

Friction Reduction by DICRONITE® Technique

Reaching exciting new frontiers by space travel proved challenging to existing technology at any time. Space, with its wide temperature swings and extreme vacuum, rendered traditional lubrication technology obsolete due to its chemical properties.

Dicronite® dry lubrication was first developed to meet the new challenge and played a key role in realizing mankind's vision of reaching the moon.

Dicronite dry lubrication technology, a proprietarily modified form of tungsten disulfide, was originally developed in the early 1960s.

The Mariner Space Probes were an early application of Dicronite dry lubrication. The Mariners were a series of planetary exploration vehicles; the first to return locally collected data on the planets Mercury, Venus and Mars. The United States National Aeronautic and Space Administration (NASA) used Dicronite during the Mariner program for lubrication on sliding and rotating surfaces. Dicronite's unique ability to deliver reliable lubrication across a temperature range of -188°C to $+1316^{\circ}\text{C}$ in up to 10^{-17} bar vacuum, while not interfering with precision tolerances due to its $8\mu\text{m}$ maximum thickness, were key to NASA's selection.

Dicronite continues to be used in multiple space-based applications, including NASA's currently operating Mars Explorer Rovers and the Space Shuttle. Dicronite has also been applied in ground-based space exploration. Germany's Max Planck Institute for Astronomy selected Dicronite for both linear and rotational cryogenic (-190°C) actuators in ground-based infrared detectors due to Dicronite's unique ability to lubricate precision tolerances over a wide temperature range. The same proven characteristics that fuelled Dicronite's selection for space exploration have driven its widespread application across many industries, like in the below mentioned examples:

The more friction the faster death of motion

Franke GmbH is a German company which develops and produces antifriction bearings and linear guide systems. The bearings prevail in daily operation in various applications. The special advantages of the bearings are the space saving design together with high load capacities for loads from whatever direction. Application areas of Franke's antifriction bearings are the medical, handling/robotics and clean room technique, the textile and packaging industry.

Looking for a possibility to increase the lifetime of a bearing within a gearbox and hence to comply with the required specifications Franke asked ESA's prime contractor for the Technology Transfer Programme (TTP), MST Aerospace for an intermediation regarding the Dicronite technology so that the contact between Franke and Dicronite was established in spring of 2005 followed by regular placed coating orders up to our days.



Antifriction bearings for a broad range of applications.

Increased life-time by abolition of lubrication effort – no contradiction

AuE Automations- und Einstelltechnik Kassel GmbH is a German supplier for automising industrial manufacturing and assembly processes who set the standards in the design and construction of special machines for the automotive industry and the automotive supplier industry. The offered products and services include handling systems, material flow systems,

adjustment systems for automotive axles, complete vehicles and assembly equipment, along with screwing systems and special equipment.

A control unit of a material flow facility including matching gear rod and pinion gear required a difficult central lubrication in the past, to provide the demanded process and life-time properties. In order to avoid this costly construction, the company looked for a competitive solution and a construction engineer came across Dicronite's technology description through its presentation on MST's technology transfer portal in the beginning of 2002 and asked for the contact details of the donor.

Successful tests conducted in the following two months resulted in a first purchase order in March of the same year. Since this first order, the application of the central lubrication isn't necessary any more because the coated rods and pinions operate without any remarkable maintenance and made AuE a regular customer of Dicronite U.T.E. Pohl.

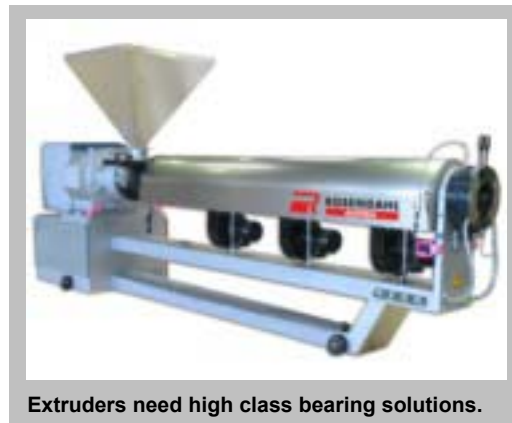


Automation facility with gear rods and pinion gears.

Reliable process in spite of deficient lubrication

Rosendahl Maschinen GmbH - is a world leading turn-key solution provider for the global wire, cable and fiber market, situated in Austria. Expertise ranges from Extrusion and SZ-Stranding to Optical Fiber and Corrugation. The principal activities also offers complete support for consulting and turn-key projects, R&D, engineering, control and software systems, installation and commissioning as well as staff training and maintenance, upgrading and online services.

Aspiring to an advanced wear resistance of grooved ball bearings for the special equipment construction, especially in facilities for the coating of wires and cables, solutions were in demand which allow the bearings to operate even under conditions of deficient lubrication. The contact, established in Autumn 2002 and the successful 3 months test phase were followed by numerous coating orders up to 2005.



Extruders need high class bearing solutions.

Grease in my mouth? No, thanks a lot!

Nouvag AG is a Swiss developer and producer of motors for the dental area. Deploying computer-controlled lathes and manufacturing equipment allows to manufacture high-precision fine mechanical devices and instrument components for the dental and medical technology.

Medical technology has to comply with numerous specifications especially regarding biocompatibility what represents an outstanding and normally insuperable challenge to traditional lubricants. In summer of 2006, the description of Dicronite's friction reducing technology drew the

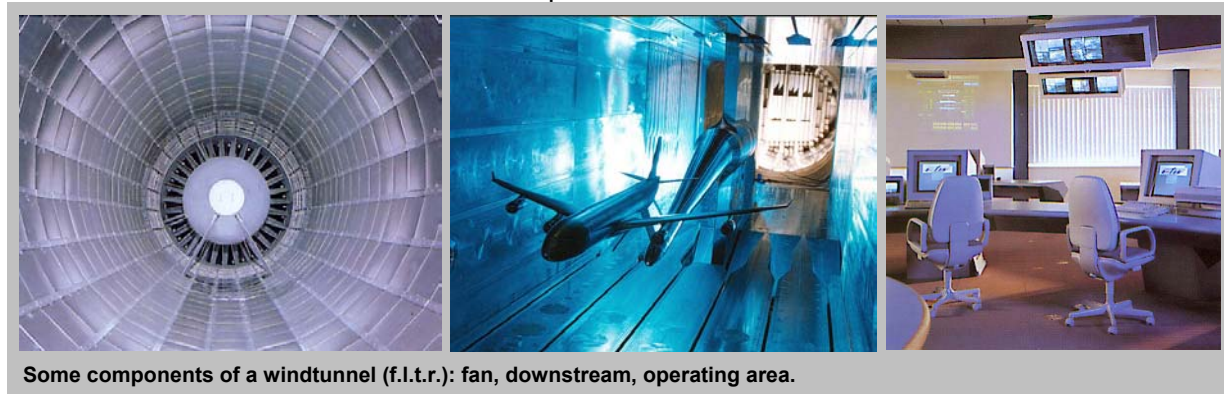


Dental instruments require biocompatible components.

attention of Novvag's design engineers. After a short test phase, Novvag decided to order coatings for small bearings with outer diameter between 5 mm and 15 mm.

Supercooled motion - not the affair of liquid lubricants

The European Transonic Wind Tunnel, ETW, in Germany, is the most modern wind tunnel in the world and a unique test facility for the development of new transport aircraft. The aircraft manufacturers from all over the world use the special features of this high technology facility enhancing the economic and environmental friendliness of their products and attaining the aimed climate protection goals. By applying low temperature operation, this modern wind tunnel is capable of simulating actual flight conditions of modern transport aircraft, defined by the Mach number and the Reynolds number. What this tunnel stands out for is its ability to match the respective high Reynolds number which cannot be done in conventional wind tunnels at ambient temperature.



Some components of a windtunnel (f.l.t.r.): fan, downstream, operating area.

However, if the temperature of the flow is decreased, the viscosity of the gas and the velocity of sound decrease and the density increases. The overall effect of cooling is that the Reynolds number increases rapidly. Thus a pressurized tunnel at very low ("cryogenic") temperatures can provide real-flight Reynolds numbers by virtue of both increased pressure and decreased temperature.

In the ETW the models are not tested in an air stream, as is the case in conventional wind tunnels. Instead, a very cold nitrogen flow with a temperature down to 110 Kelvin (-163°C) is driven through the closed aerodynamic circuit of the wind tunnel, subjected to pressures up to 4.5 bars and passes through the test section at speeds up to the low supersonic range ($M = 1.3$).

These circumstances exceed the operation limits of any liquid lubrication. In the mid of 2002 staff members of the technical department contacted MST Aerospace asking for the coordinates of Dicronite. Systematic tests with coated (axial and radial) cylinder and taper roller bearings were conducted. The bearings had to support a carrier device on which the aerodynamic model was mounted. High precision multidirectional remote position control of the carrier during the aerodynamic examinations carried out by the operator had to be enabled by the supporting bearings. The tests approved the extraordinary properties of the applied coating technology so that regular placed coating orders has been effected up to our days.