Micro Hardness Determination of Diamond Like Carbon (DLC) Coating on a Steel Substrate

1. INTRODUCTION

Diamond and diamond-like carbon (DLC) thin films and coatings possess a number of unique and attractive material properties that are unattainable from Si and other materials. These include high values of Young's modulus, hardness, tensile strength and high thermal conductivity, low thermal expansion coefficient combined with low coefficients of friction and good wear resistance. As a consequence, they are finding increasing uses for providing wear and friction resistant coatings for many component parts within the industries such as Automotive, medical and tool manufacturing.

Measuring Diamond Like Carbon (DLC) coatings for hardness has proved almost impossible in the past with the use of classical optical methods of measurement due to the coatings being very thin (approx. 4-5μm). These coatings are also very hard so measuring Vickers hardness with classic optical hardness devices are generally inappropriate due to the inability to measure the diamond indent accurately.

2. INSTRUMENTATION

The instrument used for this exercise is the Fischerscope HM2000S.

3. MEASURING PRINCIPLE

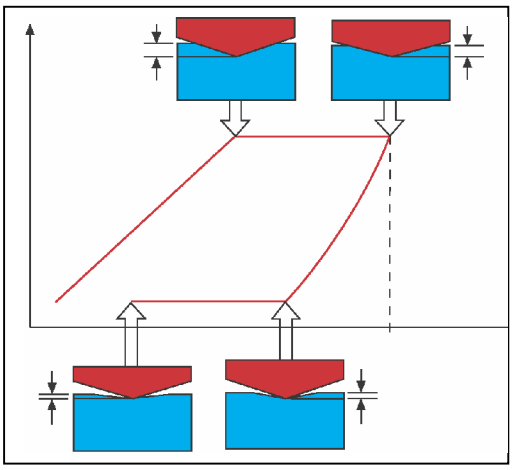
The Fischerscope HM2000S a load/indentation depth method according to ISO 14577-1. Using an intelligent load cell with user defined final load value, the Vickers indenter is continuously pressed into the material test piece with an increasing test load, and then unloaded. The respective indentation depth is measured at the same time. Taking into account the geometric relationship between the indentation depth and shape of the indenter, this measurement produces the Martens Hardness HM (HM = F/A where A represents the surface of the penetration. From this a variety of material properties and characteristics can be automatically determined

including conversion of the direct measurement of indentation hardness (H_{IT}) into Vickers (HV).

4. DISCUSSION

This report covers the theory and practice of measuring the hardness (HV) of Diamond Like Carbon coatings on cylindrical automotive piston pins. The measurements are required to be taken directly onto the finished surface of the pin. The measurement must be a direct measurement of the coating without any interference from the underlying substrate. In order to reliably determine the hardness of a layer, the indentation depth must not exceed 1/10th of the total layer thickness in accordance with ISO 14577-1. The Fischerscope HM2000S is optimally suited to this application such that the user can predefine the load and the maximum depth of penetration into the test sample giving full control of the test procedure.

Fig.1 shows schematic presentation of measurement cycle



5. TEST PARAMETERS

The table below shows the test parameters used:

Load (mN)	Time (Secs)
20	30

6. RESULTS

Tables 1 and 2 shows results taken from 5 measurements on each sample.

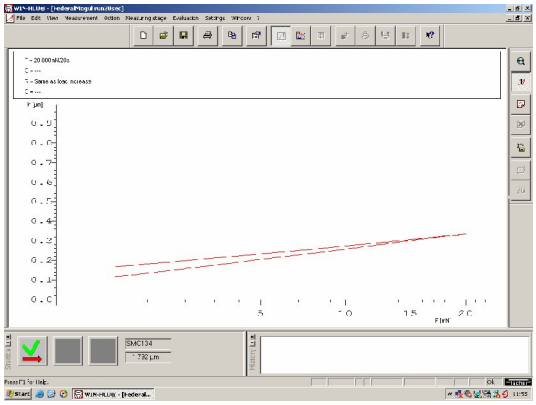
Table 1

Sample 1		Sample 2	
No.	HV	No.	HV
1	8089.8	1	1968.6
2	7842.4	2	1741.4
3	8107.0	3	1794.4
4	8023.2	4	1778.5
5	8042.6	5	1880.7
%V	SD	%V	SD
1.54	123.58	5.40	99.75

Table 2

Sample 3		Sample 4	
No.	HV	No.	HV
1	6322.3	1	1188.2
2	6613.8	2	1247.6
3	6284.0	3	1208.8
4	6253.0	4	1166.8
5	6526.8	5	1362.2
%V	SD	%V	SD
2.51	160.38	6.26	77.28

Fig.1 shows graphical representation of load/unload curves for samples 1 and 2



7. CONCLUSIONS

It can be seen from the results that the reproducibility of measurements from this instrument is exceptional keeping in mind that the measurement is totally dynamic without the need for visual inspection, and in any case visual is not valid for measurements of hard coat materials at the required low loads.

Using the Fischerscope HM2000S for this application is unique in itself in that the user has full control over the measurement in terms of load and time and therefore the instrument can be fine-tuned for each individual application. As mentioned previously, Micro Hardness measurements for very thin, hard coatings are almost impossible with conventional equipment due to the optical nature of these systems and the difficulty in reading a diamond indent at such low loads. The HM2000S makes easy work of these applications, this instrument being the only choice for flexibility and capability in these areas.