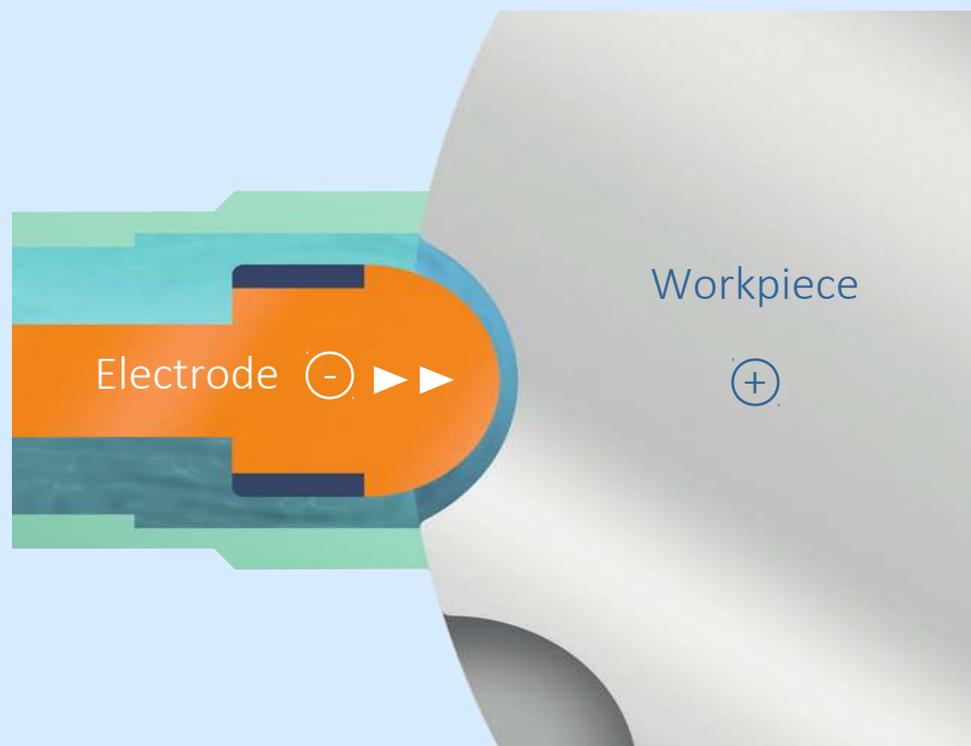


Electrochemical Machining

Köppern ECM Contract Manufacturing



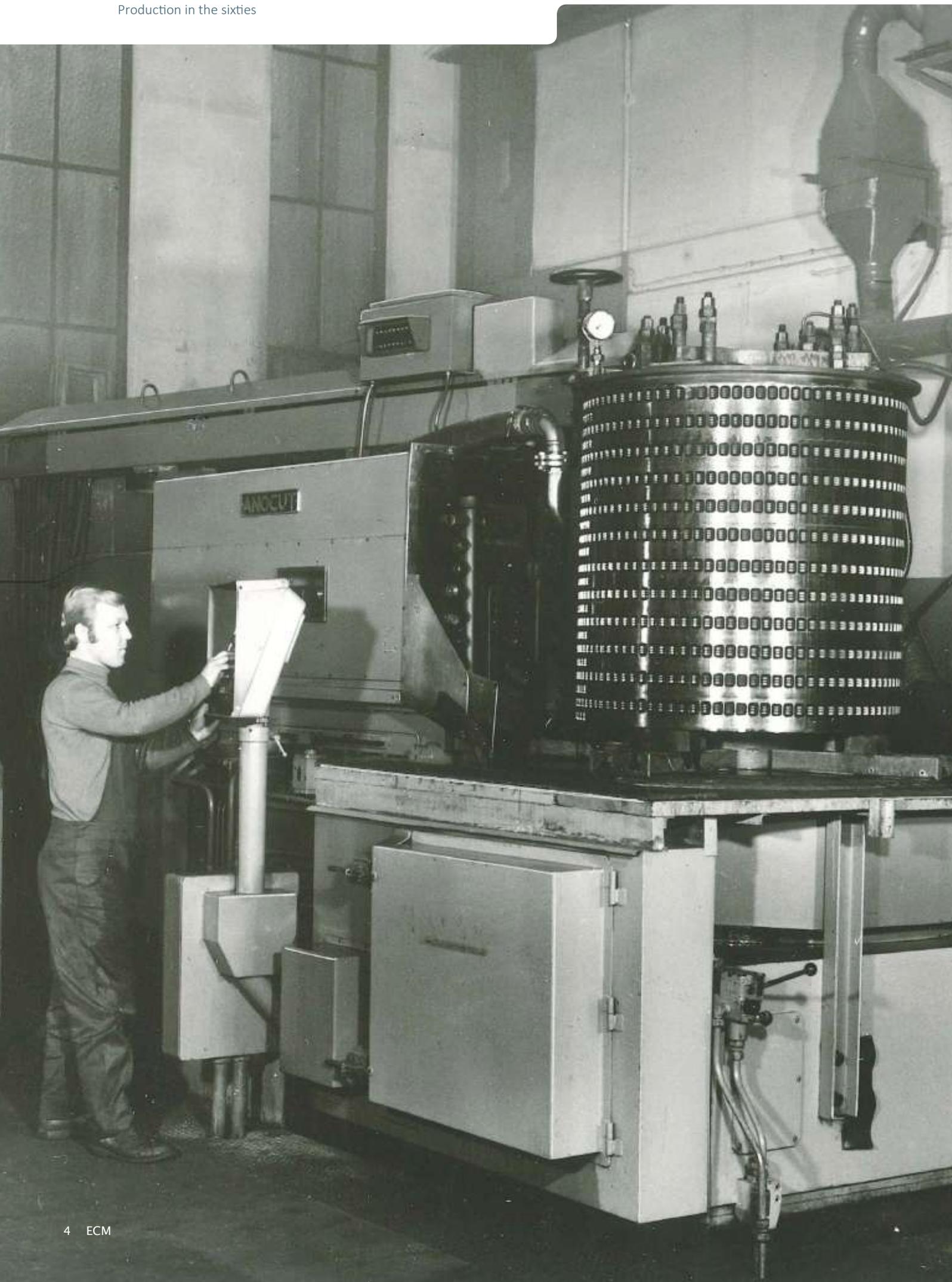
KöpperneCM

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Köppern ECM

One specialized process
for a large field of
applications.



A brief look at a long history

Founded in 1898 in Hattingen, Germany, Köppern remains a family-run enterprise reflecting its traditional values of technology leadership and highly dependable manufacturing quality, coupled with a unique regard for the individual needs of its customers. Köppern's global network of subsidiaries provides customized service on all continents.

The company's history is very much linked to the briquetting of hard coal, a process that goes back to the mid-17th century. But it wasn't until the end of the 19th century that the manufacture of briquettes became a modern industrial process.

In the course of improving the slow and expensive copy milling of coal briquetting rollers, Köppern installed one of the European continent's first heavy plants for electrochemical machining (ECM) in 1965, making the machining of briquetting rollers much more cost-efficient.

Just one year later Köppern began working together with Rolls Royce in England, who were also using ECM-technology for the machining of aero-engine housing parts – this was our first experience of exchanging know-how.

As ECM-technology became better-known in the 70s, Köppern began investing more in the contract manufacturing sector.

Orders for ECM-machining, including tool development, were often carried out together with AEG Elotherm, an ECM machine manufacturer. In the course of becoming a Europe-wide ECM-supplier, Köppern processed parts for Famat in France, MTU in Munich and for Siemens and Tutthill Powerplant Technologies.

In 2007, Köppern decided to invest in a new area of ECM-technology known as 'Combined Pulsed ECM' or PECM, which can be operated either with direct-current voltage or with pulsed voltage. This technology raises the level of precision of ECM without significant loss of machining time.

History

» 1898

Wilhelm Köppern acquires the „Berninghaus-Hütte“ in Hattingen

» 1965

Installation of the first ECM machine

» 1966

Start of cooperation with Rolls Royce

» 1968

Production of turbine blades

» 1975

Additional ECM machines installed in Hattingen

» 1988

Production of breaking disks for BMW

» 1990

Start of cooperation with MTU

» 1995

Production of turbine discs for Rolls Royce

» 1995

Manufacturing of a ECM machine for Rolls Royce turbine parts

» 1996

Production of filter-elements for power plants

» 1999

Installation of the first ECM machine in Venezuela

» 2002

Move to the new production facilities in Hattingen

» 2004

Production of ABS Hubs for Mercedes

» 2007

Development of new P ECM machine

» 2010

Production of casings for MTU

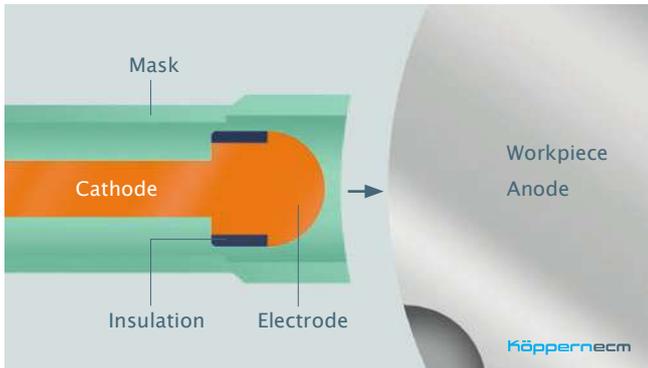
» 2012

Installation of the first ECM machine in India

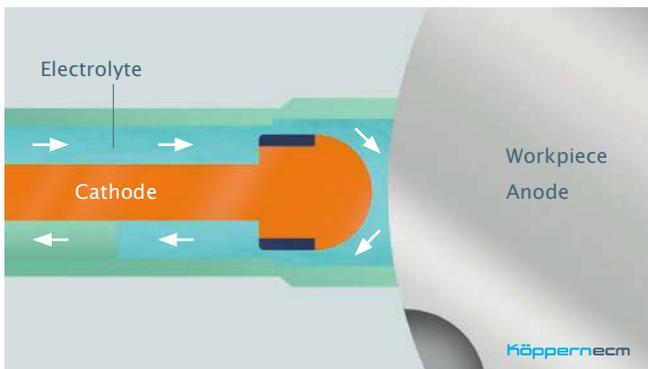
» 2015

Development of a new large-scale ECM machines

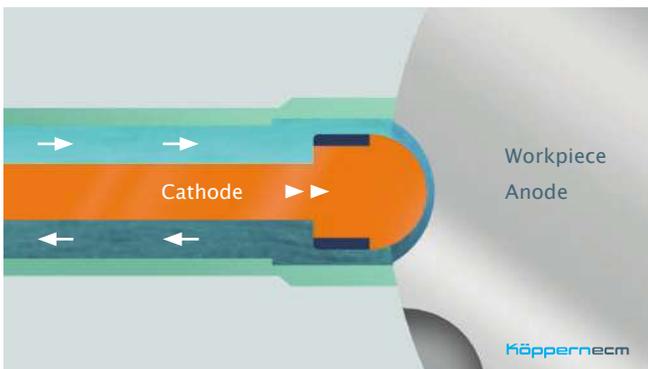
ECM – the Process



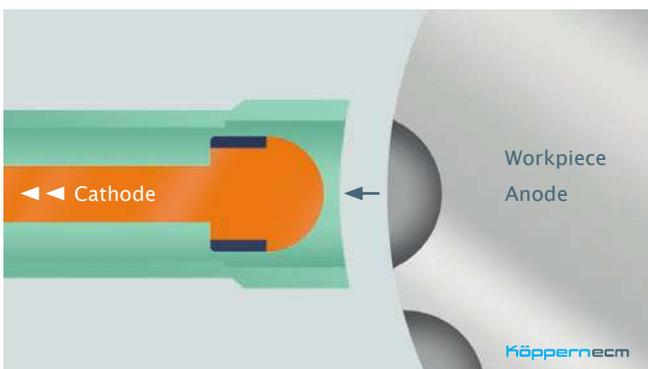
Step 1: Electrode approaches the workpiece



Step 2: Electrolyte liquid surrounds the electrode, processing begins



Step 3: Final machining depth attained, possible polishing requirement



Step 4: Withdrawal of the electrode, ready for next form

In the course of the ECM-process, metal is removed by electrolytic dissolution until the workpiece has acquired its specified form.

The workpiece to be machined is connected to a positive pole (anode), while the tool electrode is connected to the negative pole of an external direct-current voltage source. The tool electrode possesses the form of the required workpiece contour.

An aqueous electrolyte solution in the gap between anode and cathode closes the electrical circuit. The electrolyte carries the ions needed for the process, dissipating the generated heat and discharging the dissolved material. The workpiece contour is created through the guided movement of the tool. The process-related continuous flow of the electrolyte solution between the tool electrode and the workpiece ensures that the components do not come into contact with each other, so that neither the electrode nor the machining process itself are impaired by wear.

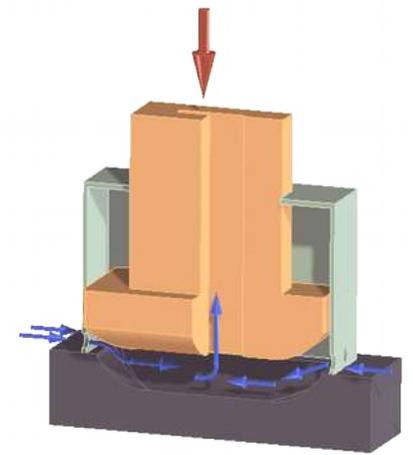
Pulsed (P)ECM-technology allows pulsed voltage to be used instead of continuous voltage (direct current) to close the electrical circuit – just like turning a light switch on and off, but in cycles of around 10 milliseconds. In combination with the conventional direct-current ECM-process, this feature provides significant benefits such as

- greater precision
- better surface quality
- shorter machining times.

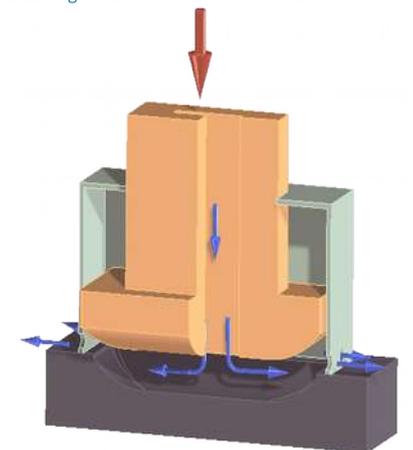
In order to channel the electrolyte Köppern uses different possibilities depending on the application and electrode geometry. In the first case, the electrolyte is introduced into a pressure chamber and returned through the electrode.

In another application, the electrolyte is introduced through the electrode and flows out of the machining gap. This is done either freely or, as shown, by means of a pressure chamber in which then a corresponding back pressure can be generated.

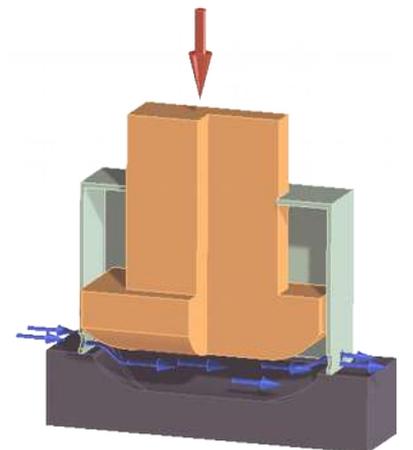
The third example shows a structure in which the electrolyte is passed across the electrode. In contrast to the first two examples, there is no flow ridge, which is caused in Examples 1 and 2 by the scavenging slot.



Electrolyte is fed into a chamber and flows back through the electrode



Electrolyte is fed into a electrode and flows back through the gap and the chamber



Electrolyte is fed across the electrode

Advantages of ECM:

- » Machining of hard materials
- » No structural alteration
- » Freeform surfaces
- » Burr-free
- » Surface quality $R_z < 10 \mu\text{m}$
- » Short processing times

Electrochemical machining has proved to be superior to other forms of processing, especially when it comes to materials with very high hardness and abrasion resistance, where cracks must be avoided and a high surface quality is required, as for example in the aerospace industry.

The forming of high-alloy materials, such as nickel-based or titanium alloys, or powder-metallurgical / hardened materials, is also unproblematic. The machining process produces a burr-free, high-grade surface quality, without thermal stress as the processing temperature is below 90 °C.



Different ECM electrode tools

Applications in Industry



Front-wheel ABS hubs

Automotive

ECM-processing is used here to produce an ABS/ASR interlocking system in a single operation. This requires a high-precision electrode, made of sheet metal, to machine the 48 gaps required, each 2.2 mm wide, 1.5 mm deep and 15 mm long. This process is carried out on a multiple tool, so that an average of more than 67 front-wheel ABS hubs can be produced per hour with a surface quality of $R_t = 8 \mu\text{m}$.

Marine technology

The following example of a piston head for heavy diesel engines, typically used in the shipbuilding industry, shows ECM's completely burr-free machining capability for large components.

This demonstrates the ability to die-sink complex geometries in a single operation. In this particular case, the outer plate has a diameter of 190 mm and the machined contour a maximum depth of 14 mm. Smooth, streamlined rounded forms and a high surface quality of at least $R_a = 0.8 \mu\text{m}$ for the various inner and outer radii are of particular importance for this component.



Piston heads for heavy diesel engines

Turbine technology

ECM-technology demonstrates its true value in the production of critical parts for the aerospace industry. Köppern uses this process to manufacture highest quality bent, elliptical coolant channels for high-pressure turbine disks (HPT) for Rolls Royce in Germany. These represent an especially critical and stress-prone aero-engine component that has to be completely crack-free, with a streamlined in- and outflow combination of the coolant channel. ECM-processing offers the only possibility of fulfilling these preconditions in relation to high-strength working materials that are difficult to machine. In production, the size of the 74 coolant channels on a disk is accurately maintained at $\pm 0.05 \text{ mm}$.



Bent elliptical coolant channels for turbine disks

Pharmaceutical industry

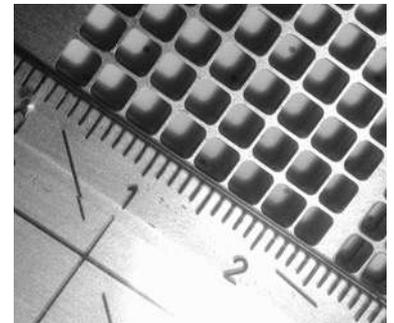
Quality demands are rising in the pharmaceutical industry in the same way as the demands of failure-safety in aero-engine construction. In both cases, ECM-processing is far superior to conventional techniques such as turning and milling. This product example shows the fabrication of tablet rollers, whereby the customer insists on a constant tablet volume of 399 mm^3 for each form. The high reproducibility of the ECM-process enables us to produce these $5.88 \times 20 \text{ mm}$ cavities to $\pm 0.05 \text{ mm}$ with a surface quality of $R_a = 0.4 \text{ }\mu\text{m}$. Generally, the ECM-process has proved to be highly flexible with respect to the design of tablets. Just a change of electrodes is sufficient to alter tablet shapes, add a score line or stamp a logo or a gram specification.



Rollers for the production of tablets

Mechanical engineering

Simple structures can sometimes be a challenge for production planners, for example when conventional manufacturing methods are not allowed or seem to be uneconomic. The following illustration shows a lattice structure with 2-3 mm-wide rectangular holes machined into a steel sheet by the PECM-process. These workpieces serve as filter elements in highly critical areas of a nuclear power station, undergoing extreme stress in terms of pressure and temperature. To guarantee that the filter remains absolutely free from cracks, a method must be used that removes material smoothly without any mechanical strain on the workpiece – which means ECM, whereby economical processing for our customers requires the use of up to 500 individual electrodes in a single tool.



Lattice structures for separation grids

Steam turbines

Our experience in making blade profiles for stationary steam turbines goes back to the 70s. This illustration shows individual blades with an additional stud, manufactured in consecutive working steps out of a closed, turned ring.



Steam turbine blades



A classic application arising from our own in-house manufacture of roller presses is the insertion of voluminous forms (e.g. 106 x 44 x 15 mm) in briquetting rings of up to 1,500 mm diameter. Four forms at a time are die-sunk by multiple tools into a ring weighing up to 14 tons – a specialty in the application of ECM on account of the removal of more than 133 kg of material. The actual die-sinking time for four forms is only 8 minutes, which would surely stretch the capacity of the equivalent conventional milling process.



From the idea to the ECM tool to the production



ECM Tool for production of tablets

The deployment of ECM-technology requires the creation of a common iterative process with the customer. The resulting designs are predominantly foreseen for conventional machining, yet a more fluid and dynamic optimization than originally planned may emerge from developing a tool with ECM-processing in mind.

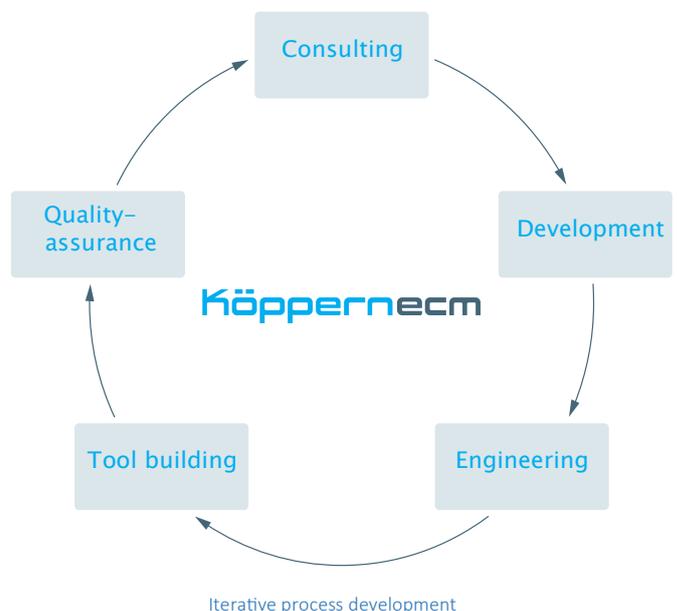
For the development of especially complex ECM-tool structures, Köppern uses a broad spectrum of manufacturing techniques, ranging from selective laser sintering, 3D printing and wire erosion to conventional machining methods such as drilling and milling.

Backed by decades of experience, Köppern offers its customers the support of qualified engineers and technical advisers who are able to assist in:

- analyzing process-related problems, and
- providing solutions to optimize your machining operations.

Working closely together with our customers, we develop machining concepts, build prototypes and undertake the in-house design, manufacture and assembly of ECM-tools, or manufacture single products or series. All products – from blanks to finished parts – are manufactured by Köppern ECM in accordance with ISO 9001 quality standards and in line with customer specifications.

Using capabilities provided by Maschinenfabrik Köppern, our ECM-facility is also able to take on conventional milling work as well as machining using automatic lathes of up to 50 tons.



Quality on the highest level

Coordinate measuring machines (CMM)

Our primary focus in terms of quality is to meet our customers' needs and to exceed their expectations. Sustained success can only be achieved by attracting and retaining the customers confidence. Every aspect of customer interaction provides an opportunity to create more customer value, so we are proud of having received solely positive feedback from our customers, who include:

Rolls Royce Deutschland
Framatome
Daimler AG
Goodrich Control Systems
MTU Aero Engines

In order to be able to provide 'measurable quality', we have focused during the last few years on the complexities of ECM-geometries and invested in the new CMM technology. We are now able to develop our own CMM programs so that they are as flexible as possible with regard to the alteration, adaptation or creation of dimension records, contour scripts and graphics.

As a matter of course, Köppern-ECM works a 3-shift system including the services of an independent quality department.

We are able to offer you a broad range of CMM capabilities, for small and big parts.



Typ: Referenz Xi 22 12 9
Max. workpiece dimension: 2.200 x 1.200x900 mm
Accuracy: 1,8 μm + L/350 μm



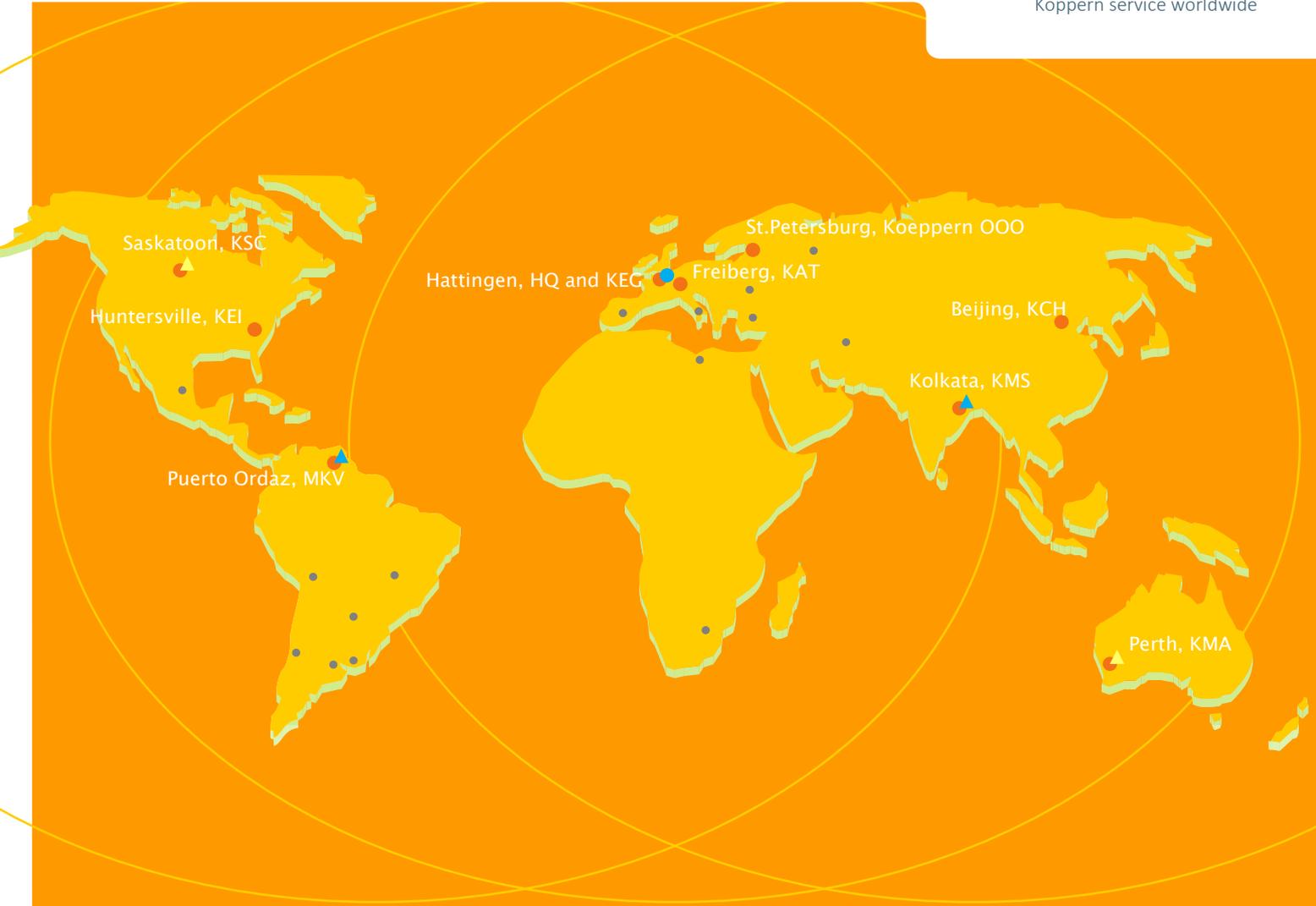
Typ: DEA Scirocco record 10-15-9
Max. workpiece dimension: 1,000 x 1,500x900 mm
Accuracy: 2,5 μm + L/300 μm

ECM Equipment



Since the beginning in 1965, Köppern has continually improved its ECM-technology for contract manufacturing. This enables us to offer our customers a broad range of machine capabilities, starting from the smallest needs and ranging up to 15 tons with a maximum diameter of 2.5 m. Our five ECM-machines are always integrated into our unique electrolyte-treatment system, which keeps the process as environmentally friendly as possible in line with economic feasibility.

Our production facilities, acquired in 2002, comply with all relevant safety standards and offer ample space to extend the process. The ECM-machinery installed in our factory can accommodate anything from single workpieces to large-scale production runs.



Sales and Service Offices

- Köppern Headquarters, Hattingen
- Köppern Subsidiary with Sales and Service Offices
- ▲ Köppern Workshop with ECM
- ▲ Köppern Workshop
- Representatives

Maschinenfabrik Köppern

GmbH & Co. KG

Königsteiner Straße 2
45529 Hattingen
Germany

Factory / Delivery

Ruhrallee 6
45525 Hattingen
Germany

T +49 (2324) 207 - 0
F +49 (2324) 207 - 207
E info@koeppernecm.de

KAT – Köppern Aufbereitungstechnik GmbH & Co. KG

Agricolastraße 24
09599 Freiberg
Germany

T +49 (3731) 2018 - 0
F +49 (3731) 2018 - 20
E info@koeppern-kat.de

KMA – Koeppern Machinery Australia Pty. Ltd.

73 Pavers Circle
Perth WA 6090
Australia

T +61 (8) 9248 - 4170
F +61 (8) 9248 - 4176
E info@koeppern.com.au

KSC – Koeppern Service Canada

3077 Faithfull Avenue
Saskatoon, S7K 8B3
Canada

T +1 (306) 373 - 2110
E info@koeppern-service.ca

KEG – Köppern Entwicklungs-GmbH

Königsteiner Straße 2
45529 Hattingen
Germany

T +49 (2324) 207 - 0
F +49 (2324) 207 - 301
E info@koeppern-entwicklung.de

KCH – Koeppern China Holding GmbH

Beijing Office, Unit 9a, Block B, Building 2
Shiyunhaoting Apartment
No. 33, Guangqu Road
Chaoyang District
100022 Beijing
P.R. China

T +86 (10) 6482 - 7348
F +86 (10) 6482 - 7341
E info@koeppern-kch.com

KEI – Kopperr Equipment, Inc.

7930 W. Kenton Circle,
Suite 305
Huntersville, NC 28078
USA

T +1 (704) 357 - 3322
F +1 (704) 357 - 3350
E moreinfo@kopperrusa.com

Koeppern OOO

Millionaya Ul. 27
191186 St. Petersburg
Russian Federation

T +7 (812) 3 09 36 46
E russia@koeppern.com

KMS – Kopperr Maco Services Private Ltd.

Sukh Sagar Apartment
6th Floor, Flat No. 6 / C
2 / 5 Sarat Bose Road
Kolkata – 700 020
India

T +91 (33) 2476 - 1720
F +91 (33) 2476 - 9052
E info@koeppern-kmspl.com

MKV – Maquinarias Koeppern Venezuela C.A.

Ud-321, Parcela 08-08, Edificio Koeppern
Zona Industrial Matanzas Sur
Apartado Postal 766
8015-A Puerto Ordaz
Venezuela

T +58 (286) 994 - 1792
F +58 (286) 994 - 1687
E mkv@cantv.net