude, the film effectively works as a filter. Moreover, the smaller the amount of molecules (atoms) that pass through this barrier film, the smaller the amount of molecules (atoms) that pass through the plastic, where the plastic film also functions to protect the gas barrier films.

Next, let us look at the method we used to investigate the...
Being specialized in the niche market of small-scale, table slit die coaters, Hideo Otsuka, president of Die-Gate Co., Ltd., says that the company will make anything that their customers request. Likewise, in 2016, the company developed its latest model, the “New Taku-Die-Mini,” based on all of the experience and knowledge they have acquired thus far. With a maximum coating width of 100 mm, the new model is much narrower than earlier models. Despite its size, the machine is equipped with a range of new ideas, such as independent coating and control units (which allows for a more compact machine), a minimum coating fluid of volume of 5 cc, a cantilevered die head, and a motorized die unit lift. Having worked with more than 1,000 customers, Mr. Otsuka is proud to say that the new model is based on a deep understanding of the demands placed on table coaters.

100 mm Maximum Coating Width

Mr. Otsuka states that wherever he looked in the world when he first developed the Taku-Die table coater in 2001, he could not find a small-scale coater anywhere. Even so, the machine was so attractive that whenever a customer made a test coat with the machine, oddly everyone wanted to use it. In fact, during the 10 years after its development, Die-Gate sold nearly 80 Taku-Die table coaters.

Mr. Otsuka was not satisfied with the machine, however, so set to work developing an improved model and released the “New Taku-Die” five years ago. This model improved on the imperfect technology of the original Taku-Die, was easier to use, and allowed for lower coating weights. Mr. Otsuka says...
1. Introduction

In April 2016, the Japanese Ministry of Economy, Trade and Industry and the German Federal Ministry for Economic Affairs and Energy signed a joint statement regarding cooperation on the Internet of Things (IoT)/Industry 4.0. By utilizing digital technology, including the internet and artificial intelligence, the cooperation aims to bring about a revolution in manufacturing, the industrial world, and society itself.

Industry 4.0 aims to realize smart factories. In other words, Industry 4.0 utilizes IoT to promote production automation as part of a shift to labor-free manufacturing and services. The printing and coating machines that we build, however, are still far from this ideal. One reason for this is the adhesive tape used to transfer the web from one core to another core in the rewinding unit. Specifically, this tape must be applied manually to the cores, which is also a factor placing direct upward pressure on production costs. In practice, we have yet to discover a method of precisely and quickly transferring the web to a new core that can replace this current method.

There are also many users who are searching for a tapeless method. Although there have been several attempts at realizing a tapeless approach, these have failed to become the standard for the converting industry. Given this desire to shift to a tapeless method, this article introduces a method that we are developing in which an electrostatic charge is used instead of tape.

2. Rewinding Unit

Photo 1 shows one of our rewinding units. Our rewinding units are equipped with a turret arm that can be mounted with two roll cores, which allows the web to be continuously rewound while the cores are exchanged. During web transfer, the turret arm rotates to bring the new core to the specified position. A contact roller then presses the web against the new core around which an adhesive tape has been wrapped ahead of time. A cutter located slightly downstream from the core cuts the web while simultaneously pressing the cut end with a brush so that the web wraps around the core and starts a new roll. Figure 1 shows the conventional web transfer process.

3. Conventional Tape Method

Today, we typically use the tape method to transfer the web. As mentioned previously, the tape method requires an adhe-
1. What Is a Bar Coater?

In general, the term bar coater refers to a spiral (wire) bar coater made of a thin stainless steel wire wrapped tightly around a bar, as shown in Figure 1. According to JIS K5400 Chapter 3.3 Test Sample Preparation, Section 7 Coating Methods, Subsection 7.5 Bar Coater, the bar coater standard is defined as follows: “The number provided to the bar coater is based on the diameter of the wire. The unit for the number indicating the diameter of the wire is mils*, where a higher number bar coater will produce a thicker coating film.”

In general, the wet coating thickness that can be coated using a bar coater is indicated for each bar coater number, but this is only one measure. Depending on the manufacturer, the wet coating thickness indicated for the same bar coater number can sometimes differ. JIS K5600-4-1 states that “different operators will produce coating films with clearly different film thickness even when using the same film applicator, so an absolute method is required.” Essentially, the actual wet coating thickness differs greatly depending on the coating fluid viscosity and the bar coater travel speed, among other factors. The degree of this difference has been covered previously, so please see these articles for details.¹⁻⁴

The coating fluid loaded between the wires, as shown in Figure 2, forms the coating film. As such, the intervening space between larger diameter wires will have a larger cross-sectional area, which in turn produces a thicker coating film. The wire, as shown in Figure 1, is typically wound tightly with narrow gaps, but such bar coaters will not supply a sufficient amount of coating fluid to produce thick coating films. As such, the gap between the wires must be opened, as shown in Figure 3, to increase the cross-sectional area. The coating fluid held between the wires is deposited on a substrate, such as chart paper, so it is easy to image how different bar coater pressures and travel speeds will produce different coating film thicknesses.

Spiral bar coaters (hereafter wire bar coaters) are made of fine wires that will break so that the bar coater suddenly

*¹ mil: Imperial System unit of length, primarily used in the US
1 mil=1/1,000 of an inch, or approximately 0.0254 mm (25.4 μm). For example, a No. 2 bar coater wire diameter is 2 mils.
becomes unusable, but an equally important or even greater factor in bringing the usable life of wire bar coaters to an end is wire gap clogging. As shown in Figure 4, coating fluid that has dried in the gaps or solids contained in the coating fluid that have become lodged in the gaps will leave marks on the wet coating fluid. It is not easy to remove such debris that becomes stuck in the gaps.

2. The Emergence of Wave Formed Bar Coaters

One response that emerged to solve the problem of wire breakage and clogging was the wave formed bar coater (Photo 1), which is made of a pipe formed with a fine wave pattern that serves the same function as the wires replaced by these waves.

As reported in “Fully Automatic Coater and Applicator Properties As Seen From Test Results” in CONVERTECH & e-Print, January/February 2016 (pp. 98-103), however, wave formed bar coaters unfortunately have a much narrower applicable range than wire bar coaters. The affinity between the wave formed bar coater and coating fluid is insufficient, and as shown in Figure 5, these are likely to leave behind a streaked pattern. As such, we cannot fully recommend this approach as a solution to the problems found with wire bar coaters.

3. New Formed Bar Coater Development

As mentioned previously, the diameter of the wire in the wire bar coater can be changed to control the volume of coating fluid that enters the bar coater and thus vary the coating film thickness. The cross-sectional geometry of the grooves into which the coating fluid enters are determined by the wire diameter, so this geometry is fixed. In contrast, the newly conceived formed bar coater is produced using a method that forms the desired geometry directly into the pipe, so there are few restrictions on the geometry. During research and development, we considered the following three factors, as shown in Figure 6, to be particularly important for the geometry of the bar coater grooves into which the coating fluid enters.

(1) Slope Angle
(2) Trough Depth
(3) Trough Width

By altering these three factors, we conducted a range of tests to determine the influence of groove geometry with high-, medium-, and low-viscosity coating fluids, as well as which combination of factors worked best.

During testing we used the fully automatic applicator shown
in Photo 2 because this allowed us to set the desired travel speed (from ultra-low to high-speed) and because an automatic coater with a high repeat precision was required. In addition, when a high film thickness precision is required, a vacuum table with a uniform suction strength across the entire surface is better at locking down the chart paper than the combination of a clamp and glass table. As such, we used a porous table with an integrated vacuum pump. The travel speed of this model ranges from 2 to 500 mm/s and can be adjusted in 1 mm increments while providing a high travel speed precision with a variance of ±1% compared to the reference speed. The equipment also includes a lift that raises and holds the bar in place to prevent the bar coater from rolling on its own after coating is complete.

4. High-viscosity Coating Fluid and the Newly Conceived Formed Bar Coater

For the high-viscosity tests, we used a 27,000 mPa·s² viscosity adhesive.

The definition of high-, medium-, and low-viscosity depends on the industry. In one example from the coating industry, anything lower than 30 mPa·s is low-viscosity, 40–60 mPa·s is medium-viscosity, and anything above 60 mPa·s is high-viscosity. Although these viscosities may be a result of assuming spray coating, this industry example has a fairly low medium-viscosity range. Meanwhile, in one example from the adhesive industry, anything below 5,000 mPa·s is low-viscosity, 5,000–100,000 mPa·s is medium-viscosity, and anything above 100,000 mPa·s is high-viscosity. This second example has much higher viscosities than the first example, and the medium-viscosity range is broad. Coating fluids used with bar coaters are found in industries ranging from coatings to adhesives, so for reasons of convenience we defined anything up to 100 mPa·s as low-viscosity, 100–10,000 mPa·s as medium-viscosity, and anything above 10,000 mPa·s as high-viscosity. As a reference, the viscosity of olive oil is 100 mPa·s, tomato ketchup is 1,000 mPa·s, and honey is 10,000 mPa·s.

4.1 Influence of Slope Angle

We produced formed bar coaters with different slope angles, including those with standard slopes, steeper than standard slopes, and gentler than standard slopes for the tests. We will introduce the results here using a standard wire bar coater as a comparison. All of the bar coaters used here have a wet coating thickness catalog value of 10 μm.

(1) Comparison With Standard Slopes

First, let us compare the standard slope formed bar coater—as the authors have defined it—with the wire bar coater. Figure 7 shows a magnified image of the standard formed bar coater. The slope angle is roughly 45°. Figures 8 and 9 show the coating test results for the wire bar coater, whereas Figures 10 and 11 show the coating test results for the standard formed bar coater. Figures 8 and 10 show the relationship between bar coater travel speed and average film thickness, as well as the relationship between travel speed and film thickness variation. Meanwhile, Figures 9 and 11 show a three-dimensional profile of the coating geometry produced by the different coating speeds (left side) and the coating surface appearance (right side). The photographs showing the appearance confirm the existence of streak patterns when the coating is placed under a white LED spot light. This test used an adhesive, but in the case of coating fluids that cure more slowly and level more easily, the streak pattern is more gentle, and in some cases vanishes altogether.

When comparing Figures 8 and 9 and Figures 10 and 11, we see very similar properties. The reason the conventional wave formed bar coater from Photo 1 more likely produces streaks in the coating surface than the wire bar coater is assumed to be caused by the shallower grooves in the bar, which

\[ \text{mPa·s: millipascal-second} \]
\[ 1 \text{ mPa·s} = 1 \text{ cp} \]
Figure 9 Wire Bar Coater Coating Test Results (2)

(a) Relationship Between Travel Speed and Average Film Thickness
(b) Relationship Between Travel Speed and Film Thickness Variation

Figure 10 New Formed Bar Coater: Standard Slope Angle (1)

Figure 11 New Formed Bar Coater: Standard Slope Angle (2)
Coating are a result of problems in the production method. The new formed bar coater does not contain any gaps between the waves used in place of the wires, so this design fundamentally solves the problem of clogging. For those troubled by cleaning, we can recommend this standard slope angle bar as an alternative. The aforementioned three factors can also be changed in various ways for the formed bar coater. Because the new formed bar coater offers possibilities beyond those of conventional wire bar coaters, we decided to look into its further potential.

Although this can be said for the tests as a whole, extremely high bar coater travel speeds of 100 mm/s result in a more attractive coating surface appearance. This is more a result of the round bar acting as if it is a flat surface than as a result of the coating fluid in the grooves forming a film. In this case, however, large waves easily form in the coating surface, and in extreme cases the coating film thickness tends to show large variation. As such, the user must take particular care in this speed region. Moreover, even if the surface appears attractive at first, it is difficult to control the reproducibility.

(2) Comparison With Gentle Angles
Let us take a look at Figures 12 and 13. When we reduce the slope angle by 10–15° compared with the standard slope angle from above, we tend to see greater coating film thickness variation and a poorer appearance. Although we expected the gentler slope to result in a coating with better leveling, high-viscosity fluids do not have the fluidity to follow the trough slope as they travel and form a film, so the results are actually worse.

(3) Comparison With Steep Angles
Let us take a look at Figures 14 and 15. When we increase the angle by 10° over that of the standard slope angle, we tend to see less coating film thickness variation and a better appearance. As such, we increased the slope a further 10° to test an extremely steep slope. Figures 16 and 17 show the
Figure 14 New Formed Bar Coater: Steep Slope Angle (1)

Figure 15 New Formed Bar Coater: Steep Slope Angle (2)

Figure 16 New Formed Bar Coater: Extremely Steep Slope Angle (1)

Figure 17 New Formed Bar Coater: Extremely Steep Slope Angle (2)
results. Although we do not see a significant change in coating film thickness or variation, we see a shift towards an improved appearance.

4.2 Influence of Trough Width

Figures 18 and 19 show the test results when the slope angle is kept at the standard degree and the trough width is doubled. When we increase only the width of the trough, we see an increase in variation and a clear drop in the appearance quality.

For this reason, it appears as though there is a close relationship between the trough depth and width.

4.3 Influence of Trough Depth

In the case of the high-viscosity coating fluid tests thus far, we found that the slope angle is important, and that a steeper slope produces better results. Therefore, we made further tests with an extremely steep slope angle (20° greater than the standard angle) and a trough depth of three times the stan-
standard, but without changing the width. Figures 20 and 21 show the results. When comparing Figures 16 and 17, for bars which have the same slope angles, we see that deeper troughs produce a thicker coating film. In the case of high-viscosity coating fluids, we see that the film thickness is more responsive to a change in the cross-sectional area resulting from a deeper trough than from a wider trough.

5. Thin-film Test Results

Given restrictions on space, we will omit the intermediate steps. Until now, it has been extremely hard to achieve thin-films of less than 5 μm in thickness using a bar coater and a high-viscosity fluid. By using a very steep slope angle and focusing on the relationship between the trough width and depth to select the right combination, however, we found that we can also coat thin-films. Figures 22 and 23 show the results.
6. Closing

In the case of high-viscosity coating fluids, our test results show that the following factors are important:

1. A steep slope angle is better.
2. There is a correlation between trough width and depth, but it is better to prioritize changing the trough depth to adjust the coating thickness. At the same time, we must determine the combination of depth and width that results in problems with appearance and thickness variation.
3. In consideration of the above points, it is possible to overcome the coating limits of conventional wire bar coaters.
4. Bar coater travel speed control and repeat precision are extremely important, so from the perspective of those familiar with hand coating, the ideal coating speed is in a much lower region than typically thought.

In this session we covered the topic of high-viscosity coating fluids. In the following session we would like to cover the topic of medium- and low-viscosity fluids.

Acknowledgments

We would like to express our appreciation to NIPPON KAZAI Co., Ltd. and OSG SYSTEM PRODUCTS CO., LTD., without whose cooperation these tests would not have been possible.

References

1. T. Tate: Fully Automatic Coater and Applicator Properties As Seen From Test Results, CONVERTECH & e-Print, Vol. 6, No. 1, pp. 98-103 (January/February 2016)
7. Non Skin Decoration (continued)

2.3 High-quality Die-mold Surface Forming Decoration

Recently, high-quality die-mold surface forming decoration techniques have been developed as a means of improving the surface quality of molded products by precisely forming the surface of the molded products using the design/texture of the die-mold surface.

The goals of precisely reproducing the die-mold surface onto the molded product can be broadly divided into two categories: precisely forming a detailed pattern on the molded product surface and improving the appearance of the molded product while maintaining a good surface condition. In this session, we will explain the latter goal. As indicated in Session 3 of this series (Chapter 2: Decoration Technology Details 2, Convertech & e-Print, July/August 2016, p. 95, Figure 31), applying fine patterns (textures) can provide functions such as fingerprint resistance and water repellency, so is not completely unrelated to decoration.

2.3.1 Factors Affecting the Die-mold Surface Forming Capability

During injection molding, molten resin is injected at high-pressure into the die-mold, and produces a molded product formed with the pattern of the die-mold surface at a macro level. The injected molten resin, however, forms a skin as it contacts the die-mold surface and cools inside of the die-mold, so standard injection molding methods do not sufficiently form a pattern on the surface at the micro level. In many cases, this insufficiency produces a molded product without a fully formed surface. For this reason, a clear coat is often applied during a later process to improve the surface condition.

The factors affecting the ability of the die-mold surface to form a pattern on the molded product are as follows.

1. Quality of the materials
2. Temperature, particularly the die-mold temperature

The die-mold temperature is generally lower than that of the molten resin, and as shown in Figure 62, as the molten resin fills the cavity and contacts the die-mold surface, the resin cools and forms a skin. Even if the injection pressure is high, a low die-mold temperature will prevent the molten resin from fully covering the die-mold surface, which means the die-mold surface design will not be precisely reproduced on the molded product surface.
In general, the failure phenomenon seen in polymer materials, such as adhesive layers, typically starts from voids, fractures, and other discontinuous points within the layer that become stress singularities inside the polymer material. In regard to these points, we analyze the stress profile for the areas near the ends of the fractures and near the voids. When evaluating the failure property of an adhesive layer containing multiple voids, however, we must also consider the size and number of voids as we analyze the stress profile of the entire adhesive layer. Today, wiring for electronic components, such as semiconductor memory chips, use a copper/aluminum (Cu/Al) multilayer film structure. During processing of these Cu/Al multilayer films, the mask is typically produced by coating the Cu/Al film with a polymer (resist film) containing a main component of novolac resin.

The authors discovered that heating multilayer structures (glass/polymer/Cu/Al/glass) to vaporize the solvent leaves behind tiny voids, which we analyzed based on the viscous fingering theory. Here, viscous fingering is defined as localized deformation of the viscous film caused by the growth of air bubbles when a gas is generated inside the viscous film. In addition, the deformation has a fractal-like geometry that resembles the shape of fingers. This phenomenon is analyzed in detail using a model for the growth of air bubbles inside glycerin. In this session we will focus on the influence that multiple voids in a polymer film will have on the failure strength of a glass/polymer/Cu/Al/glass multilayer structure. In particular, we will measure the dependency of the failure strength on the void area and use the finite element method to analyze the influence that void formation has on the stress profile for the entire polymer film.

The dimensions of the glass substrate used here are 15 mm long, 15 mm wide, and 1.0–1.2 mm thick. The washed glass substrate is first coated in a vacuum with an Al film followed by a Cu film. The Al film is 500 nm thick and the Cu film is 15 nm thick. We then measured the surface roughness of the Cu/Al/glass multilayer structure using an atomic force microscope (AFM), and selected film samples with a root mean square roughness of 9–12 nm.

Next, we spin coated a 10 μm thick polymer film on the Cu/Al/glass multilayer structure. This polymer film acts as an adhesive layer, which is used to laminate a second glass substrate (5 mm long, 5 mm wide, 1.0–1.2 mm thick). Here, we did not vaporize the solvent before adhering the second glass substrate. The polymer film (resist) used as the adhesive layer consists of three components: m/p-cresol novolac resin, photosensitizers, and solvent. The softening temperature of m/p-cresol novolac resin is 150°C, the thermal decomposition temperature of the naphthoquinone diazide photosensitizers is 135°C, and the boiling point of the ethyl cellosolve acetate solvent is 156°C. The end-point temperatures during heating were set to 150, 200, 250, and 300°C. By heating the polymer film at a temperature exceeding 150°C, we can assume that almost all of the photosensitizers undergo thermal decomposition. Figure 3.30 shows the cross-section of a sample made in this way.

As shown in Figure 3.30, a tensile tester is used to apply a tensile force (max. 156 N) to the samples until they fail. We can thus define the failure strength $F$ (N) of the samples as the
face energy $\gamma$ of the sample heated to 300°C to increase to 1.2 times that of the sample heated at 150°C. We can thus assume that the the adhesion work at the polymer/Cu film interface increases as a result of this higher surface energy. The 1.2 times increase in polymer film surface energy $\gamma$ does not explain the total increase (approx. 2.7 times) in failure strength $F$ of the sample shown in Figure 3.33. Therefore, we can assume there is some other factor that further increases failure strength $F$.

Here, we use the finite element method to analyze the polymer film internal stress profile resulting from multiple voids. Figure 3.35 shows the internal stress profile analysis results. Figure 3.35(a) shows the model for a polymer film with no voids. In this case, we see a high (100 MPa), yet uniform stress profile throughout the entire film. Meanwhile, Figures 3.35(b) and (c) show the models for polymer films with three and eight voids, respectively. From these models, we see that although the effective contact area of the adhesive layer decreases as the number of voids increases, the sections of the polymer films without voids show gradually decreasing levels of internal stress. Therefore, we can conclude that the internal stress relaxation of polymer films with voids is the primary factor for the increase in failure strength resulting from a decrease in effective contact area, as shown in Figure 3.33.

Moreover, Figures 3.35(b) and (c) show that void generation causes the local stress profiles to become irregular. In particular, stress concentrates in the areas around the voids. Looking more closely at Figure 3.32, we see that failure occurs at the Al/glass interface where stress has concentrated around the voids. Therefore, we can assume that failure at the Al/glass interface is caused by stress concentration in the area around the voids. In this way, the finite element method stress profile analysis can be used to qualitatively analyze how void formation influences the failure behavior of the adhesive layer.

In this session, we focused on stress relaxation and concentration in polymer films resulting from the formation of multiple voids as a means of analyzing the failure characteristics of glass/polymer/Cu/Al/glass structures. This topic can be summarized as follows:

- The main factors that increase the failure strength of multilayer substrates are voids that cause internal stress relaxation inside polymer films and an increase in surface energy.
- The cause of release at the Al/glass interface is stress concentration in the areas around the voids in the polymer film.

In this way, we clarified the mechanism that increases failure strength in samples of multilayer structures as a result of void formation in the polymer layer.
7. Water-based Flexo Printing Conditions for Flexible Packaging Films

High-definition film printing requires the selection of an appropriate ceramic anilox roller. Meanwhile, water-based inks can have higher densities than solvent inks, and are also useable with relatively fine line, low volume anilox rollers.

In the case of paper printing, coated and uncoated paper have differed ink receptivities, so require different anilox roller selection criteria. For example, high-quality coated paper having a very smooth surface (art paper for example) can be printed with the same fine line, low-volume anilox rollers used for film. On the other hand, uncoated paper, which has a rougher surface and higher ink permeability, can be printed using anilox rollers with relatively few lines and higher cell volumes.

7.1 History of Water-based Film Printing Anilox Rollers

Fine line anilox rollers have not always been used for film printing. During the 1990s, fine line engraved anilox rollers1 had a maximum lpi of 650 and a total cell volume of (V) of 3.5–4.5 cm$^3$. Therefore, research into process color flexo printing aimed at achieving high-resolution began using anilox rollers with these specifications. At the time, analog printing plates were also used and the process color screen line number was 75–85 lpi.

Anilox rollers with 800 lpi or more were first introduced in the 2000s, at which time computer-to-plate (CTP) technology was also adopted, both of which greatly increased the resolution of flexo printing. Even so, these 800 lpi anilox rollers did not necessarily have a significantly lower total cell volume, for which the target volumes were 3.5–4.0 cm$^3$. From 2005 on, 1,200 lpi rollers with a total cell volume of 3.5–4.0 cm$^3$ came into use.

The relationship between line number and cell volume for anilox rollers is not determined by a specific standard, so anilox rollers can be made using a fairly wide range of lpi/V combinations. In other words, the roller can be selected based on the goals of the printer.

7.2 Water-based Film Printing Anilox Roller Selection Today

Over the past 10 years, process color printing using 800–1,200 lpi and 3.5–4.0 cm$^3$ total cell volume anilox rollers has become standard, which is also true for image printing. In other words, these are the printing conditions that allow for the best balance. Although the difference in resolution between 800 and 1,200 lpi rollers is not noticeably different with water-based printing, changes in other printing conditions, such as temperature, humidity, film wetting, printing viscosity, printing pressure, and printing speed have a larger influence on resolution.

Printing methods, such as UV flexo printing, in which the ink undergoes little change on the anilox roller or printing plate, are better at reproducing fine halftones with 1,200 lpi anilox rollers. In other words, these offer improved resolution precision in the highlight sections.

Meanwhile, water-based solid color reverse printing requires the use of an anilox roller with a fairly high total cell volume to ensure the white ink density. Initially, 200–250 lpi anilox rollers with a total cell volume of 15 cm$^3$ were used, but anilox rollers having so few lines result in mottling, a high number

1 Cells with 650 lines per inch (2.54 cm) and a volume of 3.5–4.5 cm$^3$/m$^2$. 

Author Profile

Fumio Ito began working for Toyo Ink Manufacturing Company in April 1958, at which time he was assigned to the research department. In 1960 he was transferred to the Jujo Plant Gravure Business Technology Unit. In the following years he was involved in the development of gravure ink, water-based gravure ink, and water-based flexo ink, as well as printing system research. In March 2007 he retired from Toyo Ink Manufacturing and began working for NEWLONG MACHINE WORKS, LTD, where he remains today as a flexo technology advisor.
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The world around us is full of industrial products made of relatively thin materials, including paper, textiles, plastic films, thin-film glass, nonwoven fabric, and metal foils. Although this variety shows that these materials are essential to our daily lives, they are also critical in furthering the development of high-tech industries that will eventually form the core of the global economy. Some examples from the IT, energy, and medical fields include optical films for flat panel displays, solid polymer membranes used in fuel cells, and artificial biological membranes for medical applications. During the manufacturing process, however, we call these materials webs.

Web manufacturing technology relies on the converting technologies of coating, laminating, and printing, as well as on web handling technology (here we include unwinding, slitting, cutting, drying, and rewinding, etc.). Among these, coating and printing have established technology (here we include unwinding, slitting, cutting, drying, and rewinding, etc.). Among these, coating and printing have established as cutting-edge technologies, for which academics have shown great interest. In contrast, web handling technology has conventionally been refined through production plant experience; although the technology itself has reached a fairly advanced level, its academic understanding is poor.

At the strong behest of the industry, the author has spent the past 20 years working to theoretically understand the physical phenomena related to web handling, and predicting and preventing the problems that occur during manufacturing. Our research has been studied widely in Japan by industries that utilize web handling technology, and has been praised for the help that it has provided in eliminating defects and developing new products.

On the other hand, we have also received strong interest from around the world in publishing our results in English given the desire to understand the strength of Japan's web handling technology. Given that the theoretical research into web handling began outside of Japan, we are elated to be able to publish an English version of our work as it will allow us to repay our debt to those who came before. At the same time, nothing would make us happier than to see this work contribute to the opening of new horizons for readers around the world involved in web handling technology.

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(1) Differential Equation, Laplace Transform, Transfer Function, and Time Constant for Width Direction Fluctuation Between Rollers

Following the explanation provided by textbooks on control, the previous session introduced a method for displaying the differential equation and Laplace transform regarding the lateral (width direction) change in web edge position between two neighboring rollers. If we summarize the results of the previous session in accordance with Figure 435, then the differential equation for line speed \( V_0 \) and web edge position displacement \( y_{i-1} \) between the \( i-1 \) roller and the neighboring \( i \)-th roller is

\[
\frac{m_i}{V_0} \frac{dy_i(t)}{dt} + y_i(t) = y_{i-1}(t) \tag{1}
\]

If we solve for \( y_i(t) \) using displacement \( y_{i-1} \) as the step input, then

\[
y_i(t) = y_{i-1}(1 - e^{-\frac{V_0 t}{m_i}}) \tag{2}
\]

The Laplace transform of Equation (1) is

\[
\frac{m_i}{V_0} Y_i(s) + Y_i(s) = Y_{i-1}(s) \tag{3}
\]

Therefore,

\[
y_i(t) = y_{i-1}(1 - e^{-\frac{V_0 t}{m_i}}) \tag{2}
\]

Figure 435 Web Position Between Two Rollers

Figure 436 Dynamic Characteristic of Step Response
Uses pattern matching

The system takes basic positions from within the entire image (such as the line, edge, pattern and text) and stores them in memory, detects web meandering and sends out correction signals.

Uses ZNCC (Zero-mean Normalized Cross-Correlation)

Stable detection is assured, even if there are variations in external light and print density.

Easy Search function

Simply specify the reference position from within the entire image and press the Search button to record the reference position in memory and start the detection.

NI SERIES
Nireco Intelligent Camera NIC100
Nireco Intelligent Panel NIP100
6. About the PSA’s Adhesion and the Relationship Between Release Agents and PSAs

Based on the understanding obtained through our fundamental research into the silicone release property, in this session we will consider the adhesion of PSAs. In addition, we will introduce the seemingly distant but surprisingly close relationship between release agents and PSAs.

6.1 Considering the PSA’s Adhesion From the Release Property

In our investigation of the silicone release property, we looked at the significant influence the elastic modulus (viscoelastic property), critical surface tension (surface energy), and functional groups have on the peel strength. Likewise these factors are also important in considering the adhesion of the PSA to which the release agent is applied.

First, let us look at Figure 110. When we consider the problem of the release property as seen from the adherend on the left-hand-side of this figure, the peel strength decreases as the elastic modulus decreases. Meanwhile, in order to peel the adherend and the PSA apart (in other words the peel strength), basically, these must be equivalent. If this is the case, it is only reasonable that the elastic modulus plays a role in and shows a similar trend for the peel strength of the adhesive, in other words.
High Speed Inkjet System SIJ-220
SANKI MACHINERY
Osaka, Japan
http://www.sankikikai.co.jp/en/

High-speed inkjet system “SIJ-220” for label printing. Realizes high speed printing up to 83m/min, and allows for high resolution continuous printing at 1600 dpi.

Glycoluril derivatives
SHIKOKU CHEMICALS
Chiba, Japan
http://www.shikoku.co.jp/eng/

Glycoluril derivatives are heat-resistant and transparent, and can be used as cross-linking agents for resins. These automatically produce a densely cross-linked resin because their structure contains four reactive sites.

FilmPro IR Thickness Sensor
Spectris NDC Technologies Japan
Tokyo, Japan
http://www.ndcinfraredjp.com/index.htm

Supports various application, including extruded sheets, biaxial film, blown film, coatings on film, voids, micro-pores, battery separators, and breathable film. The sensor measures very thin to thick sheets and coating on film. Allows for multi-layer definition of up to 6 components and can measure clear and colored films, including black tinted film. Measures the weight and thickness of void type, micro-pore type, and breathable film.

Low Temperature Sinterable Ag nano ink/paste
DAICEL
Tokyo, Japan

*Low sintering temperature
*Flat and Smooth Surface
*Low specific resistance

*High solid concentration enables thick lines.
Supports various printing methods
*InkJet printing Ink
*Screen printing Ink
*Gravure offset printing ink for imprinted circuits and 3D-wiring circuits

Separator Film Extrusion Unit
NISHI INDUSTRY
Gunma, Japan
http://www.sunfield.ne.jp/~nishi-k/English-top.html

Application: Separator film for Li ion batteries. We utilize our experience in chemical solution cycle systems for polarizer films.

Toppan Printing Strengthens its Barrier Film Business
- Investment of approximately 10 billion yen in additional equipment for Fukaya Plant to double production capacity for transparent GL BARRIER film and respond to increasing global demand -

Toppan Printing
Tokyo, Japan
http://www.toppan.co.jp/english/

Toppan Printing Co., Ltd. (hereafter Toppan Printing; head office: Chiyoda Ward, Tokyo; President & Representative Director: Shingo Kaneko) will bolster production equipment at its Fukaya Plant (Fukaya, Saitama Prefecture), which manufactures transparent barrier film GL BARRIER, and make use of the enhanced production capacity to respond to increasing demand in Japan and overseas. The investment will be about ¥10 billion,
with startup of the new equipment scheduled for autumn 2018.

Against a backdrop of such issues as the reduction of food loss and conservation of the environment, it is anticipated that the global packaging material market will see increasing demand for transparent barrier films, which allow foods to be stored for long periods and enable glass and metal containers to be replaced with flexible packaging.

Toppan Printing began producing and marketing its original transparent barrier film, GL BARRIER, in 1986. The film’s high oxygen and moisture vapor barrier performance has enabled it to capture a leading share of the global market for transparent barrier films. The Fukaya Plant was opened in April 2009 as a transparent barrier film production base and produces and sells products to customers at home and abroad. In April 2016, Toppan USA’s Georgia Plant was launched as the Toppan Group’s first overseas plant for transparent barrier film. In addition to the domestic market, the company is strengthening its sales of the product to Europe and North, Central and South America.

By bolstering transparent barrier film production equipment at the Fukaya Plant and roughly doubling production capacity, Toppan Printing will further strengthen its supply structure for Japan, China, and the ASEAN region. Sales of highly functional products will be expanded in the market for foods, in particular retort foods, for which growth is anticipated, as well as applications in the medical, pharmaceutical, and industrial materials sectors. Toppan Printing is targeting overall sales of approximately ¥130 billion for its transparent barrier film-related businesses in fiscal 2020.

Western Europe Third Largest Global Market for Industrial Fastener Demand

Demand for industrial fasteners in Western Europe totaled $15.7 billion in 2015, representing the third largest regional market for these products behind the Asia/Pacific region and North America. Western Europe has large aerospace equipment, electrical and electronic equipment, machinery, and motor vehicle manufacturing industries, all of which are major fastener markets. As a result, overall intensity of product use (gauged against durable goods manufacturing value added) is much higher than the global average. The West European fastener market tends to be highly cyclical, reflecting the maturity of manufacturing industries in the region. Fastener demand in Western Europe grew less than one percent per year between 2010 and 2015, constrained by limited growth in manufacturing markets and declining construction spending. These and other trends are presented in Global Industrial Fastener Market, 9th Edition, a new study from The Freedonia Group, a Cleveland-based industry research firm.

Market for Boxes Used in E-Commerce to Grow 10% Annually Through 2020

Demand for boxes for e-commerce packaging is forecast to advance more than 10 percent per year to $1.1 billion in 2020, driven by continued robust growth for online retail sales, which will spur concomitant opportunities for boxes needed to ship products. These and other trends are presented in Retail E-Commerce Packaging Market in the US, a new study from The Freedonia Group, a Cleveland-based industry research firm.

Emulsion Polymers in Paint & Coatings to Grow 5.4% Annually Through 2020

World demand for emulsion polymers in paint and coatings (excluding paper coatings) is forecast to expand a healthy 5.4 percent per year to 5.0 million metric tons in 2020, the fastest growth of any major emulsion market. A continuing shift toward the use of waterborne latex paints—a trend that is occurring in virtually all parts of the world—is projected to fuel market gains. Advances are expected to be most pronounced in developing countries, as these markets have the most potential for replacement of solvent-based coatings as well as for more rapid growth in coatings production overall. Healthy growth in building construction activity in North America, combined with a turnaround in Western Europe, will also buoy gains. These and other trends are presented in Global Emulsion Polymers Market, 7th Edition, a new study from The Freedonia Group, a Cleveland-based industry research firm.

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