SPECIAL MACHINE SERIES XK

Coldforming of Involute Splines, Grooves and Threads
Coldforming Technology

Coldforming – and how it works
The chipless coldforming of profiles such as involute splines (straight or helical), spiral serrations, oil grooves, and threads only takes seconds with the MAG coldforming process and is significantly faster than cutting processes. In addition, coldformed workpieces have a higher load capacity and a better surface finish and accuracy. Involute splines and other profiles can be produced very quickly and precisely with this process.

The high precision coldforming racks roll and press the required profile into the workpiece during the coldforming process. The material is displaced and flows into the free spaces of the racks. The workpiece is pressed twice during one rotation, i.e. forming takes place in a series of steps. The height of the ground profile in the forming rack increases progressively into the forming area. This causes each rack tooth to press slightly deeper into the material than its predecessor. After reaching the full profile depth, the form gets optimized in geometry and surface finish in the calibration zone.

The XK Series from MAG, based on the Ex-Cell-O coldforming technology, meets the constantly increasing market demands with three key features:

- Simplification of tool settings
- Further improvement of workpiece quality
- Enhanced flexibility

All movements in the forming process are performed by numerically controlled axes. This results in special advantages for the user:

- Dimensional correction via control system off-sets
- Variation of workpiece tooth quantity without changing tools
- Spacing error correction
- Vertical feed during rolling
- Rolling speeds are individually programmable

New approaches optimize technology

- Process control for targeted influence on the process
- Innovative tool design to increase tool life
- Optimized machine guarding concept

3 phases of the coldforming process

Control via electromechanical axes

Wedge slides for vertical feed of tools
Machining
Machining
Wedge slides for vertical feed of tools

The workpiece is located and clamped between two live centers

Two synchronous coldforming racks simultaneously engage the workpiece from opposite sides, causing it to rotate. During rotation, the required profile is formed progressively as the racks complete their strokes.

After a few seconds, the rolling process is complete. The workpiece is removed, and the racks return to their initial position.
Rolling and Forming –
the Advantages of Cold Forming Processes

A definite advantage of the coldforming technology is the omission of the usual profile flow out for milling tools – the racks can be set very close to workpart shoulders.

Advantages of the coldforming technology
▶ Forming with minimum lubrication = no cleaning is needed after forming
▶ High contact ratio during forming due to flat coldforming racks
▶ Achieves a high efficiency with minimal thermal effects
▶ Axial tapering enables easy fitting of spline shafts at tooth end
▶ Simultaneous machining of several profiles
▶ Keeps preturned grooves free from flowing material
▶ Labeling the workpieces

Rollable materials
Acceptable materials for rolling parts on MAG machines include all alloyed and non-alloyed carbon steels with a coefficient of elongation over 7 %. A homogeneous structure is important. Usually, materials with tensile strengths between 600 and 1100 N / mm². Typical materials are: Cf 53, 16 Mn Cr 5, C 45, 42 Cr Mo 4, 14 Cr 4 as well as other alloys.

Further advantages of the process
In addition to the already mentioned possibilities like coldforming of involute splines or oil grooves close to the shoulder, the process also allows the rolling of a serration to any given radial positioned workpiece design feature within a tolerance of ± 7 minutes. In this case, a so-called “closed gap” can be made to prevent radial orientation assembly errors.

Machine automation
Due to short cycle times the machine was designed with modularity in mind for multiple mountings for various types of automation. Shortest cycle times are achieved as the change between rolled and unrolled parts already takes place during the return stroke of the machine slides. MAG offers standard automation that provides a reliable interface with existing or new transport systems. For example, it is also possible within the scope of automation to measure the premachined diameter of profiles that are to be rolled in order to avoid tool breakage and to ensure constant profile quality.
Spline standards
In general, all involute splines can be rolled. The common standards are: ISO 4156, DIN 5480, ANSI 92.1-1970, ANSI B 92.2M-1980 and GOST 6033-51. The profiles shown can be rolled with a pressure angle of 20 to 45 degrees in accordance with the restrictions for maximum profile sizes shown in the chart on page 10. Additionally, special profiles with other standards can also be rolled. MAG coldforming racks are made of heavy duty, hardened and ground cold worked steel. Depending on part material and profile, up to 500 000 working cycles can be performed with one set of racks. Racks can be reground several times. Their length is dependent on the type and size of the respective workpiece.

Special racks
Spherical radius at tooth end
- Less stress peaks at end of involute spline
- Especially suitable for highly stressed workparts

Clearance of grooves
- No material flow into the preturned grooves for lock rings. This will avoid additional machining

“Joining chamfer” at tooth entry
- Optimal pre-centering at straight-flanked press splines

Tapered tooth entry
- Assembling aid for press splines

MAG is the leading manufacturer of coldforming machines and has all the Know-how and technology in designing and manufacturing coldforming racks. Worn coldforming racks can be reground at the MAG coldforming rack center. Here, new ideas, machines, systems and work cycles have been implemented for optimized manufacturing of coldforming racks – the results are short lead times as well as the highest possible accuracy and quality. The entire production process is computer controlled. A well-trained team of specialists is responsible for the entire manufacturing process, all the way from concept to on time delivery, 24/7 if necessary. The quality of the coldforming tools and the machined workpiece profiles are measured and controlled by MAG on a special profile measuring machine.
Coldforming racks configurations

- XK 837
- XK 851
- XK 875
The XK Series – the Right Choice for Various Tasks

XK 225, XK 237, XK 251, XK 275
The XK 2 models from MAG, based on the Ex-Cell-O coldforming technology, were developed to meet the constantly increasing market demands. Among the key factors for enhanced productivity were the simplification of tool settings, further improvement of workpiece quality and increased flexibility. In accordance with the maximum module of 2 mm, the maximum diameter of profiles is 60 mm.

XK 2xx – Application range
- Passenger car drive shafts
- Passenger car axle shafts
- Passenger car joint housings
- Electric motor shafts

Highlights
- Robust forming process for simple splines
- Slide actuation by 2 hydraulic cylinders
- Proven, reliable machine design
- Synchronous drive of slides by 2 racks and a pinion
- Basic Machine in C-shape and cast design

XK 637, XK 651, XK 675
The XK 6 machines continue the success story of the renowned XK 2 models. The proven rigidity and ideally balance feed and radial forces allow for highly productive forming of profiles of diameters up to 60 mm. The machines are designed for easy operation regarding accessibility. Also, both the workpiece and feed axes are CNC controlled.

XK 6xx – Application range
- Passenger car axle shafts
- Passenger car joint housings
- Electric motor shaft

Highlights
- Hydraulic free machine – reduced footprint and noise level, CNC controlled work piece and feed axes – energy efficient and operator friendly
- Variable range of processing forces
- Electronically synchronized slides
- Correction of spacing errors via CNC control
- The rolling speed is infinitely variable
- Robust, fail-safe roundness correction
XK 837, XK 851, XK 875
Already 10 years ago, when the concept for the XK 8 models was developed, MAG implement comprehensive energy saving features. A major energy consumption reduction was achieved by replacing hydraulic axis drives with electromechanical components, which also reduced footprint and noise level significantly. With its ergonomically optimized machine guarding, the machine design is compact, while allowing for a maximum profile diameter of 80 mm and workpiece length of 1500 mm.

XK 8xx – Application range
- Passenger car drive shafts
- Passenger car axle shafts
- Efficient production of small batches

Highlights
- State-of-the-art cold forming technology with process control
- All movements are performed by numerically controlled axes
- Variation of workpiece tooth quantity without changing tools
- Vertical feed during rolling
- Rolling speeds can be programmed individually
- Hydraulic free machine – reduced footprint and noise level
- Simplified tool settings
- Increased flexibility

XK 1275
The XK 12 model is adding a new size to MAG’s coldforming machine series. It is based on the proven XK 8 machine and was thoroughly enhanced regarding rigidity and range of processing forces. Despite the massively increased application range that enables profile diameters of up to 120 mm and workpiece lengths of up to 5000 mm, the design retains its small footprint and was optimized for better accessibility. The electromechanical drives provide for low energy consumption.

XK 1275 – Application range
- Truck axle shafts
- Truck drive shafts
- Large drive components for CUVs

Highlights
- Enhanced rigidity and processing forces
- Workpiece length up to 5 m
- CNC controlled work piece and feed axes – energy efficient and compact
- Correction of spacing errors via CNC control
- In-cycle X- and Z-axis interpolation
- Variation of workpiece tooth quantity without changing tools
- Rolling speeds can be programmed individually
- Optimized machine guarding
- High flexibility
Advanced Involute Profile Technology (AIPT)
Highest Spline Quality to Highest Spline Loading Capacity

Basements and actions to the AIPT-Development
Since a long time the process related undercut at cold forming (depression in the involute line) was in discussion.

During the process both cold forming racks gets shifted through the workpart and the workpart rotates. At turn out of the tooth a geometrically needed form effects the undercut within the involute line. The deepness usually is between 10 and 40 μm.

With this intensive AIPT development process MAG reached a big improvement in the cold forming technology. The result is a essential reduction of the undercut up to the elimination.

Advantages
The standardized AIPT optimizing process effects the following advantages to our customers:

- Improvement of the spline quality especially to the valuable profile parameters (Fa, ffa, fHa)
- Improvement of the active profile lengths up to + 20%
- Less risk to frictional corrosion
- Elimination to permanent discussions to this process related quality issue

Milestones to the AIPT optimized workpart
Basement to start with the AIPT optimization are the actual tool parameters, pre diameters and the spline data sheet. With a practical test run on the MAG internal machine the status quo gets fixed.

The realization start with a AIPT CAD-simulation, changes to the tool design and further with the AIPT profile grinding process. At least a second test run document the improved result.

At the end we show the initial results versus the improved results with much more better quality related to the involute profile form.
Global Applications – Solutions in Cars, Trucks, Tractors and other Industries

- Flange parts – rolling splines, threads and oil grooves
  Drive train

- Axle parts – rolling heavy duty splines
  Drive train

- Axle shafts – rolling splines, threads and oil grooves
  Drive train

- Gear shafts – rolling 3 splines in one cycle
  Gear box

- Gear shafts – rolling 2 splines in one cycle
  Gear box

- Gear shafts – rolling 5 splines in one cycle
  Gear box

- Starter shafts – rolling 1 helical splines with axial stop
  Motor

- Line – helical – cross knurls
  Spinning industry

- Cardan shaft with long spline – rolling splines
  Drive train

- Cam shafts – rolling 8 splines in one cycle
  Motor

- Crank shafts – rolling splines
  Motor

- Crank shafts – rolling splines with radial orientation
  Motor
## Technical Data

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* including hydraulic unit – variations on demand

Subject to change without notice

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The **services team at MAG** is your single source for maintenance and productivity solutions designed to optimize plant operations. Through comprehensive support and factory-direct expertise, manufacturers achieve maximum equipment availability and utilization, reducing their cost per piece. By providing a proven and innovative service and support program, our customers maintain the lowest possible total cost of ownership of capital equipment throughout the machine’s life cycle.
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The FFG entities in Europe and the Americas unite major players from the German, Italian, Swiss and American machine tool industry with a broad range of milling, turning, grinding, and gear manufacturing technology, and the knowhow of the renowned machine tool brands VDF Boehringer, Hessapp, IMAS, Jobs, MAG, Meccanodora, Modul, Morara, Pfiffner, Rambaud, Sachman, Sigma, SMS, Tacchella and Witzig & Frank. Since 1798, these brands have substantially contributed to the progress in industrial manufacturing and are well known as reliable and innovative equipment and systems solutions suppliers for the automotive and truck, aerospace, machine building, general machining, railway industry, energy and heavy engineering industries. While being an independent group, these entities benefit from the strengths and opportunities of the global Fair Friend Group. They stand for premium technology within FFG.