Surface technology with extreme finesse

Poreless nickel plating for blown film die heads

The Kuhne Group, a classic example of the German "Mittelstand", is a world-renowned producer of machine technology for the film and sheet extrusion sector – and, in certain fields of application, even the world leader. By far the most coffee capsules and synthetic sausage casings, for example, are produced on machinery made by Kuhne. The key components of all Kuhne production lines are the extrusion dies, which, in the case of blown film extrusion, are referred to as blown film die heads. For the chemical nickel plating of these highly complex components, Kuhne relies on the precision work of the company Pallas GmbH und Co. KG, established experts in the field of sophisticated surface engineering.

Leading technology and decades of accumulated skill and know-how in terms of industrial experience and knowledge of raw materials make the Kuhne Group a sought-after expert for tailor-made extrusion lines. With three autonomous divisions, the company offers planning, design, manufacturing and installation – all under one roof. The division Kuhne Maschinenbau GmbH develops and manufactures turn-key extrusion lines for flat film and sheet. These are used for the production of, among other things, thermoformed articles like yoghurt tubs and coffee capsules, or agricultural and construction membranes. The core competency of the division Kuhne Anlagenbau GmbH is the construction of multi-layer blown film systems for the food, medical and pharmaceutical industries. But also manufacturers of balloon and battery membranes rely on the outstanding efficiency of these highly sophisticated extrusion lines. Finally, the division K-Tool GmbH, staffed by specialists in milling and polishing processes,

produces all the requisite components for all types of Kuhne extrusion lines: blown film die heads, flat dies, extrusion screws, and many more. This integrated arrangement under one roof enables Kuhne to guarantee premium quality that is 100% "Made in Germany". At the same time, international customers benefit from the resultant synergies, which are reflected in the continuous further development of Kuhne's sophisticated extrusion technology. With around 250 employees, the Kuhne Group at its location in Sankt Augustin generates an annual turnover of 75 million Euro, 80% of that through global exports.

For each property a separate layer of film

As consumer expectations become more and more sophisticated, the demands of the packaging sector regarding the properties of film packaging are getting increasingly more complex. These include characteristics like maximum gloss, brilliant transparency or soft touch and feel, as well as a wide range of mechanical and functional properties. As a result, first-class blown film has to fulfil expectations like exactly specified puncture and tear resistance, tensile strength, stiffness and thickness, as well as precisely adjustable shrink behaviour, high-quality printability and good sealability. The highest priority is, of course, maximum protection of the packaged goods during transport and storage, and meeting demands for longest possible storage life and multifunctional barrier properties. With their reliable resistance to oxygen, humidity or UV impact, high barrier films ensure that products maintain their colour and taste and that no fluids get in or out. They also ensure that precious aroma is not lost, that annoying odours are prevented, and that shelf life is maximised. Each of these property requirements may call for additional layers in the blown film. Depending on the plastics combinations in the individual film layers, additional tie layers may also be needed to promote adhesion.

Furthermore, so that packaging customers can preserve their competitive edge in spite of declining batch sizes, intelligent process optimisation measures are required to constantly cut down on production costs and material consumption.

Up to 17 layers simultaneously

Kuhne responds to all these increasing demands on the product quality and productivity of its extrusion lines through continuous further development of its technologies and designs. For example, Kuhne Anlagenbau is the only manufacturer that offers solutions for all three processes of blown film production. Whether the multi-layer blown film is to be air-cooled (Smart Bubble®), water-cooled (Cool Bubble®) or biaxially oriented without lamination or coating processes in a single work process (Triple Bubble®) – Kuhne uses a sophisticated modular system of standard components to manufacture optimally configured customer- and application-specific lines that set worldwide standards in terms of film quality and output capacity. The Kuhne core competency here is the development of multi-layer systems for up to 17 layers that can process practically all thermoplastics. In addition to this exceptionally high number of layer combinations, Kuhne systems also allow the production of extremely thin films with thicknesses down to 15 µm – and with correspondingly low raw material consumption. The central component of every blown film line is the die head, consisting of spirals which, housed in a vertical cylinder, form the melt channel. At temperatures of up to 300° C, the polymer melt is fed into these rotationally symmetrical components – mandrels or pancakes – and expelled through ring-shaped apertures under pressures of up to 500 bar. A tube – the so-called "bubble" – up to 20 meters long forms and is guided, without pressure, through a calibration cage to the collapsing frame, where it is laid flat, cut and wound to customer specifications. For multi-layer films, as

many extruders are used as the number of layers required. These are arranged in a star formation on the extruder platform. In a continuous process, all film layers are coextruded simultaneously and superimposed on each other. Nevertheless, for analysis purposes, each individual layer remains visible via a microtome section. In the case of Triple Bubble® technology, three bubbles are formed in a single work process, with the first bubble being biaxially oriented inside the second bubble, and the second bubble being heat set inside the third.

Down to the last micron

One of the responsibilities of Björn Greis, Design Manager Extrusion in the Anlagebau division and Technical Manager of the K-Tool division, is the complete manufacturing process of the blown film die heads. On the basis of the individual customer requirements regarding line type, film structure and size, and specifications for output and yield, he determines whether the job can be fulfilled with existing modules or whether special designs will be needed. Greis then discusses new designs of extrusion tools with the K-Tool team on the basis of technical drawings and CAD models before appropriate flow charts are drawn up and implementation begins. Continuous checks with the micrometer clock ensure that, even in the machining stage, all the dimensional specifications are being precisely met. During the polishing stage, the skill and experience of the tooling specialists is crucial. To avoid any resistance to the flow of the polymer melt, the surfaces are hand polished and, before coating, measured once again in a coordinate measuring machine. Even with all these measurement protocols, Björn Greis still insists on a final visual inspection: "Every die head component that comes in or out of here passes through my hands."

Contour-accurate coating

No wonder then, that his obsession with precision played a critical role when it came to selecting a new surface engineering provider for the chemical nickel plating of his die heads. Several bad experiences with imperfect surfaces had made him inherently sceptical about the value of this technology for extrusion tools. But still, due to the geometric complexity of the individual components and the extreme strain on them from wear and corrosion, chemical nickel plating remains a far superior option to all other galvanic processes. The coating produced by this chemical, autocatalytic process has excellent corrosion resistance and a hardness on a par with hard chrome. In the watery electrolyte, the coating precipitates on every component surface that is in contact with the solution, forming an absolutely even nickel-phosphorous alloy. This electrolessly deposited coating enhances even the most complex geometries with lots of fits, angles and threads – with absolute contour fidelity and micron precision. Through final tempering, the coating attains a hardness of up to 950 HV. In contrast to hard chrome plating, chemical nickel plating does not require any post-processing. However, the decisive factor for the quality of the plating is perfect mastery of this decidedly delicate process. About one and a half years ago Björn Greis finally found a proven and suitable surface engineering expert in Pallas, one that also used the sophisticated High-Phos method that Kuhne was so insistent on. This particular bath chemistry creates a nickel coating with a phosphorous content of over ten percent. Component surfaces enhanced in this way are extremely chemically stable and have a high resistance to corrosion.

Handled with kid gloves

This coating is most often used for the extrusion dies of Triple Bubble® lines. Their high-gloss polished die heads – depending on whether a

mandrel or pancake spiral design has been used – are completely nickel-plated. In the case of an 11-layer die head, the job involves plating eleven mandrels, along with a base and end plate for each of them with myriads of fine bores, angles and threads. "This kind of bore has a diameter of only eight mm and a length of 65 mm," Björn Greis explains. "Depending on the application, we need a poreless plating of 10 to 50 µm. This calls for ultimate precision and cleanliness!" The challenges that these specifications imply are enormous, alone in view of the sheer dimensions of the components. With an external diameter of 800 mm and a weight of 160 kg per mandrel – the base plate weighing in at an impressive 300 kg – these high-gloss polished components demand a correspondingly heavy-duty infrastructure and, at the same time, kid-glove handling. The plating process begins with several stages of cleaning, which has a decisive influence on the subsequent bond strength and the optics of the plating. Every last trace of grease and oxide deposits as well as other contaminants like dust has to be removed. To achieve this, the components are subjected to a sequence of alkaline and electrolytic degreasing as well as acid bating processes. Between each of these stages, they go through elaborate rinsing cycles. The next stage is to mask – by hand and with extreme care – all the threads and bores that are not to be nickel-plated. "This amounts to at least 150 masking tasks for just one plate," says Pallas Managing Director Alexander Kalawrytinos. This intricate task is extremely time-consuming and, in addition to long years of accumulated experience, also requires numerous aids and appliances like special baths and specially-made equipment. Then, once more, the components go through the 3-stage degreasing process. In the chemical nickel bath itself, a consistent concentration – thanks to continuous recycling and monitoring – of nickel ions washes around and through the die heads. Each hour, about 10 µm of the alloy are deposited, which means that Pallas can control the exact

thickness of the coating via the length of time the components reside in the bath. To ensure the required consistency of the plating structure, the bath is continuously filtered and its nickel and hypophosphite content levels are analysed. To compensate for the nickel ions that have been expended to the workpieces, additional dose of nickel, as well as hypophosphite, are added, so that the bath concentration remains constant. For each die head, Pallas prepares the bath chemistry from scratch to ensure that the coating is completely poreless and that there is no chance of foreign bodies being deposited on the component surfaces. The degreasing baths are also completely renewed for each new die head. Normal practice in the sector is to only renew the expensive contents of such baths after six to eight weeks of service life. After the plating stage, the die head is dried with compressed air and the masking is carefully removed. The components acquire their hard-chrome-like hardness of 950 HV through a subsequent heat treatment, so-called hard-tempering. Finally, the parts are packaged and transported back to Kuhne, where all they need is a quick polish before installation.

A rare expert and reliable partner

For Alexander Kalawrytinos and Dr. Klaus Möller, who controls and monitors the workflow at Pallas, this particular order is currently one of the most challenging jobs in the company's chemical nickel plating department. In addition to the required precision and high-end quality of the plating, the handling of the mirror-polished parts makes extensive precautionary measures necessary. Even the tiniest damage to the sensitive surfaces has to be avoided at all cost. The processing time of about fourteen days for the plating of a single die head is a long time for Björn Greis, because the demand for blown film die heads from Kuhne is huge: "Currently, we are building one mandrel a day here." In view of the stringent requirements he

has set for the plating jobs, he is full of praise for his surface engineering company of choice. "Pallas does a super clean and precise job. There are very few coating specialists that can produce such reliable results." He also particularly appreciates the openness of the interaction between them, something which, for him, is essential for success in such complex jobs. "What I need is not a supplier but a partner who, even when unforeseen difficulties or bottlenecks arise, has his eye firmly on finding a solution. Pallas is exactly that: a true, highly reliable partner."

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Pallas GmbH & Co. KG

The company Pallas GmbH & Co. KG, headquartered in Würselen near Aachen, is a technological leader in the field of surface engineering that offers a complete range of surface treatment processes from a single source: electroplating, thermal coating, non-stick and plastic coating as well as laser treatment. By combining the advantages of thermal, mechanical and electromagnetic procedures and working materials, Pallas develops application-specifically optimised surfaces for heavy-duty components or tools. For over 50 years now, this owner-managed family business with its circa 35 employees has regularly set new standards in the field of technical and decorative surfaces. In key industrial applications like tool- and mould-making, for sealing and bearing seats, rollers or drill pipes, Pallas offers the

attractive option of rapid repair as an alternative to time- and cost-intensive replacement with brand new components.

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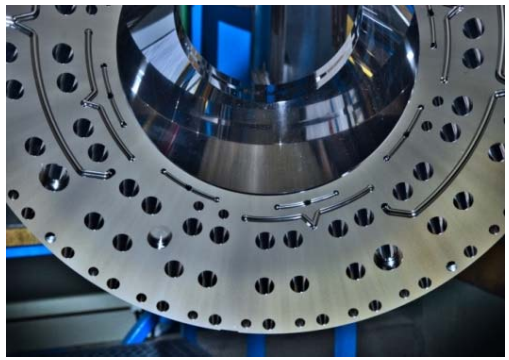
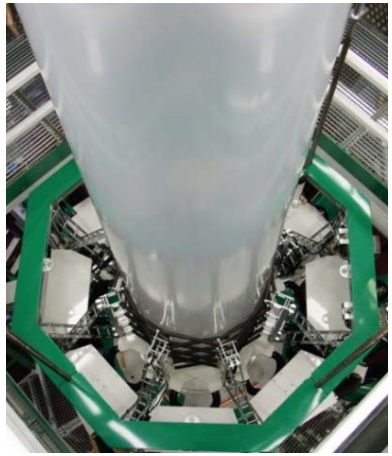


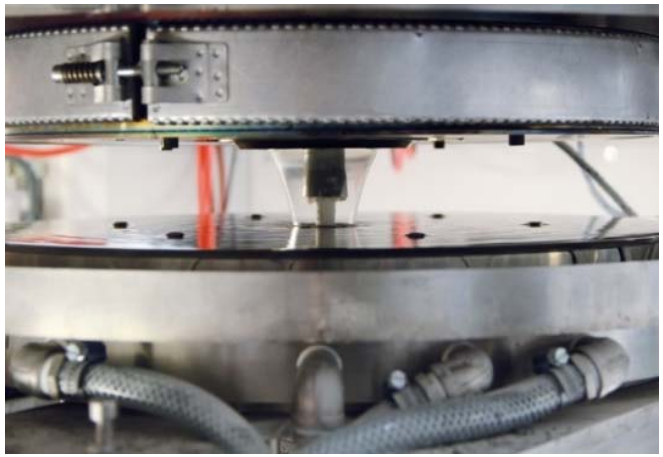
Picture 1: Untreated mandrel before chemical nickel plating

Picture 2: Multi-stage degreasing process after masking of threads

Picture 3: Coating thickness dependent on how long mandrel stays in bath



Picture 4: Air-cooled blown film (Smart Bubble®) with calibration cage



Picture 5: Water-cooled blown film (Cool Bubble®)

Picture 6: Smart Bubble® with 9-layer extruder

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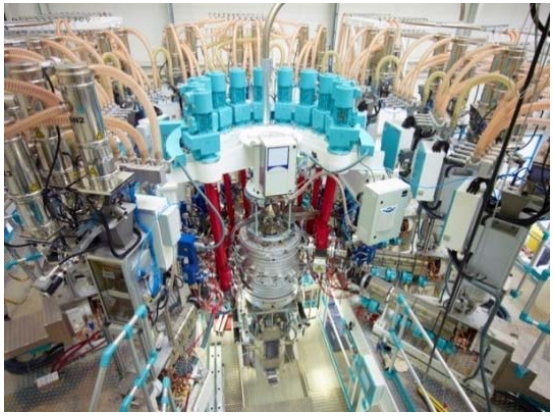
Pictures 7+8: Biaxially oriented multi-layer blown film in a single work process (Triple Bubble®)



Picture 9: Cool Bubble® mit Extrudern

Picture 10: Die head on the extruder platform

Picture 11: Mandrel after chemical nickel plating

Picture 12: An extruder platform under construction

We would be pleased to send you these or other images in printable resolution via e-mail.

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Picture 13: Calibration cage

Picture 14: Roller board for flattening during the manufacturing process

Picture 15: Model of a blown film die head

Picture 16: Mechanical assembly and metalworking shop

Picture 17: Design Manager Extrusion in the Anlagebau division and Technical Manager: Björn Greis

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