

Harmonic
Drive AG

...just move it!

newdrive

The Magazine of Harmonic Drive AG

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A look back and into the future



Ekrem Sirman
Chairman of the board
of Harmonic Drive AG

Scenario: „In the year 2050, Germany will no longer be among the five largest economies. According to a current study, the largest leap forwards in the coming decades will be made by India.“ (PriceWaterhouseCoopers)

Dear Reader,

Is this scenario just a vision, or will it soon become reality? Not even the futurologists who predict these situations can answer with a clear «yes» or «no». One thing though is sure. No matter what new technologies or innovations the coming years will bring, all of the strategic decisions and developments by the German company Harmonic Drive AG will place its partners and customers at centre stage, just as they have been doing for the last forty years.

A look back: In the early seventies, the present chair of the supervisory board Reinhard Ernst had the foresight to establish Harmonic Drive gears in many fields of machine building and drive technology throughout Europe. Today we can therefore look back on countless applications that benefit from our drive systems as high efficiency solutions. Complicated action mechanisms as presented e.g. by conventional differential gears in the printing press industries could be simplified and optimised to a considerable extent.

At present, we see ourselves well equipped for the challenges of the future. By strategically expanding our product range away from a dedicated gear supplier to a mechatronic systems provider, we are aligning ourselves consistently to the market and new requirements. We can respond flexibly to changing market conditions and launch new products.

This year, Harmonic Drive AG will be celebrating its fortieth anniversary: forty years full of innovations, forty years of successful growth moulded by people that power a magnificent team. In future too, it will be our common goal to safeguard the sustainable success of our company.

This latest issue of «newdrive» again presents many interesting subjects from the Harmonic Drive world. Have fun reading!

With best regards,

Ekrem Sirman

New | Corporate movie



The **new Harmonic Drive AG corporate movie** is presented with a fresh look and featuring the latest insights into the group. View it now at www.harmonicdrive.co.uk

Exhibitions | Come and visit us!



06.-08.09.2011
OFFSHORE EUROPE,
ABERDEEN (GB)

www.offshore-europe.co.uk
Hall 4, Stand C167



13.-16.09.2011
DSEI,
LONDON (GB)

www.dsei.co.uk/
Joint German Stand Hall South,
Stand S6-270



19.-24.09.2011
EMO,
HANOVER (D)

www.emo-hannover.de
Hall 25, Stand E24



03.-07.10.2011
MSV,
BRNO (CZ)

www.bvv.cz/msv-de
Hall B, Stand 51



04.-06.10.2011
SMART,
LINZ (A)

www.smart-automation.at
Stand 406, Design-Center Linz



05.-06.10.2011
IMA,
LYON (F)

www.mecatronique-automation.com
Stand J 20, Eurexpo



10.-13.10.2011
MOTEK,
STUTTGART (D)

www.motek-messe.de
Hall 9, Stand 9230



22.-24.11.2011
SPS/IPC/DRIVES,
NUREMBERG

www.mesago.de/sps
Hall 4, Stand 4-309



Precision thanks to the hollow shaft

CNC milling needs the highest precision. A compact hollow shaft actuator opens up new possibilities for the enhanced positional control of milling heads.

The wide variety of diverse plastics and composite materials now available opens up many new types of application. Their production places the highest requirements on speed and accuracy. Accordingly, the users and manufacturers of CNC systems for machining plastics demand from their suppliers the maximum possible precision. The CNC machine maker HG SysTech GmbH in Wiedergeltingen, Bavaria, relies on Harmonic Drive products when developing its milling heads. This company builds plastic machining systems as gantry, portal, or rotary table versions. Machining complex forms is only possible when the medium can be supplied through the centre of the drives. HG SysTech therefore chose the compact hollow shaft actuators from the Harmonic Drive CHA series.

These actuators consist of an AC servo motor, precision gear, output bearing, encoder system and optional brake. The essential feature of the CHA range is the hollow shaft through the unit that can be used to carry the medium. The high stiffness cross roller or four point output bearing can withstand high tilting

moments and is designed as a flange bearing, so that its outer ring can be mounted directly on the machine housing. The load, e.g. a milling spindle, is flanged directly to the rotating inner ring of the precision bearing. This absence of intermediate components therefore guarantees the best values for parallelism and concentricity.

Precision in a small space

The Harmonic Drive gear is attached directly to the output bearing. Due to the unique operating principle, the gears provide single stage reduction ratios with no change in basic dimensions. Moreover, Harmonic Drive gear teeth engage at the lower output speed meaning there is virtually no wear whilst the Flexspline's conical geometry pre-loads the gears over the whole life of the gear. The gear is driven by an AC synchronous servo motor. Compared with the classical cylinder motor design, the CHA rotor has a hollow shaft and a larger diameter leading to considerably shorter length for the same power. The CHA actuators are available with various optional encoder systems meaning that they can be operated with various makes of servo amplifier.

Exact positioning values

The hollow shaft rotates at the output speed and passes through the whole actuator. At the rear of the actuator the hollow shaft can therefore be used to supply information directly on the speed and position of the load. An optional encoder can be fixed to the shaft to capture these values directly for the position control system. The separate values for the servo motor and for the load can be used to compensate for load dependent errors for the axis control. For instance, the drive load varies with greater feed speed and differing machined materials. The resulting changes in torque can cause a difference between the target and actual position of the milling head that an encoder on the motor shaft cannot detect. So when the positioning control circuit's actual value is supplied separately from the motor control circuit's, the feed speed can be increased with even better geometry tracking. This permits machining at higher speeds, resulting in better performance and improved surface quality.



The future – precision surgery on the ear

Precision mechanics is gaining in importance as a tool in surgery. This alone helps to develop moving mechanical equipment that can perform complex surgery with the greatest precision and reliability. The extraordinary performance of these systems benefits greatly from the outstanding properties of Harmonic Drive gears.

“Robot cutting into the base of the skull” – what sounds like a horror film is actually a great step forwards in medicine as a high tech method for helping the deaf and hearing impaired to hear better in future. They will still wear their hearing aid as usual over the ear, but they will have a receiver plus electrode implanted directly in their cochlea. For the minimally invasive and precise implantation of these hearing aids, a robot assisted navigation system was developed by Dominik Widmer, Professor Einar Nielsen of the technical university NTB in St. Gallen, Professor Stefan Weber of the ARTORG Center for Biomedical Engineering Research of Bern University, and Professor Marco Caversaccio of the Inselspital Bern university clinic for ENT surgery.

Surgical implants require high precision work on the base of the skull, so the maximum possible

precision is a key requirement. First, the receiver implant needs a bed cut into the skull. The next step involves opening an access passage to the cochlea for the electrode. To date, the extremely small scale made surgery of this kind impossible without a microscope. Moreover, the surgeon, when cutting through the bone behind the ear, had to make the access passage to the cochlea larger than necessary because the precision of 0.3 to 0.5 mm needed for this surgery was not possible with the conventional methods. A special surgical robot system was developed for achieving this precision. It was particularly important for this system's acceptance in the operating room that the surgeons were involved in the development from a very early project phase. Thanks to their help, the system's technical properties and the requirements for its integration can be defined with the greatest precision for field applications.

The system operates on the basis of three dimensional image data that are used to align and move the robot always relative to the patient.

Although the robot has to move a full load of about one kilogram in the form of drills and endoscopes and apply a cutting force of up to 10 N, the robot's position and orientation may deviate by no more than a few tenths of a millimetre from the planned drilling axis. The positional resolution at the cutting tip is expected to be 0.01 mm with a repeatability of ± 0.05 mm, and a max robot deflection of 0.2 mm under load.

The current stage of development is for a five axis robot with a max reach of 500 mm. The axes present similar technical layouts and they are all made with Harmonic Drive gear sets whose hollow shaft provide the perfect solution for



It can be seen even today that high precision robots will be providing crucial contributions to the surgery of the future. Soon they will be performing surgical methods that today are impossible with any other technology.

carrying cables through these zero backlash and high precision products. The last axis also features a force-torque sensor that can be used to regulate the contact forces and operate the robot via touch sensitive controls.

The power electronics for the drive are fitted inside the robot. In the event of power outage, all axes are locked and their positions stored digitally so that the controller can reload their exact positions the next time the system is started up. For safety reasons, the operating room is also fitted with an additional positioning monitor with an optical measuring system. This shuts down the system immediately there is abnormal behaviour owing to hardware or software errors in the controller or drive unit.

Harmonic Drive precision gears are used in pioneering surgical methods

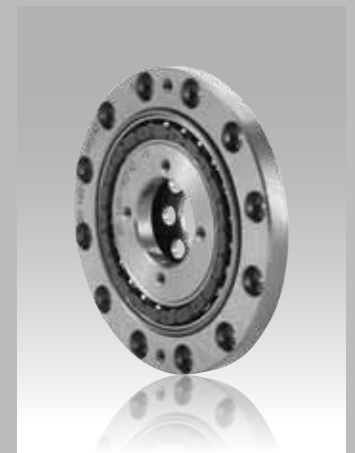


CPL – the lightweight gears

The CPL gears, based on the proven HFUC components, have been optimised by careful cross section design and material removal to achieve a weight saving of up to 50 %. The Wave Generator and Flexspline have increased internal diameters allowing for larger hollow shafts through the gear.

CSD – the slim gears

The key feature of the Harmonic Drive CSD-2A series component sets in comparison to the HFUC-2A series is the reduction of axial length by nearly 50 %. This enables the design of particularly compact positioning drives and indexing tables. Designs with hollow shaft are available.



PMA – compact DC mini servo drive

The compact PMA DC mini servo drives combine precision Harmonic Drive gear sets with output bearing and dynamic DC servo motors in the smallest possible space that can feature an incremental encoder as the measuring system. Thanks to its compact design this series can therefore provide the maximum torque capacity in the smallest of spaces. The optimised installation serves to improve transmission accuracy by up to 30 %.



QM – The opposite of chance

Quality management enjoys a status that is growing in importance every day. Companies are setting up automated processes and introducing consistent standards. Harmonic Drive has been relying on sustainable quality for a long time. Our quality management system was introduced as early as 1995 and since then has supported a continuous improvement process for fulfilling the requirements on the sector both now and in the future.

Since the first DIN EN ISO 9000 was published in 1987, quality management systems have been used over a wide front. Companies still failing to tackle the strategic alignment of their future quality management systems will very soon be compelled by the law, regulations, the market, the competition, and customers to introduce approaches adapted to the new circumstances. These affect not only the “classical” fields like quality and environmental protection, but also components like hygiene, industrial safety, risk management, economic efficiency, and the protection of health. Competitive advantages

arise where management does not rely on island solutions, but utilises the synergies of an integrated management system. The central task is to plan, control, and improve continuously the processes at the company for the environmentally friendly, reliable, and responsible provision of efficient, quality services.

We started merging a range of management systems into the one integrated management system (IMS) as early as 2002. The simultaneous use of continuous improvement (synergy effect) was one of the key reasons for setting up our IMS. Quality,

environmental, and industrial safety management systems exhibit similar structures, so these systems can be combined into the one “integrated documentation” with little additional effort.

Achieving unvarying high quality is not the product of chance, but the result of directly experienced management processes. Yet processes are experienced only when their criteria and improvement also benefit from the contributions of employees, e.g. in CIP teams (CIP = continuous improvement process). The motivation to contribute is crucial to our success.



A management system is only as good as the extent to which employees are included in the implementation and change processes (bottom up approach). "Quality as a strategic focus is a keystone of our sustainable success," explained Detlef Schmidt, Head of the Management Systems Department. Constant examinations of processes safeguard their modern relevance and continued advancement. Products are adapted and optimised so that "state of the art" does not degenerate into a mere advertising slogan, but becomes a promise to the customers.

Nevertheless, we are faced with the same question every day: "How can we maintain and enhance high quality?" "Processes can fill a lot of pages, but if they are not put into practice they won't help anybody. That is why we maintain a constant dialogue with suppliers, partners, and internal process agents for examining process compliance

in all activities," explained Daniel Liedke, Deputy Head of Management Systems. Both internal and external audits constantly inspect the process landscape at Harmonic Drive. Quality management has therefore become a part of the strategic company management.

At present, Harmonic Drive is the only company in Germany to be certificated under EN 9100:2009, the new aerospace standard based on DIN EN ISO 9001:2008. "This shows us all that directly experienced dedication to our processes has set us on the right path. All employees at Harmonic Drive have contributed towards this extraordinary success, because only team spirit can make such a performance possible," added Detlef Schmidt.

Modern quality management systems are focused on sustainable quality. Sustainability is one of the great challenges of our time. Whereas this concept has become a little fuzzy following its widespread popularity, the objectives it pursues have become an integral constituent of modern economy for its continued survival on the market. How can sustainability be measured, assessed, and certificated?

Economic sustainability

In minimal economic terms, sustainability must be inherent in every quality management system. Alone for economic reasons, the focus is placed on

production processes and measures that minimise the drain on resources not only with short term effects, but also with consequences leading to the objective.

Ecological sustainability

This is a different matter when the definition of objectives embraces ecological sustainability. The examination and assessment of a process's sustainable environmental compatibility should be a matter of great importance to every company. Formerly, these examinations were mostly conducted as island solutions testing environmental compatibility. How can they be integrated in quality management?

Sustainability is an integral constituent of quality assurance because this is quality aligned to a cross section as defined by modern quality management. Accordingly, sustainability criteria and quality management systems should be implemented like a common thread. Redundancies are eliminated, and the paper deluge of static manuals makes way for a dynamic, upgradable system. Multimedia elements dispel verbiage and are more readily accepted for the employees' information.

The role of pioneer is not a matter of prestige at Harmonic Drive, but first and foremost a promise to its customers.



The gear units of the CPU series: CPU-H with central hollow shaft, CPU-M for attaching directly to motors, and the version CPU-S with an input shaft.

CPU-H



CPU-M



CPU-S



perfect, smooth running

The CPU-plus series from Harmonic Drive: high performance gears with a new, environmentally friendly lubricant.

Harmonic Drive has been offering its CPU series precision gear units since 2005 with high ratios, zero backlash and high transmission accuracy. Featuring an integrated, pre-loaded cross roller output bearing with high tilting stability, these gears are used in many demanding applications. This concept allows for the flexible and efficient production of various versions; either as a hollow shaft version, with an input shaft or for direct motor adaption. With the latest CPU-plus generation, Harmonic Drive has also considerably boosted the efficiency and widened the operating temperature range without limiting the advantages inherent in the CPU design. The improvements are based on optimised tribological contacts within the gear, improved sealing and lubrication which results in significant reductions in friction and wear.

Raising gear efficiency with the new lubricating grease Flexolub-A1

The improvements are based on a newly developed environmentally friendly lubricant, Flexolub-A1. This is a grease lubricant with a polyolefin base oil, a special lithium soap, and a specially designed package of additives. In particular at low temperatures, the resulting improvements in efficiency and the reduced power losses are unlocking new markets for the CPU units. For example, the improved operating temperature range of -40 °C to $+120\text{ °C}$ now allows mobile applications without restrictions to the maximum torque. Tests with special lubrications are no longer necessary. Cold starts in particular can benefit from the considerably lower starting torques, leading to an improved energy balance. For instance,

a no load starting torque of less than 0.4 Nm was measured on a size 20 unit (reduction ratio of 100) at a temperature of 0 °C.

And the lower power losses in the gears improves the energy balance.

The reduced power losses also benefits the no load running torque, which is now up to five times lower than the CPU series. And this, in turn, effects the efficiency: at 0 °C this is 15 % better (when loaded with a rated torque of 40 Nm and an input speed of 3500 rpm). Also, the higher maximum operating temperature has its benefits, for example to better utilise servo motor performance. Less heat needs to be removed allowing for smaller, more compact solutions.

Gear units available in three variants

The CPU-plus units have zero backlash, excellent radial runout, and a very high repeatability and transmission accuracy. Featuring identical bodies, the units are available in three versions (see figures). The greatest advantage of the CPU-plus series is found in the hollow shaft versions. The limit for average speeds has been raised over 250 %, allowing for reduced machine cycle times. The sizes 14 to 20 now have an allowable average input speed limit of 3000 rpm – an increase of over 270 %.

Also, the larger sizes benefit from the new lubricant. For instance, the average input speed limit for the size 40 units was raised to 1300 rpm, and even the size 58 now achieves 1000 rpm. The maximum input speed is unaffected: speeds of up to 8500 rpm are possible, depending on the size.

These new features provide many advantages in many applications:

- higher average input speeds for shorter cycle times
- higher maximum operating temperature for more compact solutions
- cost savings due to motor performance and optimised electronics scaled down for the improved starting torques
- improved efficiency for units and motors

Economic advantages and higher environmental compatibility

All these features go to improving the economic efficiency of applications with CPU-plus drives. Besides the financial benefits, the environment will also profit from the improvements to the CPU-plus series: energy consumption drops, and performance rises. Also, the lubricant Flexolub-A1 is characterised by a high level of environmental compatibility (water hazard class 1). In conjunction with an optimised sealing concept, Flexolub-A1 is

one reason for the sustainable improvement of the CPU-plus series.

The Harmonic Drive principle makes high torque capacity possible

The CPU units are based on the Harmonic Drive principle. The powerful and precise units provide a high gear ratio from 30:1 to 160:1 in a single stage. The drive consists of three main components, a Wave Generator, Flexspline and Circular Spline. The Flexspline is slightly smaller in diameter than the Circular Spline resulting in it having two fewer teeth on its outer circumference. It is held in an elliptical shape by the Wave Generator and its teeth engage with the teeth of the Circular Spline across the major axis of the ellipse. As soon as the Wave Generator starts to rotate the zone of tooth engagement travels with the major elliptical axis. When the Wave Generator has turned through 180 degrees the Flexspline has moved by one tooth relative to the Circular Spline. Each whole turn of the Wave Generator clockwise moves the Flexspline two teeth anti-clockwise relative to the Circular Spline.

Owing to this particular meshing mode, a special tooth profile is needed to transfer high torques. Harmonic Drive uses the specially developed and patented IH tooth profile, resulting in a 30 % tooth engagement at any one time. The result is a considerably increased transferable torque.





Investment in the future

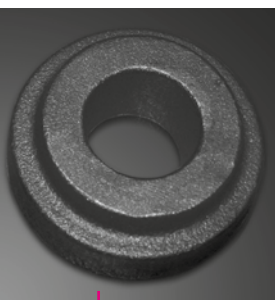
Since its very beginnings, Harmonic Drive AG has placed the greatest value on safeguarding the quality and reliable delivery of its products for the future. So that we can continue justifying this claim, we have invested in an ultra modern fully automated multi axis turning centre.

During the past few years Harmonic Drive AG has experienced impressive growth resulting in a need to increase our production capacity. We had reached the point where we had to expand our production plant with a multi axis turning centre with automation. This required lengthy preparations and a great many production trials with various machine manufacturers until we decided on a Mori Seiki NZ2000 and a Promot automation unit.

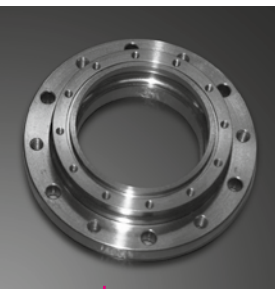
We had good reasons for this decision. For instance, the NZ2000 is capable of simultaneous machining because it is fitted with two spindles and two turrets with integrated milling motor. There are no fewer than 32 powered tools for high performance and high speed cutting. The 6000 rpm tools of 5.5 kW each come very close to the performance obtained on a milling centre. Tuned to optimal effect on the machine, the interactive programming software MAPPS IV greatly simplifies programming with the maximum process reliability. Handling is made even simpler and more reliable by the clear display of activated programs, the simultaneous traversing of all axes and

spindles at the one hand wheel, and the 3D real time collision control in all modes. Yet not only the machine tool, also the chucks have a key role in the machining of components. Accordingly, the main spindle for taking the blank is fitted with the tried and tested INO-GRIP chuck system by HWR Spanntechnik GmbH, and the second receiver on the counter spindle takes the form of a precision power chuck with rapid jaw change. This system exchanges top jaws with very high precision.

The linear portal was designed in collaboration with PROMOT Automation GmbH specifically to our requirements. It is made up of a clocked belt with thirty pallets, a belt conveyor for ejecting finished parts, an integrated embossing station, and two portal arms for loading and unloading the workpieces. With this new, very high performance machine system, we can now reduce turnaround times to a considerable extent. And our customers will continue to benefit from our reliable deliveries in the future as well.



Before



After

Overview | Harmonic Drive AG worldwide

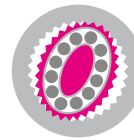
For over 40 years, Harmonic Drive AG has produced precision drive units to the very highest demands for virtually all areas of mechanical engineering.

In addition to three subsidiaries in Germany, five more in Europe and two partners in Japan and America, Harmonic Drive AG is represented at over 20 sites throughout the world to be able to offer direct sales routes and optimum on-site service. You will find an overview of the company's sites along with contact details at www.harmonicdrive.co.uk



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