# STATISTICAL CORRELATION BETWEEN THE HARDNESS OF THE COMPOSITES AND THE APPLIED LOAD

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**Abstract**: *Composite materials are used for their properties. They have properties from both materials which they are done: matrix and bond material. Because of the liaison of the two elements the composite materials get important properties such us: resistant to abrasion, dimensional stability, resistant to fatigue, resistant to high temperature. In this paper it is done the determination of the hardness of the composite material, from statistical point of view, influenced by the deposits thickness and the application of a wide range of loads.*

**Key words**: hardness, distribution, load, thickness.

## 1. INTRODUCTION

The rapid progress of technic and technology was due, last but not least, to the evolution of the used materials. Product performance is closely related to the quality of the used materials and their properties are an important factor in their choice.

The development of science and technology has led to the design of new materials based on already existing and known materials [1], the discovery of new materials to meet new requirements [2] and the development or improvement of techniques for obtaining them. All of these have also led to their use in many sectors of activity [3].

A composite material occurs by combining two or more homogeneous macroscopic materials whose properties and structure are often different and which, by combining the individual qualities of the components, form a heterogeneous material with improved overall performance.

Due to the remarkable properties they have, composite materials have a wide use in many sectors of activity: in the automotive industry (fuel system, brake system, bodywork, etc.), in electrical engineering and electronics (for circuit boards integrated insulation of high and low pressure polyethylene cables, satellite transmissions etc); in road transport (in the manufacture of automotive liners, vehicle filters, etc.); in air and space transport; in shipping; in the medical field (transplants, prostheses, cardiac implants, blood clotting substances, in orthopedics, for the creation of artificial tissue in case of severe burns or for the replacement of organs (cardiac valves, artificial arteries, artificial lungs, bone implants) construction (exterior walls, partitions, roofs, doors, furniture etc), chemical industry (pipes and receptacles manufacture) [4] etc.

Addition the metallic layers of different thickness on the surface of the composites materials help to improve their properties. The thickness of the deposition offer to the composite material the possibility to resist under a wide range of loads applied on their surface. The purpose of this paper is to study the influence of the thickness of the deposited layer on its mechanical and adhesion properties after applying loads perpendicular to the surface of the layer. The research will be done on the P20S80 samples whose thicknesses vary and the loads required to perform the hardness tests are applied perpendicular to the surface of the layer.

## 2. EXPERIMENTAL PART

In the paper is presented the hardness of the composite materials type Ni-P and Ni-P / SiC [5,6]. Thus, for Ni-P / SiC composite materials obtained from constantly contained electrolytes of acid phosphorous (20 g/l $H_3PO_3$)) and the constant content of SiC particles (80 g) having a variable layer thickness (5 µm 10 µm, 30 µm, 60 µm), the hardness decreases when the applied load increases. The small and medium loads applied causes a similar evolution of hardness, they show a grower up to a layer thickness of 27,66 µm (the hardness having the maximum value above 588 HV at the 15 g load), after which the curve is a descending evolution at a thickness of 59 µm and a maximum hardness of 673 HV.

For 1000g and 2000g loads, the hardness increases steadily from 106 HV for the 1kg force and 102HV for the 2kg force at a layer thickness of 5µm to a maximum of 476HV for 1kg and 331HV for the 2 kg apply at the same thickness of 59 µm. This demonstrates that when applying small and medium loads the resulting hardness is that of the layer, and at the high loads of 1000g and 2000g, the substrate intervenes so that the hardness obtained is the hardness of a composite material formed by the substrate and deposition. The hardness tests performed showed that the hardness depends on the applied load and the thickness of the deposited layer. When applying loads of 1000g and 2000g, the hardness of the layer decreases significantly and thus the support intervenes with a higher percentage in the measured hardness value. Therefore, the hardness measured is no longer the character of the intrinsic hardness of the layer, being the hardness of a composite material consisting of substrate and deposition. Statistical programs may be used for data processing which correlates experimental and statistical data [7, 8].

The hardness was measured from the statistical point of view using skewness and kurtosis coefficients. The skewness coefficient shows to what extent the normal data flow curve moves away from the middle, moving to the left side of the graph or to the right side of the graph. The kurtosis coefficient refers to the height of the curve as compared to the normal curve so it can be leptokurtic and platykurtic distributions on the graph [9].

For samples containing SiC particles (P20S80-5µm, P20S80-10µm, P20S80-30µm, P20S80-60µm), five hardness determinations were performed for each applied load and the mean value of these hardness was considered.

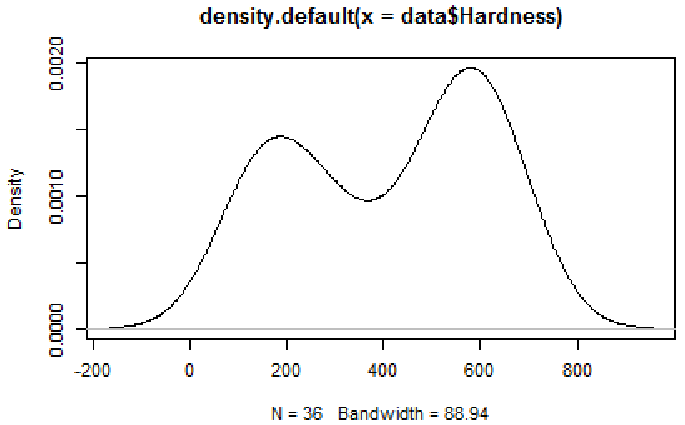


Fig. 1 Density of probability of the composite

```
> s<-sd(data$Hardness)
> s
[1] 202.3644
> m<-mean(data$Hardness)
> m
[1] 412.2111
```

Fig. 2. Mean and standard deviation

```
> summary(data$Hardness)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  101.2   197.6   467.2   412.2   597.9   688.3
> skewness(data$Hardness)
[1] -0.2235593
> kurtosis(data$Hardness)
[1] -1.59074
```

Fig 3. Skewness and kurtosis coefficients

The skewness coefficient has a value of -0,22, which shows that the analyzed distribution is tilted to the left, having more extreme values to the right. The kurtosis coefficient is -1,59, so there is platykurtic distribution, more pay than a normal distribution with values dispersed over a larger range around the mean. The results obtained from these tests show that the hardness of the deposits incorporating silicon carbide particles are higher than the hardness of the NiP deposition.

The dependence between the layer hardness and the applied loads is similar to the variation in the hardness of the deposits depending on their thickness and the load applied to the samples that do not incorporate silicon carbide particles.

For the same thickness of the layer, the hardness obtained decreases as the applied load increases.

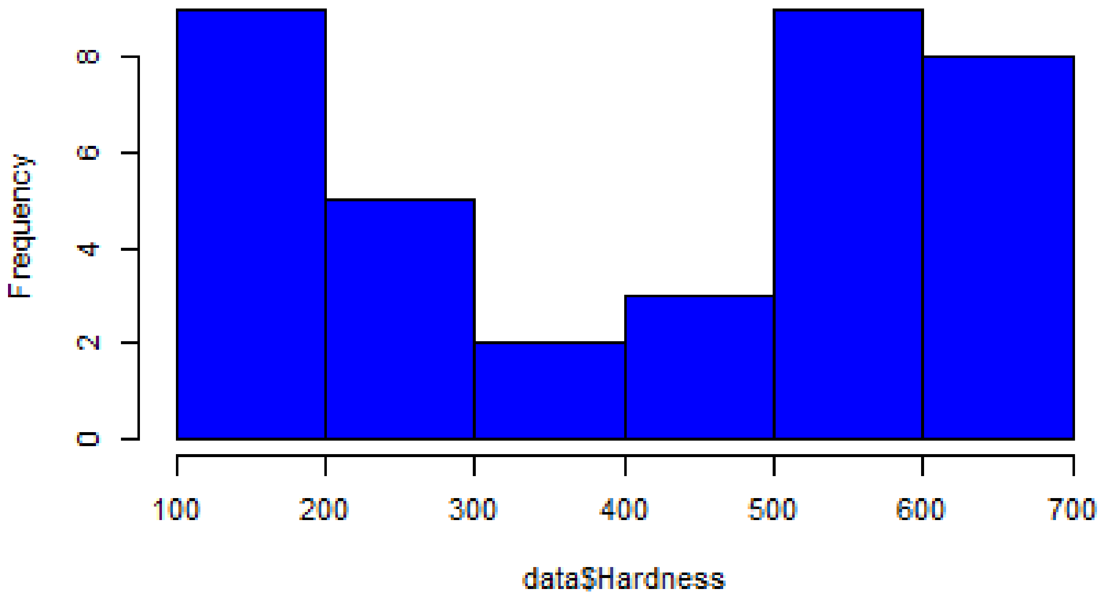


Fig. 6 Histogram of the Hardness of the composite

From the histogram presented above we can observe the frequencies of the obtained hardness. The highest frequency is registered for two ranges of values, six between 100 and 200, and six between 500 and 600. At the opposite side, values between 300 and 400 are appearing just twice.

## 3. CONCLUSIONS

The hardness of the composite surface depends of the layers thickness and also of the applied load on the layers.

As we saw form the graphs, the hardness distribution varying to the left or to the right part of the graph (different values – min and max) for every type of layers according with the applied load.

The significant decrease in hardness in the use of large loads shows that in this case the substrate has a growing weight in the measured hardness value.

It can thus be said that the hardness measured is no longer the intrinsic hardness of the layer, but becomes the hardness of a composite material consisting of substrate and deposition.

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