WHITE PAPER

MERCEDES GP PETRONAS Formula One Team

Racing to the Championship With PerkinElmer

TECHNICAL PARTNER OF
MERCEDES GP
PETRONAS
FORMULA ONE™ TEAM

Laboratory testing and analysis was introduced into Formula 1 Motor Racing in the early 1990s. At that time it was used primarily in a "forensic" role solving faults and enabling counter measures to be put into place. A more sophisticated second phase worked to improve reliability by writing the techniques followed in the Teams' R&D laboratories into their manufacturing and condition monitoring processes. We are now arguably in the third phase of laboratory testing; the development of expert systems which allow us to fully understand the condition of the various parts in service and run the cars as close to the limit of performance without risking failure. Within the MERCEDES GP PETRONAS team something like 90% of the reliability testing is carried out either in computer simulation, laboratory testing and the Power Train Systems (PTS) Dynamometer.

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For the Better

Ensuring the integrity of composite structures with PerkinElmer Instruments

Figure 1. Suspension wishbone. Metal end parts are bonded to the main composite structure using an adhesive which must be properly cured to avoid failure, this is determined using DSC.

Much of the chassis of a modern Formula 1 car is made from multi-material structures based primarily upon fibre reinforced polymer composite materials. Many of these structures are highly loaded and safety critical. We operate a "zero defects" total quality management (TQM) process throughout the team, enabling full traceability from raw materials through to obsolescence using our ERP. Parts are required to be managed and conformance guaranteed throughout their life wherever they are in the world and under whatever service conditions. PerkinElmer equipment is used at all stages in the process whether it be screening of materials, quality checking during manufacture or condition monitoring in service.

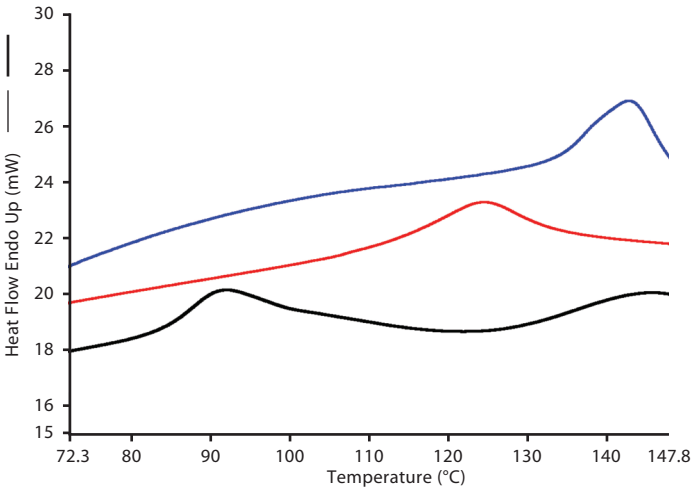

Figure 2. Effect of progressive curing on the glass transition (Tg) of a composite measured using DSC.

The lower (black) trace shows an under cured material. The Tg is seen as the initial step in the baseline which in this case is followed by further curing. In more highly cured materials (the red and blue traces) Tg shifts to higher temperatures. This means that the extent of curing of the material can be determined from measurement of Tg by DSC.

It is imperative that the structural integrity of composite parts and adhesive joints is proven. The PerkinElmer DSC enables the MERCEDES GP PETRONAS team to establish quality of composite and adhesive cures carried out during component production. Small samples taken during each stage of assembly are supplied to the lab by composites technicians. Inspection of the DSC plot allows us to determine that all of the mixing and cure parameters are within specification. Each operation carried out by the composites department is checked and the information fully documented within the ERP. Inspection of this type is carried out on 100% of the parts produced, at every stage at which value is added to the component. Indeed so much testing is carried out that an auto sampler is required to improve throughput. DSC is so critical to our 24/7 operation that there is a second DSC always ready should the prime instrument have a malfunction or its workload become too high. On rare occasions, a sample will fail the DSC test. This initiates a series of procedures with the aim of correcting the fault. In such situations the component is "quarantined" pending further action to rectify the issue which may consist of a re-cure, reworking the part or scrapping and replacement depending upon the severity of the defect.

The PerkinElmer DMA is used for checking the quality of composite structures for their mechanical properties with respect to temperature. A temperature scan provides the necessary results (storage modulus, loss modulus and peak tan delta) to determine the suitability of the part for its proposed use. The team also uses the DMA with quartz probe and sample holder to determine the thermal expansion of temperature critical materials.

Sporting Regulations and used oil condition monitoring

The Fédération Internationale de l'Automobile (FIA) Sporting Regulations requires that gearboxes must be used on the race car for four races. This ruling places a direct emphasis upon the requirement for a method of periodically analyzing the gearbox for an indication of deterioration. One of the methodologies employed by the MERCEDES GP PETRONAS team is to study used transmission oil for traces of wear metals and equate that to the "health" of the gearbox. To achieve this we utilize the Optima 5300V Inductively Coupled Plasma (ICP) to analyze samples of gearbox oil taken from the PTS dynamometer and correlate these samples to those taken trackside. By plotting the 'normal' wear of the gearbox internals and mapping the increase in wear metals, it is possible to build a profile of what levels of wear are considered acceptable and not race critical. When trackside samples fall outside of these levels and an increase in wear metals is greater than expected then a decision is to be taken whether to change the gearbox or not. This decision is critical and a gearbox change before the four race limit will result in a 5 place penalty on the starting grid.

In conjunction with the ICP analysis, the MERCEDES GP PETRONAS team use the Spectrum 100 Fourier Transform Infrared (FT-IR) spectrometer with the automated Oil Express system to check for the presence of worn seals and other non-metallic debris present in the used oil. The Spectrum 100 is also for fault finding. It is the instrument within the lab that is used for the widest range of activities, which can vary from determining clutch plate contamination to testing cooling system flush cycle rinse outs to ensure that the radiators are properly cleaned. Small samples of fluids are often brought to the Material Testing lab, which are suspected to be contaminated. The Spectrum 100 is used in conjunction with a database of reference spectra, built up by the team, to establish what, if any, contaminants are present. This information is used to help reduce the number of defects which could lead to accidents or race stopping faults.

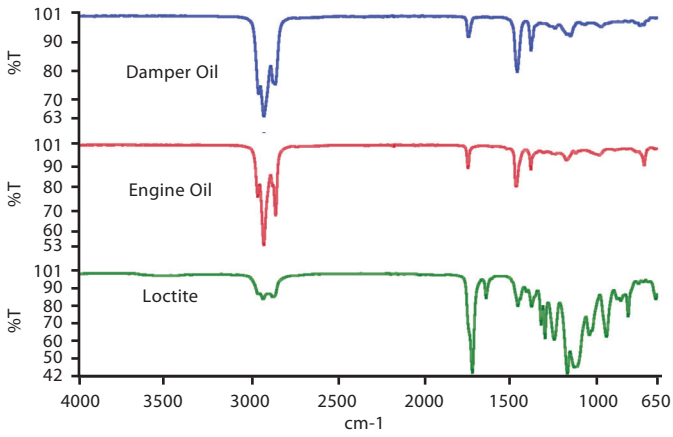

Figure 3. Spectra of three common materials used in the cars development. Spectral variation is a good indication that the material has changed highlighting materials or processes that may advance or impair the cars performance.

Article by: Prof. Gary Savage

PerkinElmer Life and
Analytical Sciences
Chalfont Road
Seer Green
Beaconsfield
Bucks
HP9 2FX
www.perkinelmer.com

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