3MA NDT Investigation for Process Monitoring and Quality Control in Press Hardened Steel

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Abstract —**The press-hardening or hot stamping is an innovative production of car reinforcement structure. These parts served for the improvement of crash performance and passenger safety, therefore there was a hard necessity to control the crash material characteristics, such as hardness, strength and the other parameters related to microstructure (coating, diffusion layer). In this case of press hardened steel (PHS), the materials are adjusted during the forming process not in the production process. Therefore, the part has to be tested during the press hardening with arbitrary sampling. Destructive measurement for this application remains not sufficient and time consuming and too expensive in order to be used for an accurate process monitoring.**

Fraunhofer IZFP institute offers more accurate and less time consuming method; 3MA NDT system [1-2], is designed and optimized for studying several material grades and geometries. Furthermore, 3MA system provides a complete characterization of the material at different depths and access to the targets in few second with good accuracy.

Index Terms—Press hardening steel, 3MA Non-destructive testing, destructive reference: Rm, Rp, A50, FEM modelling approach.

I. Introduction

For hot forming steel, most of sheet blanks are pre-coated with protective area in order to avoid decarburization and oxidation. The widespread of protection is an AlSi layer preventive scale formation on the steel during the direct hot stamping operation. During the heating of the coated blank, the steel diffusion process from coating substrate interface area to the coating surface is thermally activated. The AlSi has a melting point around 600C; however due to the presence of Fe in the substrate, an AlFe alloy with higher melting point immigrate to the interface with based material and reaches the surface. In order to insure accurate weldability during the post processing, it is necessary to control the thickness of the diffusion layer. According to some studies [3] the total layer thickness (diffusion (DLT) + coating layer) should not exceed 40µm during the austenization in the furnace. The total layer thickness (TLT) varies with temperature and the time in oven illustrated in Fig.1. The monitoring of the total layer thickness remains important to insure an accurate weldability and paintability. For the second hand, other parameters such as hardness, strength and elongation request also control in order to insure good ductility.

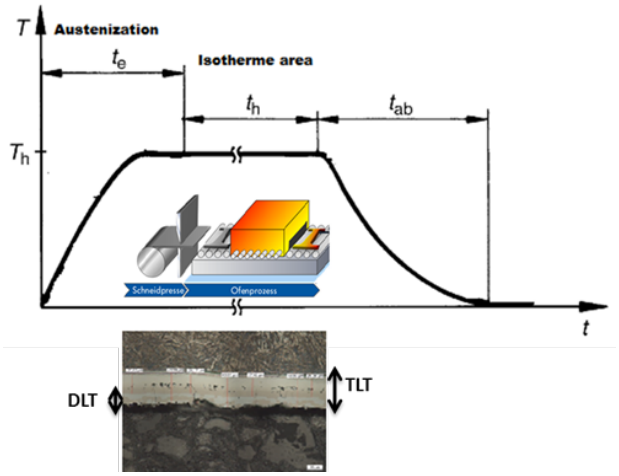


Figure 1: diagram of autenization

The 3MA Micro-magnetic Multi-parameter Microstructure and stress Analyser [4] is applied and validated in press hardening steel. It is based on methodical and operative combination of 4 electromagnetic testing modes (fig2), namely Barkhausen Noise (BN), harmonic analysis of the tangential magnetic field strength (HA) and multi-frequency eddy current analysis (EC) and incremental permeability (IP).

Figure 2: 3MA in inspection situation

This methods offer a more comfortable measurement by the investigation of the material at different depth with optimized set up parameters. The geometric spherical poles

of the yoke leg allow insuring contacts with non-canonical geometry of the part and minimize the stray field effects.

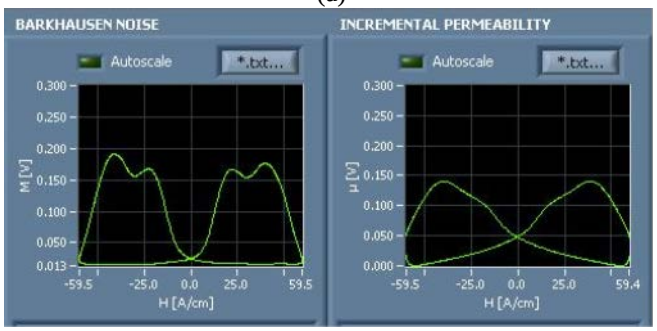
II. Calibration

In case of new 3MA application, i.e. new materials, part geometries, etc. The correlation between mechanical properties (target quantities) and magnetic properties (3MA measuring quantities) is a priory unknown. For each target quantity a so-called calibration function, which describes the mathematical model of the correlation between 3MA outputs and reference values (targets), has to be determined first.

The first step of calibration procedure consists on the collection of the 3MA measurement on calibration parts, i.e. complete parts from serial of production or sections from them. After that the samples are submitted to destructive values in order to define target quantities such as hardness, strength. The measuring data are stored on a database and analyzed with statistical methods. Based on this, calibration function is defined. Often linear combination of measured quantities is used for the model. But also other models based on pattern recognition have been used. Statistical methods, like regression analysis is used for the determination of calibration functions giving the best approximation of the measured values and the targets. The precision of 3MA is linked to the reference values.

The fig 3 illustrates the comparison of coated material (AlSi) with different hardness: hard (a: 488 HV) and soft (b: 231 HV) [5-6].

(a)



(b)

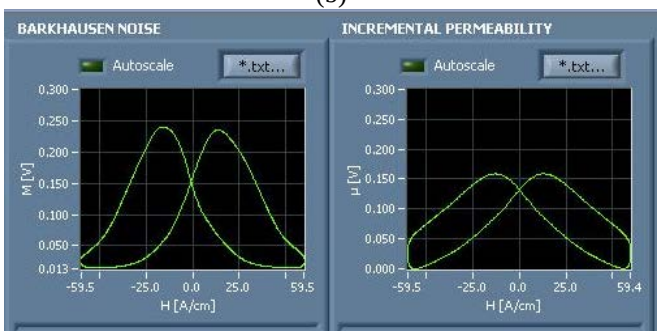


Fig. 3. BN and IP signals for coated hard and soft 22MnB5

By this way, data from microstructure could be characterized such as the thickness: total layer and diffusion layer. It was also observed that the thickness of the samples has an influence on the 3MA signals.

Then, separated calibrations for specific thickness have proved to be beneficial.

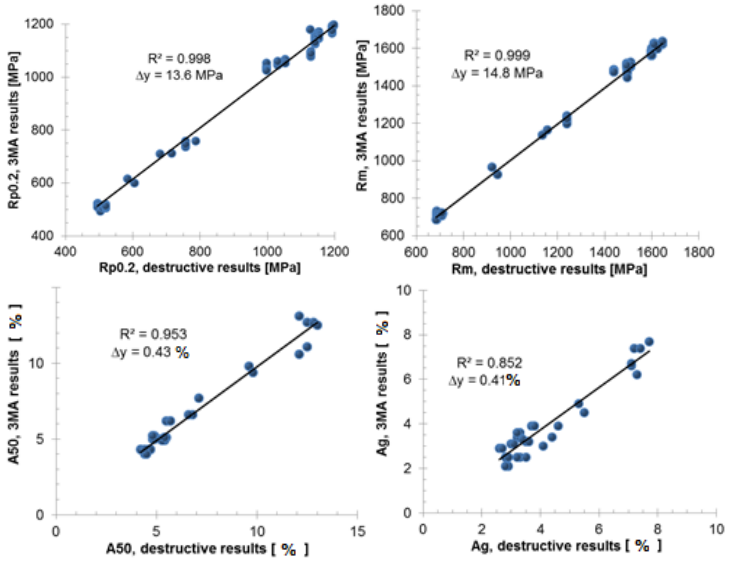


Fig4: Validation of calibration on different targets

So far 3MA system operates in manual mode. The PHS steel is characterized via more 6 targets, some of them are intrinsic properties others describes the microstructure. 3MA offers good correlations and precisions in few seconds.

III. References

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