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Pages 1-2 and 2-15 of Garcia-Aranda thesis

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Thermomechanical study and numerical modeling of Usibor 1500 hot stamping

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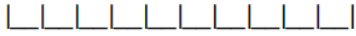
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Thermomechanical study and numerical modeling of Usibor 1500 hot stamping

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2.5 Mechanical properties in cold state

Physical properties as a function of temperature were provided by Sollac for 20Mb5, which has a chemical composition very similar to Usibor 1500 [5]. Young's modulus as a function of temperature, as well as thermal conductivity, heat capacity and density, for 20Mb5 are shown in Figures 2.3, 2.4, 2.5 and 2.6.

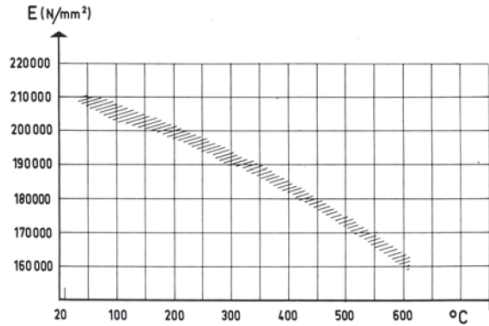


Figure 2.3: Progression of Young's modulus [5]

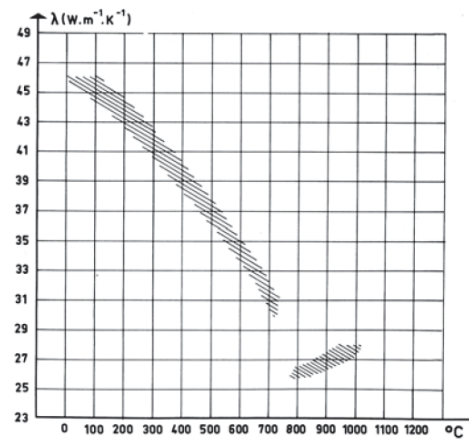


Figure 2.4: Heat conductivity [5]

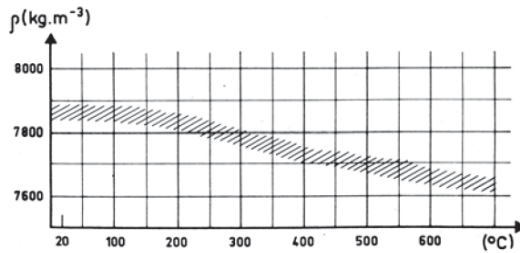


Figure 2.5: Density [5]

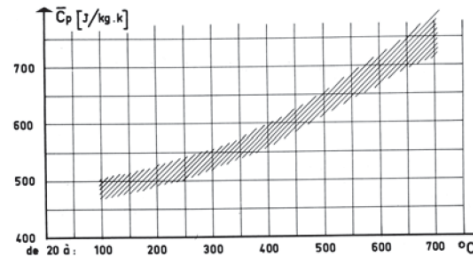


Figure 2.6: Heat capacity [5]

2.6 Characterization of the microstructure as a function of the heat path

2.6.1 Introduction

A study of the microstructure and coating progression was carried out at CEMEF. Tests were carried out under two cooling conditions: air-cooled and water-quenched. Coated Usibor 1500 sheet metal samples with a geometry of 50 x 50 mm and a thickness of 1.2 mm were first brought to 900°C for 5 min for austenitisation. The microstructures studied are compared with those in the initial state, i.e. without heat treatment.

Once the tests are carried out, the polished samples are etched for 10 seconds with Nital 2% (nitric acid and ethanol) and observed under an optical microscope.

Microhardness tests were carried out; these tests allowed the material's resistance to penetration to be measured. A series of factors must be taken into account in this type of testing, the main ones being: elastic and plastic deformations, friction, the geometry of the indenter (in our case, a pyramid), its mechanical properties and the load applied. Vickers hardness is used for testing, the properties of which are described in Figure 2.7. For our tests, we used a weight of 200 gf for 15 seconds; each hardness value is given as the average of 5 indentations.

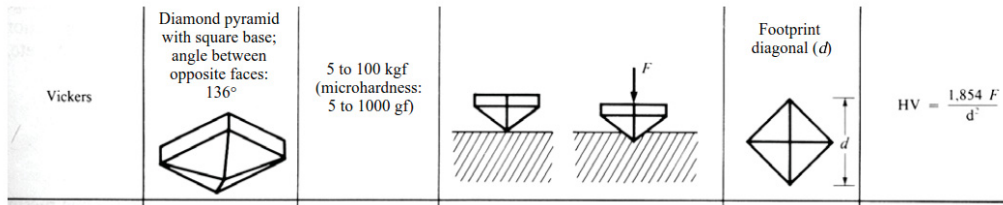


Figure 2.7: Schematic diagram of the microhardness test

2.6.2 Microstructure and initial coating

Figure 2.8 shows the ferrite/perlite structure of the material on delivery: grain size is between 5 and 10 μm , with the perlite (black grains) oriented in the lamination direction. The cross-section (Figure 2.9) also shows the coating, which is 30 μm thick.

Lamination $\longrightarrow$

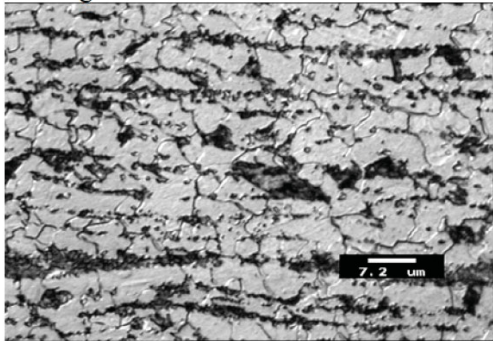


Figure 2.8: Ferrite/perlite structure

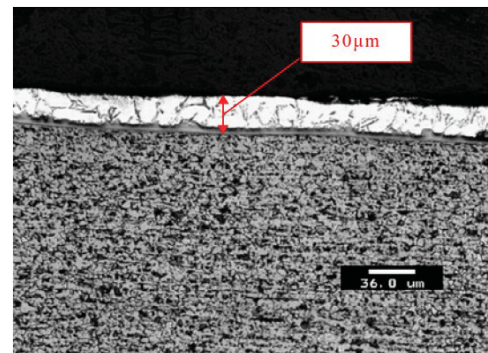


Figure 2.9: Observation of the coating

2.6.3 Microstructure and coating after air cooling of the sheet metal

The microstructure observed in Figure 2.10 is that of bainite formed during slow cooling. After heat treatment, the coating (Figure 2.11) increases in thickness to 47 μm following the heat treatment. One notices the appearance of cracks, probably due to cooling.

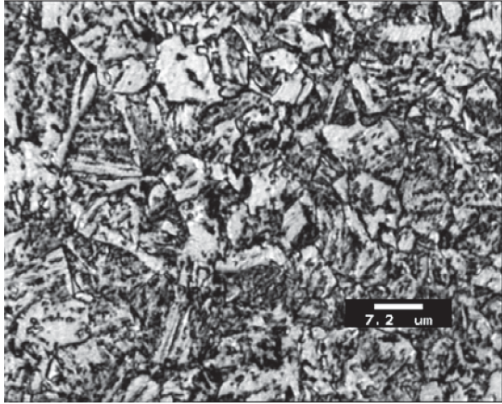


Figure 2.10: Bainitic microstructure

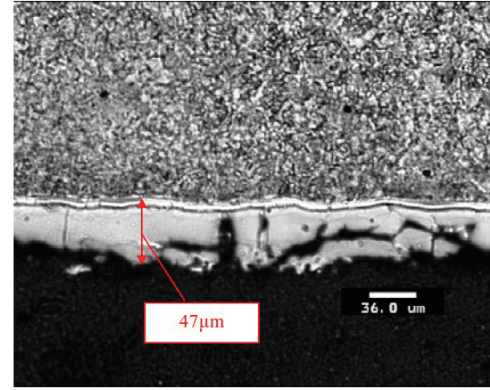


Figure 2.11: Coating thickness

2.6.4 Microstructure and coating for a water-quenched sheet metal

Figure 2.12 shows the martensitic structure obtained after water quenching. Cracks in the coating can be seen in Figure 2.13.

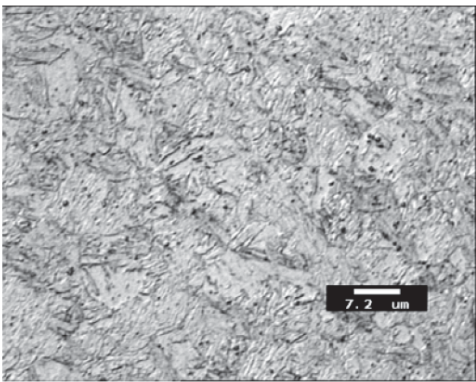


Figure 2.12: Martensite microstructure

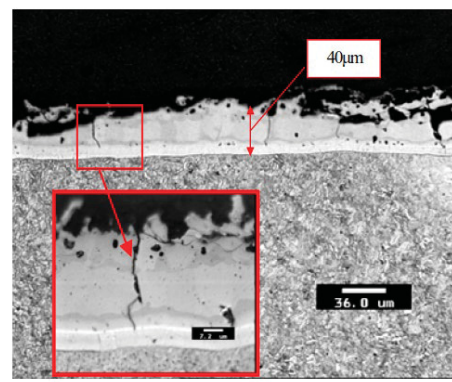


Figure 2.13: Cracking of the coating

In all cases, the grain size is very small (a few μm) and as the minimum measurement of the pyramid is 30 μm , the measurements made are therefore of the overall microhardness of the sample.

2.6.5 Microhardness measurements

The results of the microhardness measurements are summarized in Table 2.3.

State of the sheet metal	Microhardness (HV)
initial	181 ± 3
air-cooled	242 ± 3
water-quenched	431 ± 7

Table 2.3: Microhardness measurement results

One notes the influence of the heat treatment, which increases the sheet metal's hardness, and the role of the cooling method: the structure progresses from ferrite/perlite to bainite or martensite.