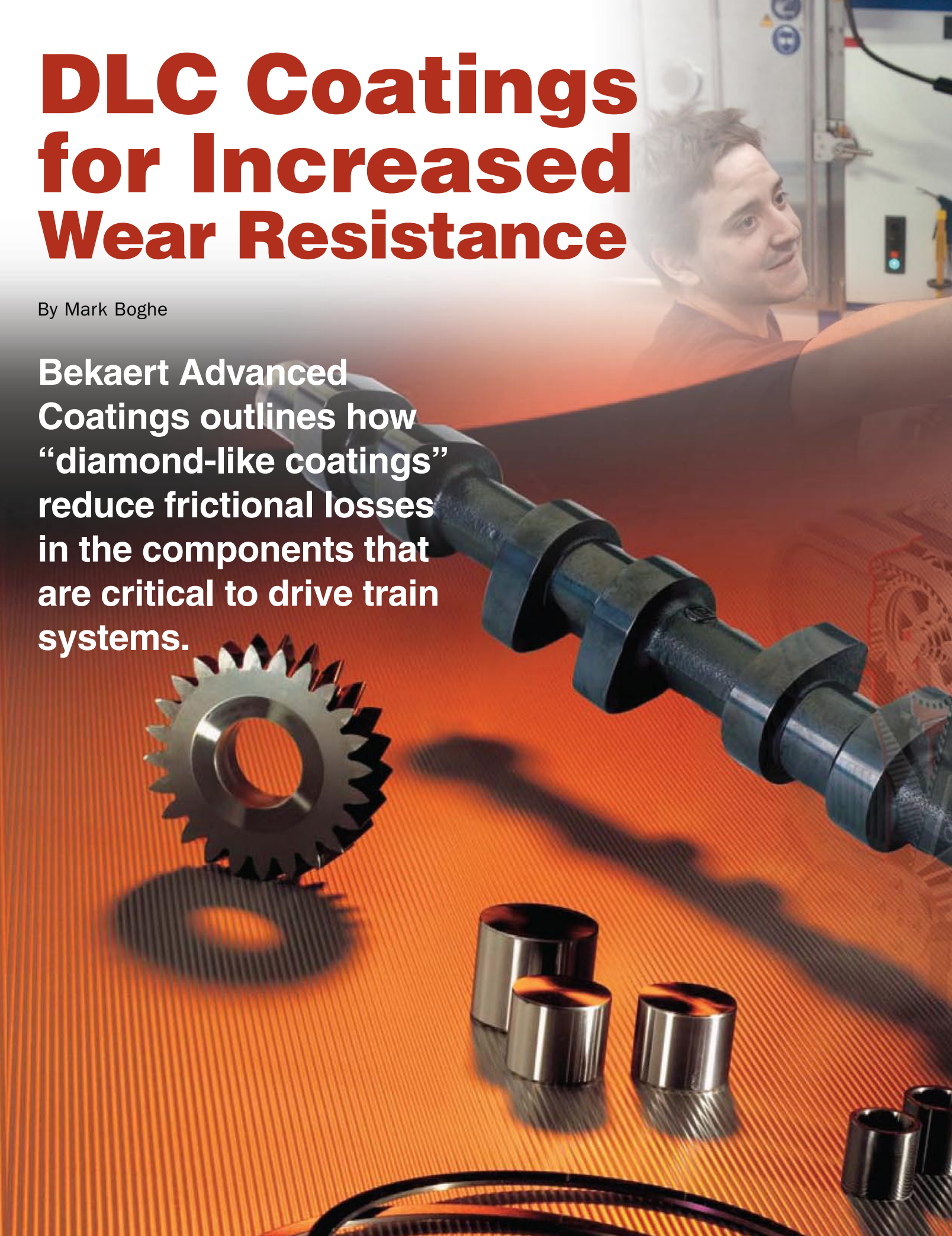
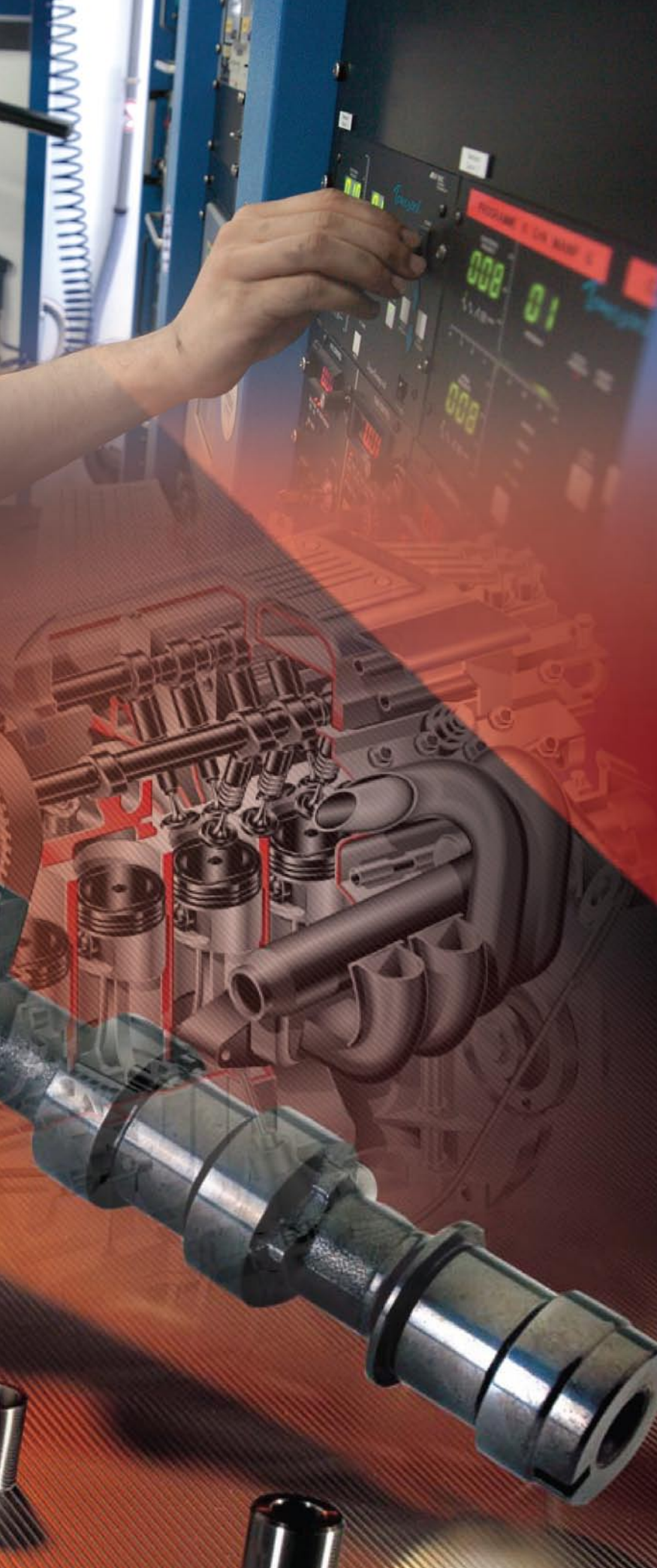


DLC Coatings for Increased Wear Resistance

By Mark Boghe

Bekaert Advanced Coatings outlines how “diamond-like coatings” reduce frictional losses in the components that are critical to drive train systems.





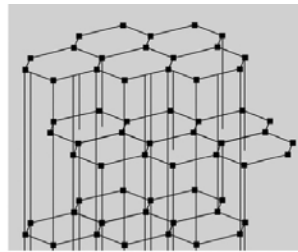
An increasing number of DLC coatings have been brought to market in recent years. The main reason for the success of these “diamond-like coatings” (DLC) is the fact that they combine several exceptional qualities. DLC coatings are inherently self-lubricating and resistant to abrasive, adhesive, and corrosive wear.

DLC coatings are a family of coatings made up primarily of carbon chains in an amorphous structure with sp^2 (trigonal) and sp^3 (tetrahedral) bondings (fig. 1). Sp^3 is the cubic form of carbon known as diamond, compared to sp^2 that is graphite. There are different types of DLC: hydrogen-free (a-C), hydrogenated (a-C:H), or metal-doped (Me-C:H) coatings. These coatings are typically thin-film and are applied during a vacuum deposition process (PVD or CVD).

No other single surface treatment offers this unique combination of properties. Possessing a low coefficient of friction and a low surface energy approaching that of Teflon®, DLC has a hardness greater than that of carbide or chromium nitride (CrN). The result is a coating solution that provides a combination of unique wear and low friction. Depending on the deposition technology used, it can be possible to deposit very smooth coatings, exactly reproducing the surface roughness present prior to coating. DLC coatings are typically characterized by the following properties:

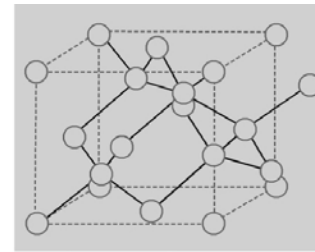
- High hardness, up to 20 GPa (measured by nano-indentation) with the possibility to tailor this hardness as a function of the requirements of the application. This high hardness guarantees a high abrasive wear resistance;
- Good adhesion, better than HF2 following the VDI 3198 norm and a critical value (Lc2) exceeding 25 N in the scratch test (coating deposited on M2 steel for both tests);
- The temperature during the process is between 200°C and 350°C, depending on the application and the component material, in order to avoid loss of parts hardness and distortions of parts;

Crystalline structure of graphite (only sp^2 bonded)



Graphite

Crystalline structure of diamond (only sp^3 bonded)



Diamond

Fig. 1: Sp^2 (tri-gonal) and sp^3 (tetrahedral) structures.

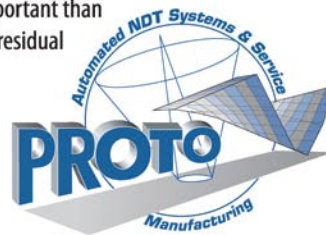
RESIDUAL STRESS MEASUREMENT

LABORATORY & FIELD SERVICES • XRD SYSTEMS • RETAINED AUSTENITE

Reduce costs and improve quality.

Residual stress plays such a critical role in the fatigue life, cracking and distortion of components, that its characterization is more important than ever. In today's tough economic times, X-ray Diffraction (XRD) residual stress measurement can both improve quality and help lower component cost by reducing scrap rates, shortening design cycles and ensuring full component life.

Our comprehensive line of XRD residual stress measurement systems and full service laboratories have the accuracy, speed, technology and knowledge to keep your product perfect right from the start.



LABORATORY SERVICES



FIELD SERVICES



PORTABLE XRD SYSTEMS



LABORATORY XRD SYSTEMS



www.protoxrd.com

1 (800) 965-8378

USA

Proto Manufacturing Inc
313-965-2900
xrdlab@protoxrd.com

Canada

Proto Manufacturing Ltd
519-737-6330
proto@protoxrd.com

Japan

Proto Manufacturing KK
047-402-2703
info@protoxrd.jp

- The typical thickness value is between 1 and 5 μm with a spreading of 15 percent;
- No impact on the original surface roughness.

Besides the properties mentioned here, DLC coatings show very good coefficient of friction values. The DLC coating for the high volume market developed by Bekaert on the basis of its racing experience, Dylyn® Plus, presents a unique, very low coefficient of friction in dry as well as in lubricated conditions. The ball-on-disc (BOD) test allows the determination and the study of the coefficient of friction with varying time, contact pressure, velocity, temperature, humidity, and lubrication factors. Compared to uncoated substrates or to other coatings such as TiN or CrN or other commercial DLC coatings, Dylyn Plus has the lowest available coefficient of friction of about 0.05, remaining low in combination with different lubricants (fig. 2). The results of the BOD tests were confirmed in real engine tests.

In dry conditions the effect of the low coefficient of friction of Dylyn Plus is obvious, but this is not applicable for engine components. In full film lubrication conditions, the effect of the coating is as negligible as that of all the other coatings. But in the boundary or mixed lubrication regimes, as happens for example at a low engine speeds range for valve train components, the decrease of friction from the use of Dylyn Plus is effective.

BENEFITS TO ENGINE PARTS

Dylyn Plus is produced on Bekaert's proprietary large-scale equipment (vacuum vessel larger than 3 m^3 for example)

Coefficient of friction: lubricated conditions	COF typical value	
Test description	Dylyn®Plus coating	
	Load	
	10 N	25 N
80°C; Castrol 5W30 oil; 8000 m; sliding speed: 0.1 m/s; against 100Cr6 steel ball	0.05	0.05

Fig. 2: Test results under different conditions.

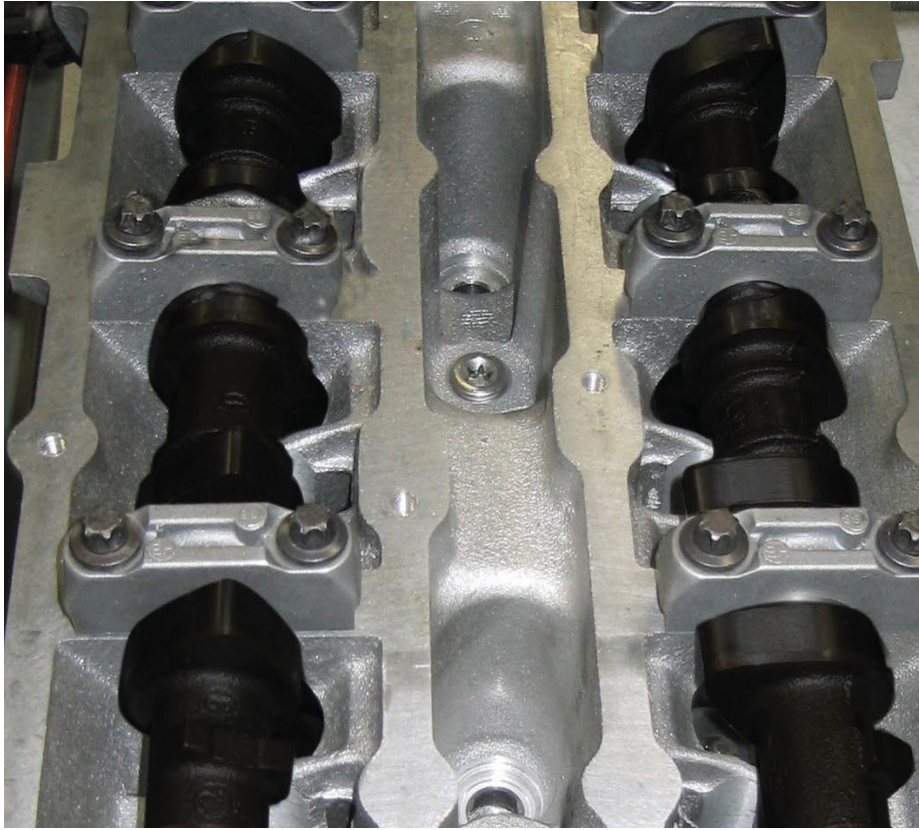


Fig. 3: Coated camshafts.

Bekaert Coating Technologies Applications

Bekaert can provide DLC solutions for the following applications:

- Automotive;
- Drive train;
- Valve train components- due to the low coefficient of friction, Dylyn Plus reduces frictional losses and increases the lifetime of valve train components, i.e. camshafts, lifters/tappets, finger followers, valves, retainers;
- Pistons rings-the high wear resistance of Dylyn Plus coatings in cold welding areas leads to an extended lifetime and an increased reliability of components;
- Wrist pins-Dylyn Plus helps to reduce galling and improves lifetime performance;
- Gears;
- Fuel injection and pump components.

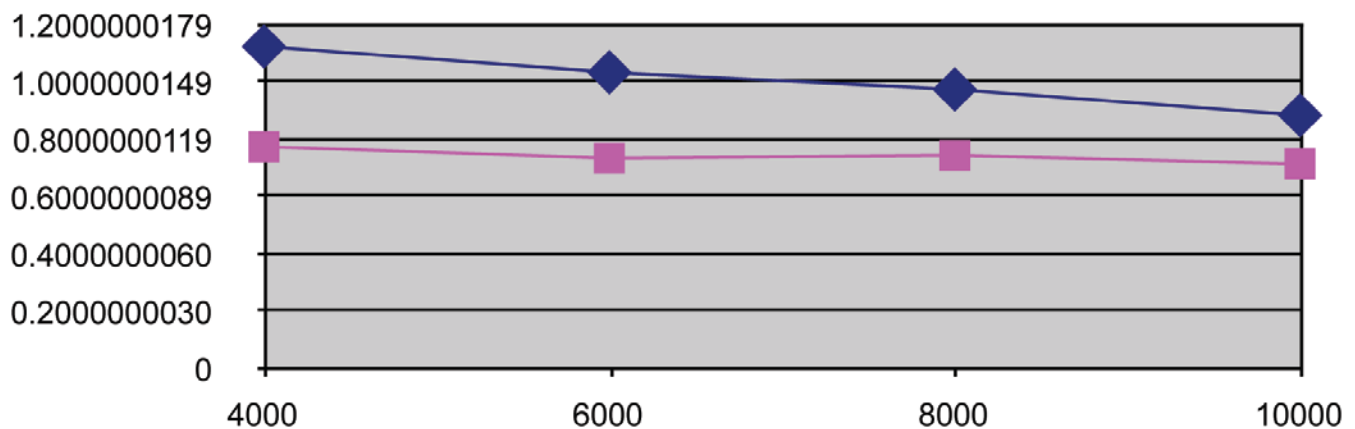


Fig. 4: Reduction friction results.



Fig. 5: Test rigs.



resulting in a high and reproducible quality at a very low cost. Dylyn Plus is therefore well adapted to help the engineer to reduce mechanical friction losses in combustion engines. The focus is first on the valve train components.

Several tests have been conducted to demonstrate the impact on frictional losses in different valve trains. Components like tappets, camshafts and finger followers have been coated with Dylyn Plus (fig. 3).

In these tests, conducted on an electrically-driven test rig (fig. 5), the torque needed to drive the valve train at a certain speed is measured in different configurations. A reference measurement is made with the original cylinder head. Then, after the replacement of some components with coated components, the measurements are repeated. A

THE ANSWER FOR TOUGH FRICTION PROBLEMS



WS2 DRY FILM LUBRICANTS

Tungsten Disulphide & Molybdenum Disulphide

- Professionally bonded in house
- Eliminate galling, fretting and drag
- Extend wear life
- Capabilities beyond practical limits of oils and greases
- Used in ultra-high vacuum, aerospace, medical and more

TIMESAVER LAPPING COMPOUNDS

For Soft & Hard Metals

- Guaranteed not to imbed – will not continue to cut
- Helps to fit bearings, valves, bushings, gears and guides
- Removes tool marks and high-spots
- Precision Finish

PROCESS SL39 - MIL - SPEC - DOD - L - 85645



408.723.0700

270 Hillsdale Avenue | San Jose, CA 95136

Fax: 408.723.0710

E-mail: info@ws2coating.com

www.ws2coating.com

Seamless Rolled Ring Technology

Our Technology

Used by some of the world's most innovative companies.



AJAX supplies quality rolled rings used in the manufacturing processes of some of the world's most innovative companies.

See how Ajax seamless rolled rings drive innovation at ajaxring.com.

AJAX
ROLLED RING AND MACHINE

803.684.3133 | www.ajaxring.com | sales@ajaxring.com

typical set of results is shown in fig. 4. One can observe an average 25 percent reduction of torque by coating the finger followers, with even greater improvements at lower rpm rates (exceeding 30 percent friction reduction). Coating the camshafts in this configuration will typically reduce the overall friction with an additional 10 percent.


Tests with coated tappets show similar results: an average reduction of 15 percent of the torque but a bigger improvement in the lower rpm range.

Besides the reduction of frictional losses as described above, the use of coatings on valve train components also enables car manufacturers to eliminate wear problems. With increasing combustion pressures, EGR systems, suit contamination and new oils, valve train components are increasingly exposed to very harsh conditions that lead to premature wear. The combination of the low coefficient of friction combined with the high hardness to be found in DLC coatings offers an interesting answer to wear problems. Endurance tests prove that DLC coatings form lifelong solutions for these difficulties.

CONCLUSIONS

The application of a tribological coating such as Dylun Plus offers the possibility to reduce frictional losses in the valve train system. Besides the valve train there are other parts of the engine where these coatings could help reduce the frictions; e.g. the piston assembly and other components that benefit from these properties such as gears. One could even consider the use of lighter materials to decrease the moving mass, and thus reduce friction and fuel consumption. Here again, the wear resistance and low friction properties of the coating are the key parameters.

In any case it is necessary to consider the use of DLC coatings at the beginning of the development phase. In order to achieve a successful design, the substrate has to be selected in relation to

the function of the coating. Parameters such as substrate material, heat treatment and surface roughness, are essential factors enabling the coating to reach its maximum performance. 

ABOUT THE AUTHOR:

Mark Boghe is with Bekaert Advanced Coatings in Zulte, Belgium, and can be reached at mark.boghe@bekaert.com. Also go to [www.bekaert.com].

ECONOMICAL SOLUTIONS FOR PRECISION GEAR GRINDING

Riverside Spline & Gear is proud to feature our new Hofler Rapid 900 Gear Grinder, offering the latest in form grinding technology. With AGMA class 14+ capability, and on-board gear inspection, you are assured that your gear will meet all design specifications.

EXTERNAL GEARS

Gear Diameter	50-1000 mm
Center Distance Above Table	360-1360 mm
Axial Stroke (Max)	650 mm
Helix Angle	+/- 45°, 90°
Module	1-25 mm (extendable to 34 mm)
Profile Height	41 mm (extendable to 60-80 mm)
Grinding Wheel Width	60 mm (extendable to 90 mm)
Grinding Wheel Diameter	400 mm
Table Load	3000 kg



WITH OVER 45 YEARS OF EXPERIENCE, IT'S EASY TO SEE WHY INDUSTRY LEADING MANUFACTURERS CHOOSE RIVERSIDE AS THEIR #1 GEAR GRIND SOURCE.

Riverside Spline & Gear Inc.
P.O. Box 340 • Marine City, MI 48039
Phone: (810) 765-8302 • Fax: (810) 765-9595
valerief@splineandgear.com

splineandgear.com

