

ADVANCES FROM AACHEN

WZL AND GRC CONTRIBUTE TO GEAR MANUFACTURING



The WZL Gear Department Staff—Projects sponsored by the Gear Research Circle are performed by the WZL gear department's staff. Klaus Peiffer, Gleason Corp.'s representative in the GRC, describes the staff as "a source of very well educated specialists for the gear industry."

Borg Warner, Dana, General Motors, Gleason, Klingelnberg, and ZF. These companies are heavyweights in the gear industry. They're international operations with thousands of employees in offices and factories around the world—Argentina, Australia, China, England, Germany, India, Japan, South Africa, and the United States.

But even these companies don't always have the time and resources to spare for long-term research & development projects to advance gear manufacturing. So they and many other companies, including Caterpillar, DaimlerChrysler, Samputensili and Saint-Gobain Abrasives, come together in a consortium: the Gear Research Circle.

Founded in 1956, the GRC consists of 70+ companies in the gear industry that jointly sponsor R&D projects. And while GRC companies have international operations, their joint R&D is done in one building in Aachen, Germany. The city is home to a well-known technical institute, RWTH Aachen University, which houses the Laboratory for Machine Tools and Production Engineering, probably best known by its German acronym: WZL.

The lab includes the chair for manufacturing technology,

which is headed by professor Fritz Klocke, and the chair of machine tools, which is headed by professor Christian Brecher. The two chairs share the WZL gear department. GRC work is done by professors, scientists working toward doctorates, technicians and undergraduates in that department.

The research furthers the art of gear manufacturing for GRC members. The advances show up in the form of better machines, tools and other technologies, which benefit the gear industry.

"Many of the technologies that we currently use on our machines have been developed at the GRC," says Klaus Peiffer, vice president—product development & technology for Gleason Corp.

Peiffer, Gleason's representative in the GRC, can easily think of four GRC contributions to gear manufacturing:

- 1.) better understanding of hobbing, shaping and bevel cutting through simulations;
- 2.) development of processes for dry cutting gears with high speed steel tools;
- 3.) improvement of skiving through study of its tool systems, tool materials, cutting geometry and operating data, like speeds and feed rates; and

A Well-Equipped Gear Department

Research work is done with modern gear manufacturing and measuring machines, including:

- a Gleason-Pfauter P 300 hobber, installed in 2000;
- a Kapp VAS 55 P gear profile grinder, in 1996;
- a Liebherr LC 122 hobber, in 1997;
- a Liebherr LFS 182 gear shaper, in 2003; and
- a Sampuntensili K 250 HSC bevel gear cutter, in 2003.

Besides machine tools, the department has numerous test rigs:

- a power train test rig,
- a bevel gear power-circulating (PC) test rig,
- 24 back-to-back test rigs,

- 11 twin-disk test rigs,
 - four pulsator test rigs,
 - a Klingelnberg T20 bevel gear tester, and
 - two spur and bevel gear noise test rigs for single-flanks tests.
- The gear department also has several metrology machines, such as:
- two Zeiss CMMs,
 - a Klingelnberg P40 gear measuring machine,
 - a Stresstech X 3000 X-ray analyzer
 - a Seifert XRD 2000 X-ray analyzer,
 - a Stresstech Rollscan 300 Barkhausen-noise analyzer, and
 - a scanning electron microscope.



Modern Gear Machinery—The WZL gear department includes several modern gear machines on loan from GRC companies. The department uses the machines to conduct its 25+ research projects, both GRC and non-GRC.

4.) better understanding of profile grinding, so grinding burn can be prevented.

Peiffer adds that the profile grinding research is recent, even ongoing, with its results only now being introduced into industry application.

Dividing Up the Work

The department's research covers gear design, gear manufacture and running behavior. Design is handled by the gear calculation team. The gear manufacturing team works on hobbing, shaping, shaving, grinding, honing and other manufacturing processes. Studies of load carrying capacity and running, stress and noise behaviors of gears are performed by the gear investigation team.

Together, the three teams include some 16 scientists. These mechanical engineers hold diplomas equal to master's degrees in the United States, and most are working toward doctorates.

Undergraduate assistants help perform and evaluate trials. Manufacturing engineering students, they work on the teams for 11–19 hours a week—in addition to their regular studies.

GRC companies provide equipment and funding for the department to do its work. The money comes from two sources: a one-time admission fee for new GRC members and an annual membership fee. Each fee ranges from 3,500€–14,500€ (about \$4,200–\$17,500). GRC annual fees alone make up about 30% of the WZL gear department's budget.

Both admission and annual fees, however, vary depending on a company's size and what it manufactures.

GRC money supports two types of research: common and applied. Common research is funded by groups of companies, and applied research is sponsored by one or very few companies. The third type, pure research, is funded by public organizations. Of the department's 25+ projects, only some of them are GRC projects.

Membership Has Advantages

GRC research results are restricted to members, so the com-

panies gain a competitive advantage over nonmembers. GRC companies also receive the results of the department's German and European publicly funded projects.

The department presents the research results of 16–18 technical papers to GRC members during its annual spring gear conference, which is held at Eurogress, Aachen's convention center.

This August 17–18, the department will give a shorter version of its conference at The Gleason Works in Rochester, NY. This version will consist of the best presentations from the '05 conference—held in April—and will be for the benefit of U.S.-based member-companies who didn't attend the Aachen meeting.

Members can send employees to either conference. Each attendee receives a copy of the spring conference's proceedings, including a detailed report of each presentation and a list of all other literature published by members of the WZL gear department.

Another advantage of membership in the GRC is that members participate in many segments of the gear industry, including machine tools, metrology, cutting tools, abrasives and coatings. Many R&D partnerships are possible.

"It's all these partnerships that make a total system work," Gleason's Peiffer says. "In the GRC, we can find any kind of partner in this business."

Coming Up with Ideas

Thinking of research projects for 70+ companies is a research project in itself.

"It's hard to find topics that are of interest to all of them," Klocke says. "However, we continuously ask them for ideas and their opinions about future challenges, and we consider them in our proposals for new projects.

"We have to make sure that larger groups of member-companies can take advantage of the research results."


Results

Klocke sees the long-term research work as the starting



A New Home, A New Test Rig—WZL is expanding its research work to include aspects of the system behavior of transmissions and has taken steps to prepare for this work. WZL's new building, though still being constructed, already houses a universal gear test rig in its basement.

point for advances in gear manufacturing. From the WZL building in Aachen, the research results are taken by GRC companies and used in their factories around the world, enhancing techniques for designing and manufacturing gears or becoming improvements or innovations in gear machine tools, cutting tools and materials.

"It's up to the technology suppliers to develop a technology to industrial relevance," Klocke says. "Our job is mainly to show the potential." 

For more information:

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The WZL gear department is working on more than 25 projects.

The following isn't a complete list of them, but it shows projects undertaken by each WZL gear team, both for the GRC and for other organizations:

Gear Manufacturing Team

Discontinuous Form Grinding

- Potential of new dressable grinding wheels. The goal: Learn the behavior and potentials of modern grinding wheels in relation to grinding burn. Sponsor: GRC
- Determination of characteristic values to avoid grinding burn. The goal: Find a systematic way to predict grinding burn in discontinuous profile grinding. Sponsor: German Federation of Industrial Cooperative Research Associations (AiF)

Gear Honing

- Potential of ceramic tools. The goal: Study the performance of different types of honing tools in the cutting process and in the dressing process. Sponsor: GRC
- Process simulation by means of FEA. Honing is a grinding process with very low cutting speeds. The goal: Obtain fundamental information about grinding processes with very low cutting speeds. Sponsor: German Research Foundation (DFG)

Hobbing

- Potential of cermet cutting tools in hobbing. The goal: Study types of new cermet materials to determine their potential in hobbing. Sponsor: Research Association for Machine Tools and Manufacturing Technology (FWF)
- Reconditioning of carbide hobs. The goal: Learn why carbide hobs in industrial applications do not show reliable wear behavior and find the solution to this problem. Sponsor: Research Association for Machine Tools and Manufacturing Technology (FWF)

Bevel Gear Cutting

- High speed cutting of bevel gears. The goal: Study the effect of process parameters, cutting materials, coatings and other influence factors on the wear behavior in bevel gear cutting. Sponsor: German Federation of Industrial Cooperative Research Associations (AiF)

Gear Shaving

- Process Simulation by Means of FEA. The goal: Determine loads on tools under specific conditions of the gear shaving process, a very complex process geometrically and technologically. Sponsor: German Research Foundation (DFG)

Gear Calculation Team

Tooth Root Geometries

- Optimization and generation of arbitrary tooth root geometries in gear manufacturing processes. The goal: Find a way to determine tool geometry based on a given tooth root geometry. Sponsor: GRC

Tooth Contact Analysis

- Influence of gear errors on noise emission of gears. The goal: Find critical and less critical gear geometry errors in terms of noise emission. Sponsor: GRC
- Design of function-oriented, acceptable manufacturing errors for bevel gears. The goal: Determine the effect of different gear geometry errors on excitation of and contact patterns for bevel gears. Sponsor: Industrial Research Foundation (Stiftung Industrieforschung)

Process Simulation

- Development of SPARTapro. The goal: Help manufacturing engineers optimize the hobbing tool and its process. The software is available only to GRC member-companies. Sponsor: GRC
- Modeling and calculation of chip creation parameters in bevel gear cutting. The goal: Create a bevel gear version of SPARTapro. Sponsor: German Research Foundation (DFG)

Gear Investigation Team

Noise Behavior

- Noise analysis of a real gearbox. The goal: Learn the influence of bearings and housings on noise emission of a real gearbox in addition to noise emission of the gears. Sponsor: German Research Foundation (DFG)

Load Carrying Capacity

- Potentials of PVD coated gears. The goal: Determine the potential of PVD coatings on gear flanks to replace toxic additives in the oil. Sponsor: German Research Foundation (DFG)