

HOLLOW GLASS EQUIPMENT

The glass industry is demanding. Drive and transport solutions not only need to reliably master operating processes, they also need to be highly resistant to harsh conditions and incredibly efficient. In this article, Renold gives us an idea of the important role its inverted tooth chains play in transporting hollow glass in today's glassworks.



RENOLD

inverted tooth chains
for cost-effective production

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Glass is a highly versatile and malleable material. It also offers unique characteristics which make it indispensable in numerous products. Today, glass not only plays an important role as an object of everyday use but can be increasingly found in new areas – in research, science, and numerous cutting-edge industries:

- Food and beverage packaging
- Household, gastronomy, furnishings
- Motor vehicles, electrical devices
- Windows, facades, construction industry
- Optics, solar, research, science
- Medicine, pharmaceuticals, cosmetics
- Chemical and general industrial applications

SAFE, RELIABLE DRIVING AND GENTLE TRANSPORT

Renold has created a full range of inverted tooth chains which are temperature-resistant up to 450°C and operate at speeds up to 50 m/s., during smooth, precise operations with minimal



chain link impact and extremely low, even wear. The interlocking power transmission eliminates slippage. The Renold rolling pivot joint minimizes elongation, which has a positive impact on the service life of the chain. Optimized link plate forms provide even larger sliding areas.

Other factors to be taken into account include:

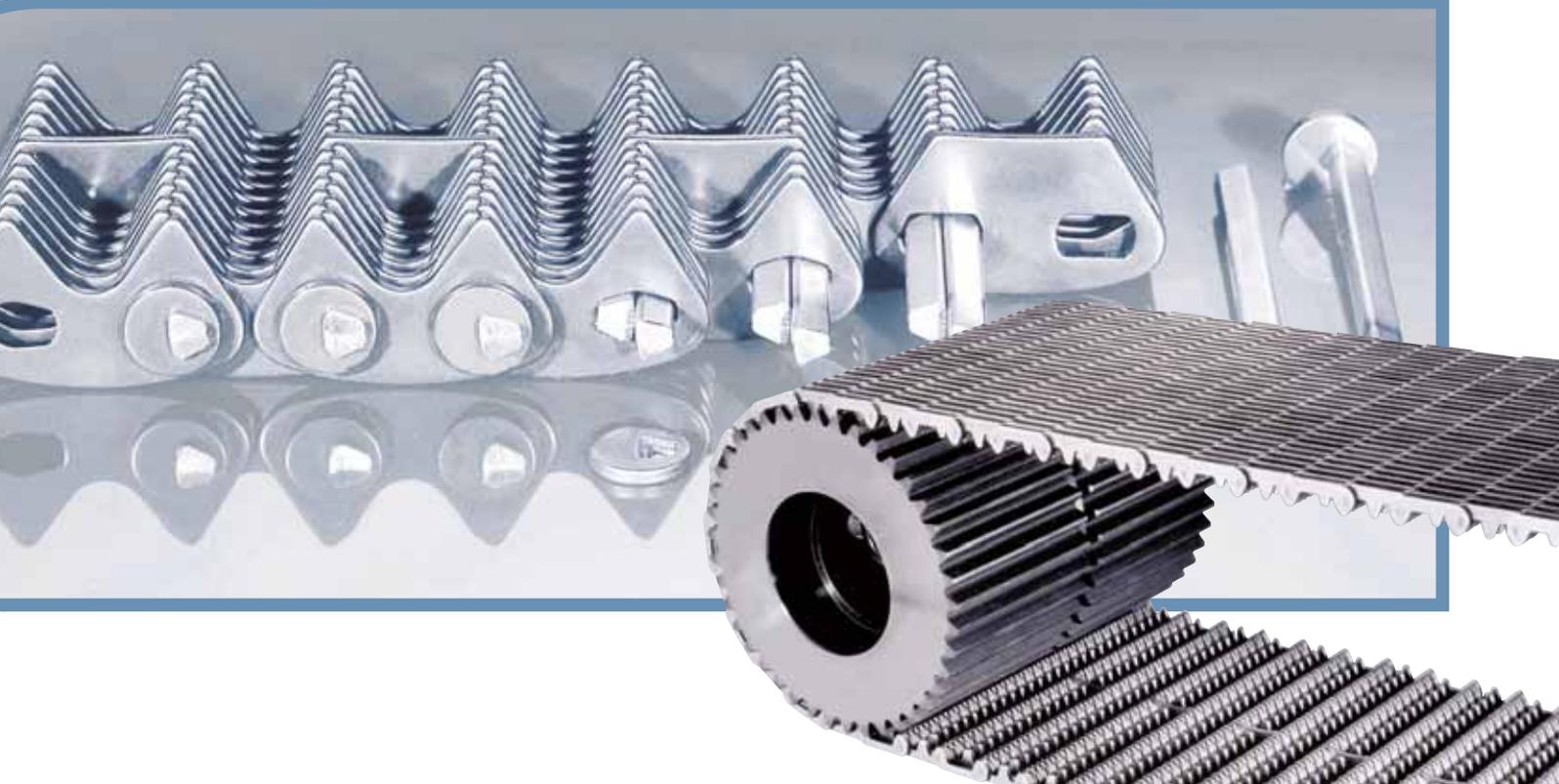
- The elongation behaviour of an inverted tooth chain refers to the operation-related elongation of the chain under tensile stress. After a certain amount of elongation, the chain ceases to run smoothly and must be replaced.
- In glass production, especially during transport, properly regulated cooling is important for the gradual stabilization of hot products.
- Every machine, system, and application requires an individually configured solution that is

ideal for the specific installation situation, including spatial conditions.

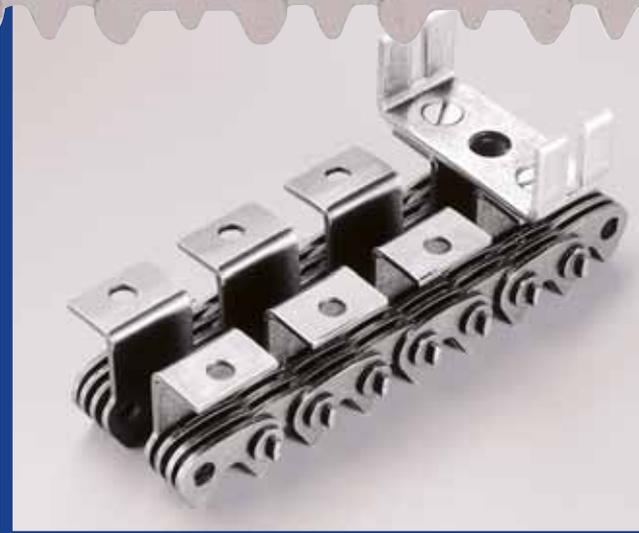
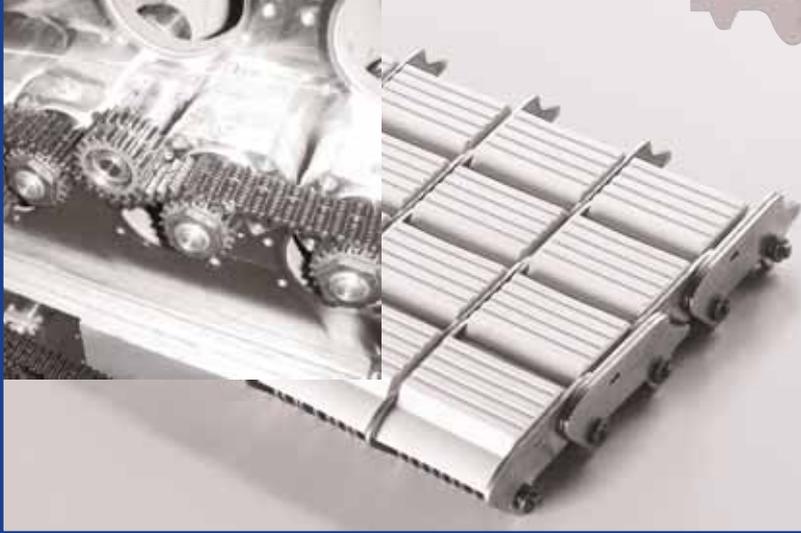
- In terms of temperature behaviour, both the product throughout the production process as well as the operating characteristics of the inverted tooth chain must be taken into account.
- The properties of the inverted tooth chain materials must be optimized for the specific application conditions.
- A comprehensive range of individually configurable products, components, and optional extras is required to cater to the wide variety of applications in the glass industry.

CONVEYOR CHAINS IN THE HOLLOW GLASS INDUSTRY

Whether as an IS-machine conveyor or a cross conveyor in front of the furnace – inverted tooth conveyor chains offer ideal guiding characteristics.



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Machine conveyor on IS-machines

Machine conveyors take the hot bottles and transport them to the ware transfer. Their features: stable standing surface, high resistance to abrasion, minimal spacing at the machine bed, low sliding friction, air permeability for conveyor cooling, minimal heat withdrawal by the chain, heat resistance even during pre-heating, chemical resistance against annealing agents.

tures: a stable standing surface, high abrasion resistance, minimal spacing at the cooling furnace, low sliding friction for easy shifting, resistance against thermal stress caused by radiant heat, and chemical resistance against annealing agents.

Long service life, reliable transport

Rolling pivot joint with low sliding friction, link plates with FE-optimized contours made of high-strength heat-treated steel or stainless steel, laser-welded outer links, sprockets with hardened involute toothing for smooth, impact-free meshing – there are plenty of reasons why inverted tooth conveyor chains offer consistently precise and reliable operation. Factor in the virtually unlimited options to tailor the inverted tooth chains to the specific requirements of equipment and overall applications.

- Low-vibration, smooth operation
- High production speeds
- Low reject rate for increased efficiency
- Minimal sliding resistance

Cross conveyor at the cooling furnace

Cross conveyors take over the previously stabilized glass containers and transport them to the cooling furnace. Their fea-

Higher productivity, lower costs

Whether for shaping on a blowing machine or precisely coordinating the movements of a rotary table system – inverted tooth drive chains are always the right choice when smooth running and accuracy count. On IS-machines, our inverted tooth drive chains in the take-out gear



ensure power with precision.

- Reduced downtimes
- Improved dynamics
- Increased temperature resistance
- Considerably longer service life compared to belt drives

Renold inverted tooth chains used in a take-out gear helps

hollow glass manufacturers to reduce costs by increasing productivity. Longer service life means less downtime for maintenance and repair work on the IS-machine. With optimum dynamics, the installation of an HPC type inverted tooth chain from Renold can reduce the installation width and weight of the drive components.

In the take-out gear, wear of the drive element must be reduced to a minimum to ensure exact positioning in the long term. Inverted tooth chains with a two-pin rolling pivot joint with hardened axle and rolling pivots maintain smooth operation and thus ensure repeatability of the swivel motion, even over a long period. The HPC type inverted tooth chain used in the take-out gear generates almost exclusively low-wear rolling friction and is suitable for speeds up to 50 m/s.

DRIVE AND TRANSPORT SOLUTIONS FOR A WIDE VARIETY OF PRODUCTS

In addition to their attractive technical prop-

erties, the absolute flexibility of individually manufactured inverted tooth chains makes them ideal for nearly every application. Regardless of whether the product is large and heavy or small, lightweight, and prone to tipping, our inverted tooth chains are well-equipped for all situations, from transport to drive applications. They can implement strong forces, torques, and high speeds as reliably as unerring precision – for both fast and slow-moving applications.

- Suitable for vacuum applications
- Also for glass articles without a standing surface
- For crystal glass and small glass products
- For robust and heavy glass products

RENOLD INVERTED TOOTH CHAINS FOR AUTOMATION SOLUTIONS

Renold inverted tooth chain technology maintains the world's largest delivery program:

- Pivot joint with 2-pin system, laser-welded outer links, unique rounded edges
- Continuous optimization and product variety
- Application-specific versions





- Inverted tooth chains and sprockets from a single source
- Individual configurations based on modular concept
- Wide range of materials, constructions, guide types, pitches

Continuous optimization of link plate forms

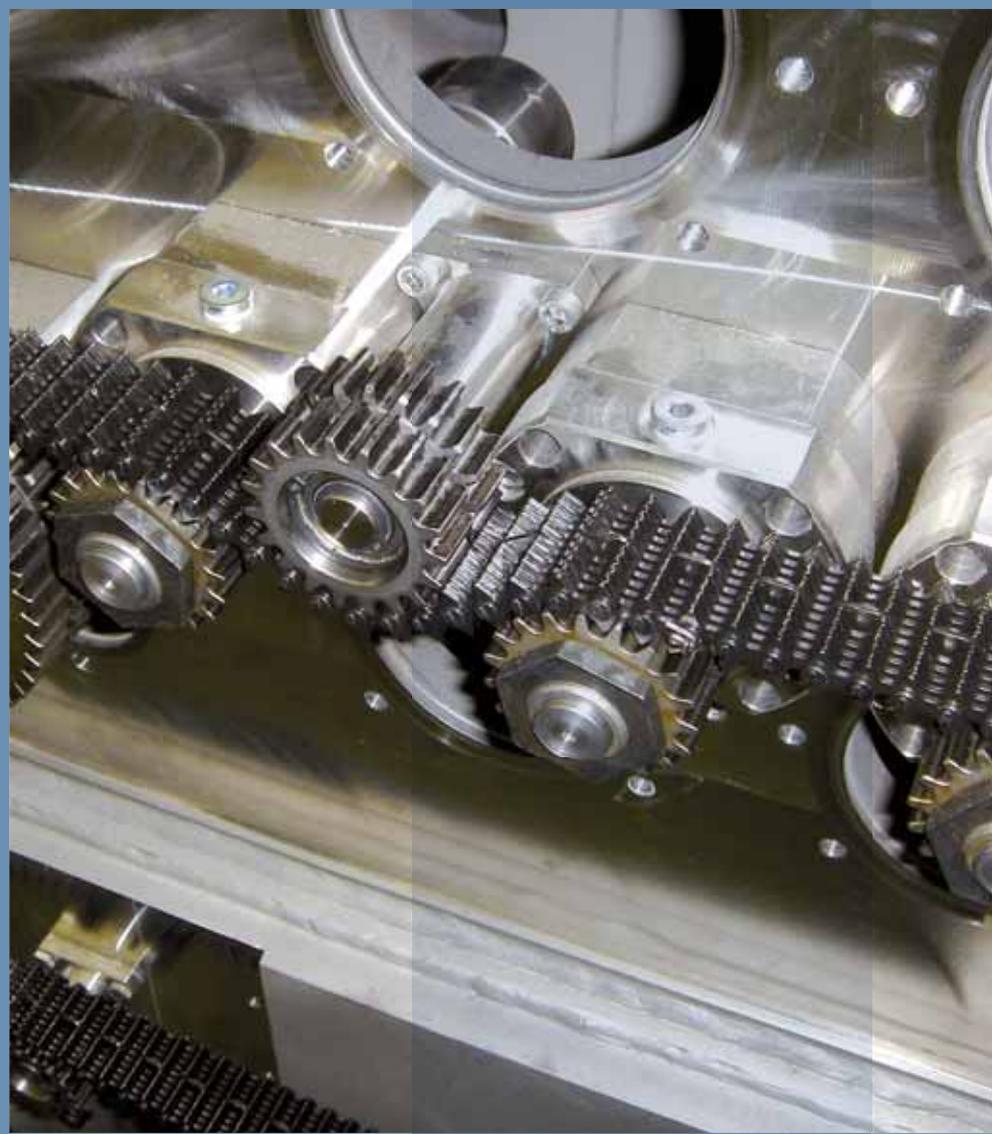
Renold consistently translates practical knowledge into new product solutions. One example is the enlarged contact surface for inverted tooth chains with an extended pitch. Compared to multiguides, the problem of vertical wear caused by abrasion on the teeth is reduced across the entire chain width.

Special versions and optional extras

Each day is different from the next. With special link plates and specific contact surfaces, the wide range of applications for inverted tooth conveyor chains can be broadened even further. Ceramic supports are one example for especially gentle transport with minimal temperature loss.

Laser-welded outer links

Laser-welded inverted tooth chains have a smooth contact surface on both sides and can be routed directly alongside the dead plates in the IS-machine or the side rails. Minimum side gaps ensure reliable transfer on the machine conveyor and to the cross conveyor as well as easy sliding of the products into the cooling furnace.



- Connecting links with uniform plate width
- No lateral movement of joint pivots
- Larger side surface prevents lateral wear

WHY ARE INVERTED TOOTH CHAINS WITH ROLLING PIVOT JOINTS THE RIGHT CHOICE?

Unique two-pin rolling pivot joint

Renold's inverted tooth chain solutions have a unique two-pin rolling pivot joint, where an axle pivot rolls against a rolling pivot. The pivots are pressed into the link plates under tensile force, preventing any further movement. Because the pins maintain permanent contact, the layout

of the inverted tooth chain has no impact. Inverted tooth chains with rolling pivot joints therefore permit a variety of design options and can be tailored to individual production processes and requirements. Because the link plates are static in relation to the pins, any loss of strength due to thermal strain is insignificant. With their low friction coefficient, inverted tooth conveyor chains can also be operated without any lubrication.

Conversely, on the one-pin joint, the link plates slide onto an oval pin as they mesh with the sprocket. This results in wear on both the pin and the link plates. Because the holes punched in the link plates are usually not



cylindrical, the surface pressure between the pin and link plates is increased, creating additional wear.

INTERLOCKING CONNECTION: INVERTED TOOTH CHAIN AND SPROCKET

The correct meshing of chain and sprocket is a prerequisite for trouble-free, continuous operation. All relevant dimensions and profiles are optimally aligned to achieve slip-free movement.

Whenever technically feasible, sprockets are manufactured according to the specific needs of the customer. The design of the toothing is adapted to the guide type of the selected inverted tooth chain. Of course, all special versions are also available with guide slots for various chain widths and can be prepared for centre and side guides. C45 steel sprockets with hardened tooth flanks are used as a standard with proven resistance to wear. For an even longer service life for cross conveyors subject to extreme thermal loads, without compromising on strength, we also use vacuum-hardened tool steel.

OPTIMAL JOINT KINEMATICS

Elongation

Due to sliding friction and increased wear of the joint, elongation in 1-pin chains can be up to three times higher than in 2-pin systems. Renold 2-pin rolling pivot joint with hardened axle and rolling pivots only creates rolling friction. Over time wear also occurs at the contact line of the pins; however, this wear is evenly distributed on both pins as well as the inner and outer links. The meshing conditions remain constant over the entire period of use. These characteristics are the basic prerequisite for precise angle synchronization in applications for the hollow glass industry.

As shown in the diagram, studies have demonstrated that the elongation of inverted tooth chains is up to three times less with rolling pivot joints instead of single pin joints. Single pins generate constant sliding friction which accelerates wear.

Renold rolling pivot joints only generate rolling friction. For an RT type inverted tooth chain, this means a minimal elongation of 0.17% after approximately 4000 test hours, i.e. about 1.7 mm elongation per meter of the chain. This horizontal wear is negligible when it comes to the performance and reliability of inverted tooth chain applications. Inverted tooth chains with a one-pin system, in contrast, exhibit an elongation of approximately 11 to 14 mm per meter, based on a comparison with Renold KT type chains as an example for single pins.

With a simple comparison of friction coefficient μ for rolling and sliding friction, it's easy to see that rolling friction requires far less force.

*Friction coefficient: steel on steel
Sliding friction $\mu = 0.1$, rolling friction $\mu = 0.01$*

Rolling pivots are laser-welded in the outer plates of Renold inverted tooth conveyor chains. The rivet heads no longer protrude and the belts can be placed flush to the sides without any gaps. This increases the operational reliability of the chain and the chain width remains constant throughout its service life.

INVERTED TOOTH DRIVE CHAINS IN THE HOLLOW GLASS INDUSTRY

Glass is a special product. It places highly specific demands on production equipment and tools for production and processing. The main requirements include:

- High temperature resistance,

since glass is often processed at temperatures above 500°C.

- High requirements for drive synchronization and accuracy, since even minor deviations can leave marks or scratches on the product, and glass is fragile after cooling.

Wrap drives are drives that enable the cost-effective implementation of larger centre distances. Various drive elements, such as belts, roller chains, and inverted tooth chains are available. Belts, regardless of whether toothed, flat, or wedge-shaped, can usually be ruled out, since the temperatures are too high. Roller chains often lack the required accuracy due to sliding friction and wear. Inverted tooth chains with rolling pivot joints are the only viable option ideally equipped to meet all requirements and should always be the first choice.

CHAIN DRIVE FOR SHAPING ON A BLOWING MACHINE

Inverted tooth drive chain for shaping on a blowing machine for the production of high-quality drinking glasses (goblets/wine glasses). An inverted tooth chain at each of the 18 stations drives the mould for the bowl, an additional inverted tooth chain rotates the stem to weld it to the bowl. Both parts must be rotated with equal precision in order to join the elements.

The application uses an HPC inverted tooth chain. A special feature: both drives are positioned laterally, i.e. with vertical axes.

TAKE-OUT GEARS IN CONTAINER GLASS PRODUCTION

These gears are used to lift glass while it is still glowing out of the IS-machine and onto sheets from which the glass items are shifted onto an inverted tooth conveyor chain. The rotation

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usually does not exceed 180° by much; the entire gear housing is rotated. The gear rotates around the drive shaft, enabling a swivel motion.

A difficult factor in this process is repeated reversing with relatively high accelerations. Inverted tooth chains meet these demands over a long period. They are unaffected by radiant heat and continuous directional changes with rapid accelerations. In addition, the drives demonstrate exceptional precision and robustness.

WHY IS TRANSPORT SO CRITICAL IN HOLLOW GLASS PRODUCTION?

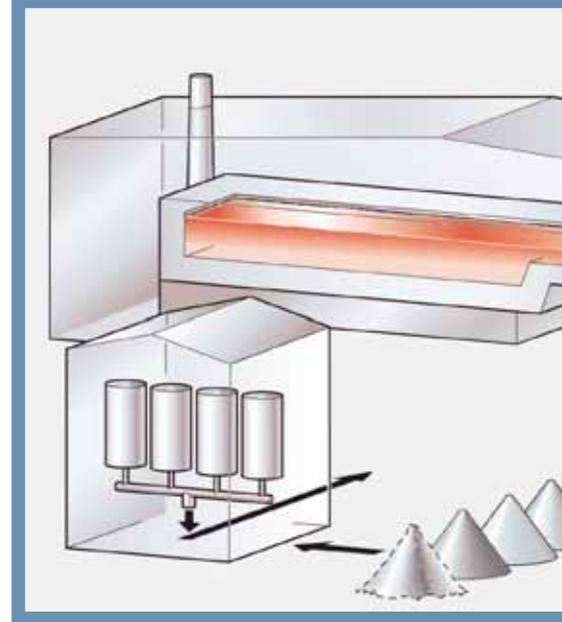
The glass product comes out of the IS-machine with a temperature of over 500°C and must be gently and reliably transported to the individual processing stages. However, the product is not

yet fully stabilized and is highly delicate.

Additional production steps are required along the path from the IS-machine to the cooling furnace. First, belt cooling stabilizes the product. The next step is hot-end coating. Transport must be accomplished without any slippage to ensure that the product stays properly positioned. The spacing between the products is reduced in the ware transfer for optimum space utilization in the cooling furnace. Contact between the products must be avoided at all costs.

BASE CRACKS

To withstand harsh operating conditions, inverted tooth chains are usually made of high-strength heat-treated steel. Like all metals, steel is an excellent heat conductor, which presents a problem: the glass needs to



cool down during transport in order to stabilize, but at the right rate. If the hot product makes contact with the inverted tooth chain, heat flows from the glass to the chain. The inverted tooth chain dissipates warmth from the glass more quickly than it can be resupplied by the surrounding glass. This results in areas with different temperatures at the contact points with the glass, creating tension that can become visible through micro-cracks (base cracks). When the product is cooled with air on the belt, this effect does not occur. Air acts as an insulator so the glass can continue to supply adequate warmth and cool down slowly and evenly.

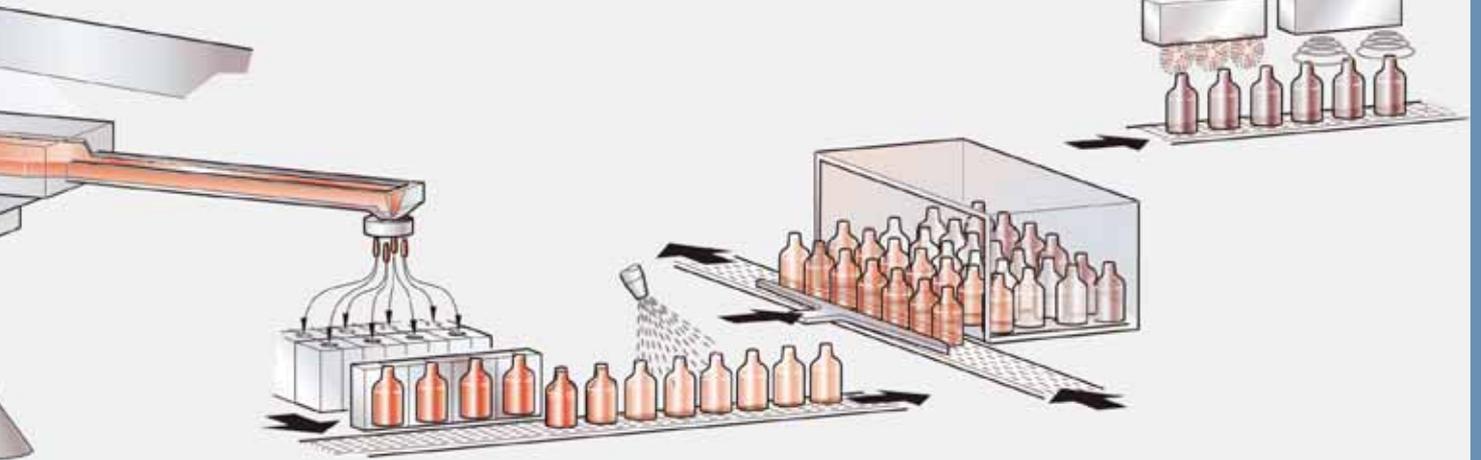
FLAME POLISHING

During flame polishing, burners on the conveyor belt partially melt the product surfaces. Inverted tooth chains can sustain damage from exposure to high temperatures. Stainless steel can provide an adequate solution for these applications.

HOT-END COATING

Hot-end coating smoothens surfaces and creates an excellent surface for subsequent cold-end coating. Coating agents in combination with lubricants can





damage the inverted tooth chain. However, there are steps you can take to protect the quality of inverted tooth chains.

WAYS TO REGULATE THE COOLING PROCESS

First, the melt itself is a decisive factor. A high alkaline content (Arabic: “al qalya” = potassium carbonate) reduces the tendency towards base crack formation. Potassium carbonate or potash is a network modifier and fluxing agent.

Network modifiers alter the properties of glass by depositing atoms in the quartz network and therefore disrupting the even network structure. As a fluxing agent, potash lowers the melting temperature and thus the processing temperature. A lower processing temperature means a smaller temperature difference between the glass and the inverted tooth chain, and thus a reduced heat transfer from the glass into the chain.

An additional factor in preventing base cracks is the design and shape of products. The base of a bottle is curved inward and the remaining circular ring equipped with additional fluting. This reduces the contact surface with the inverted tooth chain

considerably.

Finally, the construction of the inverted tooth chain has a significant impact on cooling processes. Tightly constructed chains have a larger closed surface than those with spacers or an openly configured extended pitch.

THE RIGHT MATERIAL

Should a combination of all measures not eliminate base cracks, stainless steel inverted tooth chains could help to solve the problem. Steel with a high nickel content reduces the withdrawal of heat from glass, which is determined by thermal conductivity, measured in W/m K (watt per meter kelvin).

Compared to heat-treated steels, the use of stainless steel reduces the withdrawal of heat by an approximate factor of 3. This also reduces energy consumption and cuts down on melt quantities.

IMPROVED SLIDING CHARACTERISTICS

Some glass bases have minimal contact with the inverted tooth chain. This disrupts the sliding quality when shifting the products on and off the chain. The same applies to angled fluting in the glass base. Renold has

developed a solution for these challenges: toothed plate edges are rounded off in an extra work step. This keeps the contact area to a minimum while reducing sliding forces. In addition, the risk of toppling during lateral shifting is minimized, which is especially important for tall, top-heavy products. Rounded edges can cut the forces required for lateral shifting (both static and sliding friction forces) by roughly one half.

- Reduces the risk of base cracks
- Reduces toppling in topple-prone bottles
- Reduces the sliding resistance of glassware
- Improves sliding properties

THE RIGHT LAYOUT

Inverted tooth chains have a lamellar design, which always results in a gap between the individual link plates. The additional integration of spacers and/or the use of extended pitches increase this gap, which promotes cooling.

ADVANTAGE: VARIETY OF CHAIN TYPES

The correct selection of the inverted tooth chain type, construction, and specific version enables an ideal combination for

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the specific requirements of an application and the product to be manufactured. Once all aspects are considered, the result is economical production costs combined with error-free transport. In short: utmost efficiency.

Despite this customizing, it is a fact that few production facilities manufacture the same product day in and day out. Instead, products tend to change frequently: bottles are followed by foodstuff jars, top-heavy products by broad-based, stable bottles. The main objective is therefore to find the best possible compromise, for example, between cooling and standing surface properties.

This requires ample experience from practical applications and extensive configuration options. We can offer you both. Our range of inverted tooth chains provides unparalleled options worldwide.

We have also been catering to the specific needs of the glass industry for over 50 years.

ADVANTAGE: INDIVIDUAL CONSTRUCTION

Compared to other providers, Renold not only offers 1.5 mm link plates in several different constructions, but also 2 mm link plates with six additional construction combinations. This is the largest range of inverted tooth chain versions worldwide. The possibilities are virtually endless. This wide range of configuration options only provides an advantage in combination with knowledge about critical factors. The main objective is usually to implement a suitable compromise for systems and the products to be manufactured.

In addition to the specific functionality of the inverted tooth chain, existing installation situ-

ations, and belt cooling requirements, the type and properties of the product itself play a key role. Often, individual testing, combined with specific experience, is required to find the best solution:

- RS = Standard for universal use. Suitable for medium-sized and large products. Air permeability approx. 22%.
- RT/RD = For small glassware and products prone to tipping. Air permeability approx. 12%. Limited belt cooling.
- TT/ET = Suitable for universal use, also for small glassware and products prone to tipping thanks to a level surface. Air permeability approx. 31%. Good belt cooling.
- TS/ES = For medium-sized to large products. Air permeability approx. 53%. Excellent belt cooling. Highly suitable for glasses with a solid base or large volume.

PRODUCT DEVELOPMENT AND INDUSTRY SOLUTIONS

Because requirements change, improvements are always possible, and a technological edge can mean the world, Renold uses the latest technical methods and field-specific knowledge needed for the customers' tasks, calculating and developing the most suitable configurations. Inverted tooth chains and sprockets are perfectly matched throughout planning. ■

RENOLD | Tooth Chain

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