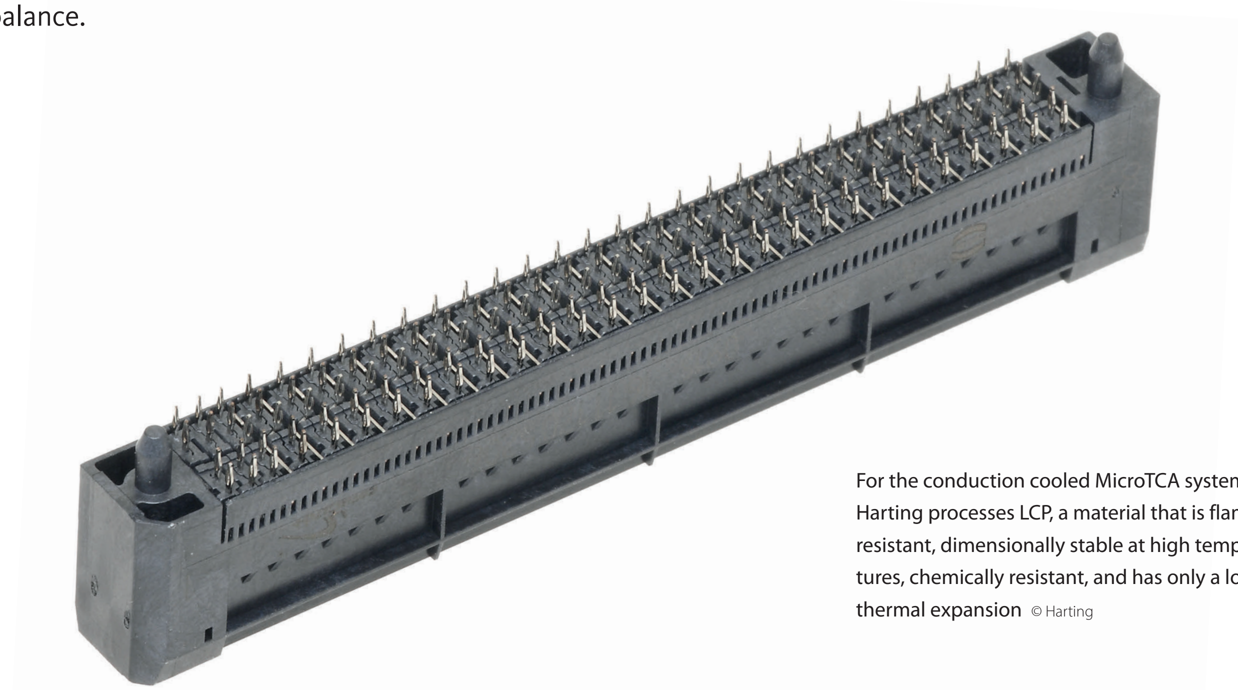
Well-Balanced Hot Runner Technology for LCP Processing

Connectors for Industrial Lifelines: High-Tech Injection Molding at Harting

Aside from offering high mechanical strength, versatility and durability, polymer materials are ideal for applications in the electrical industry because of their ability to isolate electrical current. For the production of connectors, Harting processes liquid crystal polymer (LCP), which lends itself to the production of intricate, thin-walled molded parts. LCP processing relies on hot runner systems that can guarantee a uniform thermal balance.



For the conduction cooled MicroTCA systems, Harting processes LCP, a material that is flame-resistant, dimensionally stable at high temperatures, chemically resistant, and has only a low thermal expansion © Harting

Thinner, lighter, more stable and safer – this would be an apt description of the requirements imposed on the polymers found in electrical and electronic (E+E) components. To this list can be added good flowability for particularly thin-walled or small components, high rigidity in metal-substitution applications, and high impact strength. What often complicates the processing of polymers for E+E applications, however, is high safety-related approval hurdles.

For example, the materials should generally be additivized with flame retardants, yet these must not exert more than a minor influence on the electrical isolation behavior and the mechanical property set. Also important is corrosion behavior vis-à-vis metals during processing and electrical contacts in the component. The rationale here is that the components must continue to operate electrically even in critical conditions, i.e. permanently elevated temperatures, such as those encountered in humid tropical climates. Not for nothing, then, does Espelkamp Harting Technology Group, one of the world's leading suppliers of industrial connector technology, refer to data, signal and power as the industry's three lifelines.

Founded in 1945 by Wilhelm and Marie Harting, the company initially produced household items such as hotplates, irons, waffle irons and energy-saving lamps but has since evolved into the market leader in connectors. Harting now chiefly offers industrial connectors, developing and manufacturing applications as well as customized and one-stop solutions for mechanical engineering, wind energy, traffic and automation technology, and the automotive sector. In the last decade, the company has also emerged as a driver of Industry 4.0.

The Complexity of Simplicity

The simple component known as a "connector" holds the key to electrical and electronic connections in our increasingly electrified and digitized world. Basically, it

Fig. 1. Harting's polymer molding shop also designs and adapts many new injection molds based on its own practical experience © Harting

is the component that makes it possible to get the optimum use out of the systems employed in the transmission of electrical energy and electronic and optical signals. Connectors are designed with the place of use and required transmission quality in mind so that they are the optimum solution for the intended purpose and planned application – and always with technical circumstances and economic requirements, efficient manufacturing, adaptability to current and future technologies, ever-higher data transmission rates, greater performance and reliability in mind. To this list can now be added progressive miniaturization of electronic devices, with the spotlight increasingly being trained on the use of polymers, because they can be processed to tolerances ranging from a few hundredths to thousandths of a millimeter.

Consider Harting's MicroTCA backplane connector (**Title figure**). MicroTCA stands for micro telecommunications computing architecture, an open standard that governs the design of mod- »

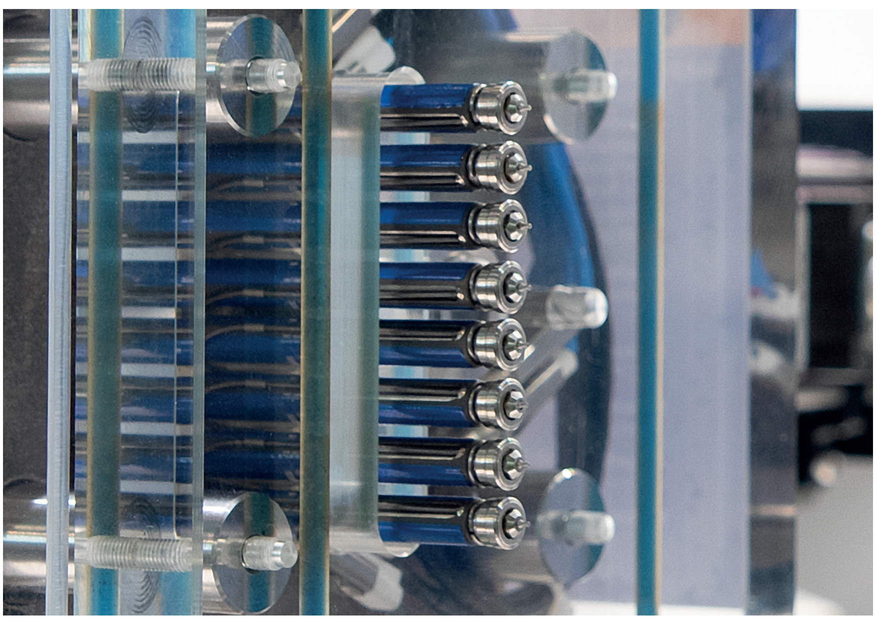


Fig. 2. Minimal cavity spacing, as can be seen here in a trade show exhibit fitted with the patented Blue Flow thick-film heating element (see Box p. 22), is key for many applications © Günther

Fig. 3. "Lined up end to end, the 85 contact segments form the backplane for the printed circuit board," explains Mark Gosewehr © Günther/H. Wollstadt

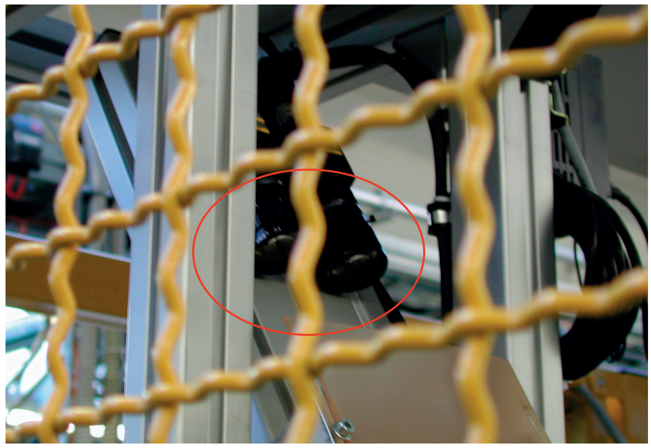


Fig. 4. A camera checks that the 85 contact segments are correctly positioned. Only then is the strip carrying the segments fed automatically into the injection mold © Harting

ules and complete basic systems. The MicroTCA specification describes general mechanical, electrical, thermal and management characteristics. The Harting connector was the first to be recommended for Conduction Cooled MicroTCA systems and can therefore be used in harsh industrial and transportation environments.

Harting uses liquid crystal polymer (LCP) for this purpose, because it lends itself to the production of intricate, thin-wall molded parts. LCP is also notable for its flame resistance, dimensional stability at elevated temperatures, chemical resistance, low thermal expansion, and good mechanical properties. Furthermore, the polymer is resistant over a wide temperature range to hydrolysis, weak acids and bases, alcohols, aromatics, chlorinated hydrocarbons, esters, ketones and all chemicals that otherwise cause stress cracking, except for strong oxidizing acids and strong alkalis. Weatherability and resistance to gamma- and short-wave radiation are also correspondingly good.

Some variants of LCP are inherently flame retardant (UL94 rating of V0) and, aside from a low tracking resistance, possess very good electrical characteristics. Boasting heat resistance of up to 240 °C, and even up to 340 °C for short periods, LCP can also be subjected to thermal stresses of the kind commonly found in lead-free soldering. For these reasons, for example, Harting uses LCP for its innovative har-flex connector family.

Hot Runner Nozzles with a Very Good Thermal Profile

Hot runner systems are ideal for processing LCP because they guarantee a uniform heat balance. This is important because high-performance polymers, such as LCP, are highly sensitive to thermal influences. Hot runner nozzles are also advantageous because they ensure very good thermal profiling during both injection and metering. "Narrow runner cross-sections are essential for processing," explains Mark Gosewehr, Team Leader Injection Molding at Harting Electronics in Espelkamp, Germany. He has been with the company for more than 23 years, having become a master plastics engineer after completing his apprenticeship as a plastics molder. Today, he oversees mold maintenance at Harting's polymer molding shop, which also carries out optimizations in consultation with the mold-making department.

"We have 32 injection molding machines in operation here in Espelkamp, mostly machines from Arburg, Engel, Fer-

Blueflow Nozzle Series

Valve gate nozzles fitted with space- and energy-saving BlueFlow heating elements are characterized by the following user-friendly features:

- Precision needle guide
- Needle guide makes contact with articles
- Cylindrical sealing of the needle in the guide
- Long service life – wear parts can be replaced
- Guide geometry not in the insert
- Hardness approx. 60 HRC
- Plug-in connections for current and thermal connection
- Split shaft for positioning and sealing

© Günther

romatik and Netstal, as well as about 420 injection molds," he says. The department is also called on to use its extensive practical experience to design and modify numerous new molds (**Fig. 1**). "And that," continues Gosewehr, "is where hot runner technology from Günther comes into play. Because, when you're processing LCP, you can save a lot of material by using hot runner systems. Which is why we have been collaborating with Günther Hot Runner Technology for over 20 years." Hartmut Schmidt, a sales representative at Günther says, "We have a wealth of experience in processing LCP, and that was very important for Harting. With LCP, you should endeavor to maintain an exact temperature profile and balance the runners properly so as to maintain a reasonable flow to all cavities. That is the main thing."

Thermal Balance in the Hot Runner Is Essential

The system has been designed to allow for the fact that, due to its liquid crystal structure, the viscosity of LCP drops as the shear rate rises. The hot runner system from Günther is characterized, among other things, by uniform temperature control and good thermal isolation between hot runners and mold. The cross-sections of the melt channels in the manifold and the hot runner nozzles have specifically been made smaller for processing LCP.

A 16-cavity needle actuator fitted with a 4NFT60S type nozzle was installed for overmolding the µTCA strip. This nozzle has a flat housing so that the distance between nozzles can be kept to a minimum (**Fig. 2**). The gate is small in relation to the shot volume to enable the polymer's viscosity to be kept low. "The cycle time is about 7.5 seconds for a shot weight of about 1.5 grams across 16 nozzles," says Gosewehr. And Schmidt adds, "1.5 grams spread across 16 nozzles is not exactly massive throughput, of course. That's why the thermal balance in the hot runner has to be right – I can't afford to have any temperature peaks."

Punched Strip Accumulator Installed Upstream of the IM Machine

That remark by Schmidt should not be taken lightly, as many separate components come together in this mold. One of these is a small punched strip that is fed into the mold. "The contact segments that you see on a MicroTCA PCB connector are packaged in a certain order. Inserted between them are ground plates that ultimately produce the card edge connector. Lined up end to end, 85 contact segments form the backplane for the printed circuit board," explains Gosewehr (**Fig. 3**).

The strips come on reels from the electroplating shop, already punched and electroplated. They are then welded together into a continuous strip. To make the process as seamless as possible and to compensate for any interruptions or reel changes, a strip accumulator is connected upstream of the injection molding machine. Before overmolding occurs, a second punching operation is carried out. The first punching operation is done as the strip is being created and the second serves to slightly angle the contacts and expose them. The strip then enters the injection mold via an automatic strip feeder. A camera checks that it is positioned correctly (**Fig. 4**). Downstream of the molding machine is a separation cell, where the contacts are separated.

Hartmut Schmidt stresses once again, "There are so many factors to do with the mold and the machine that we have to take into account. That's why we need the thermal balance in the hot runner to be very stable." Gosewehr adds, "Although LCP generally absorbs little water and so has good dimensional stability, we use dryers with a dew point of –40 °C to lower the residual moisture to the target value of 0.02 %. Drying the material meticulously before processing makes a not insignificant improvement in the molded part properties."

25 Years' Experience of LCP Processing

It pays when dealing with this simple yet intricate backplane to have experts like those from Günther Hot Runner Technology on board. Gosewehr sums up the complexity of the simplicity of a connector, "Getting all the balancing and design right so that all the cavities are connected properly, i.e. that they are filled uniformly and completely – with LCP at a melt temperature of 340 °C – does take a certain amount of experience. And when we are working with the experts at Günther, we know we're in very good hands." ■

Company Profile

The company was founded in 1945 as "Wilhelm Harting Mechanische Werkstätten" by Wilhelm Harting and his wife Marie. Since 1950, its headquarters have been in Espelkamp, East Westphalia, Germany. In the early days, Harting initially manufactured household items such as hot plates, waffle irons and energy-saving lamps. At an early stage, Wilhelm Harting recognized that the emerging German industry needed new technical products. Working with a number of experts, the company set about developing a connector that would be rugged, easy to handle and suited to a variety of purposes. A patent application for the han connector was filed in 1956. Today, han connectors are as synonymous with connectors as Hoover is with vacuum cleaners. The range of connectors was expanded in 1966 to include printed circuit board connectors. Various connector solutions, extending as far as flexible module systems in hardware and software, soon followed. One of Wilhelm Harting's maxims regarding quality has remained valid down through the years: "I don't want to see any products being returned."

» **www.harting.com**

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Service

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