



Note 103

"Diamond-Like-Carbon" (DLC) surface treatment

"Diamond-Like-Carbon" (DLC) was developed first as a highly-wear-resistant surface coating for steel in the '80s for tool applications and machinery guides and seals. As its name implies it is extremely hard:- Vickers test figures of 3,000 to 4,000 are quoted (989), compared to 850 for nitride steel and 10,000 for real diamond. This reduces greatly the surface friction in rubbing mechanisms compared to untreated parts.

However, initially, DLC was found to be too brittle and having insufficient adhesion where impact occurred such as in 4-stroke piston engine valve gear. Applying himself to this problem in 1993 Jacques Buchaux (founder in 1969 of the French engineering firm JPX which later turned to producing precision motor-sport components) in collaboration with Claude Lory (founder in 1989 of Sorevi, a French firm already specialising in DLC using their patented "Cavidur" plasma-cum-physical vapour deposition process developed in 1985 by Limoges University) developed a multi-layer technique which overcame the brittleness and lack of adhesion of the original coating. This began at the parent metal with a soft, ductile, material and led through stages increasing in hardness to give the required working surface, the combined layers still aggregating only around 4 microns thickness.

A first successful application of the new process was on the inverted-cup tappets of the 1993 Peugeot DOHC 80⁰V10 3.5 L Le Mans engine (978), replacing a previous hard chrome coating (989).

JPX had been supplying PVRS sleeves to Renault for the RS series since 1991 (989) and therefore it seems extremely likely that they applied DLC to such parts from 1994.

By 2004 it was possible to provide DLC coatings (giving a shiny black surface finish) to steel alloys on parts such as :-

- Camshafts; tappets; finger followers; PVRS cylinder bores and their pistons;
- gudgeon pins (allowing deletion of bronze bushings); and gears.
- Also to Ti-alloys (valve stems).
- Also to Al- and Mg-alloys.

It was stated by Buchaux that it would have been impossible to run 2004 Grand Prix valve gear speeds (MVSP around 10 m/s) for more than a few minutes (even in a well-lubricated environment) without DLC* but with it there is no limit. Apart from the life extension there is a reduction in the friction power losses. Ref. (1024) states that in a MotoGP motor-cycle racing engine a gain of 8HP was made by coating the cams and followers with DLC – this would represent +3% or more of power output.

Development work was in hand in 2004 to apply DLC to piston rubbing surfaces (978).

The sources do not indicate what DLC coatings cost.

*In 2000 at the Indianapolis GP circuit, which permitted a wide-open throttle for 22 seconds along the pits straight, a longer time than any other venue, Hakkinen's Ilmor-Mercedes FO110J engine blew up on this section at 1/3rd distance after an acknowledged finger-follower coating (almost certainly DLC) adhesion failure (700).
