STUDIES ON INCREASING THE DRILLING/PUNCHING TOOLS DURABILITY BY APPLYING HOT THERMO-CHEMICAL TREATMENTS

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Abstract: The tools for processing by hot plastic deformation are exposed during their use to some impact load conditions extremely complex and rigid featured by-very strong working stress. The alloyed steels 12% Cr containing about 1.5% C and additionally alloyed Mo and V present the peculiarity that as you increase the temperature of heating for hardening, it increases the proportion of residual austenite, the resulted hardness after quenching varying according to a curve with variable maximum.

KEY WORDS: tools, thermo-chemical, hardness

1. STEELS FOR TOOLS OF HOT PLASTIC DEFORMATION

The tools for processing by hot plastic deformation are exposed during their use to some impact load conditions extremely complex and rigid featured by-very strong working stress whose values are close to the yield strength of the steel used for manufacturing the stamping die:

- high heating temperatures, superior or close to those critical ones of transfroming in solid phase of the steel used to the tool manufacture;
- the cyclic actions of the mechanical stress generated by the deformation forces, of the thermal stress caused by the conditions in which it was done the heating and cooling of the structural tensions caused by the phase transformations;

In the mentioned conditions, the hot plastic deforming dies are deteriorated due to the following reasons:

1. as a result of the plastic deformation or of the brittle fracture according to the size , direction and characteristics of the operating voltage and the temperature at which the deformation occurs;
2. due to the formation of a network of cracks on the working surface of the stamping die;
3. as a result of the strong wear triggered by the chemical interaction at the liquid (semi- liquid) stamping and the pressing of the metal and non-ferrous alloys, or oxides of materials of construction which are less active at deforming;

The steels used for the execution of hot deformation stamping dies must have the following properties:

- high heat stability which is defined as the resistance of the steel to the plastic deformation, to the crushing during the heating and it is evaluated by the yield strength of the steel, the temperature of distortion ; most commonly, the heat stability is expressed as the return temperature with a hold time of 4 hours after which the steel hardness is 45 HRC - to provide a high toughness a high strength of the steel to the brittle fracture; - high resistant to oxidation , decarburization and stress corrosion - decreased susceptibility to stress corrosion and deformation - a wide range of hardening temperatures - as high hardenability as possible - satisfactory processing by plastic deformation and cutting.

2. FINAL THERMICAL TREATMENTS APPLIED TO THE STEELS FOR TOOLS OF PLASTIC DEFORMATION

Thermical treatment for secondary hardening. The alloyed steels 12% Cr containing about 1.5% C and additionally alloyed Mo and V present the peculiarity that as you increase the temperature of heating for hardening, it increases the proportion of residual austenite, the resulted hardness after quenching varying according to a curve with variable maximum. Because of the presence together with Cr, Mo and V of the residual austenite and martensite, it is modified the kinetics and morphology of the processes occurring during the heating at different reversible temperatures. Namely, at relatively low temperatures, around 100 ^{0}C, it is transformed in the martensite a small proportion of residual austenite, causing a slight increase in hardness (fig. 1). By increasing the reversible temperature it is accomplished the transformation (decomposition) of the martensite accompanied by a decrease in hardness, the residual austenite remaining untransformed.

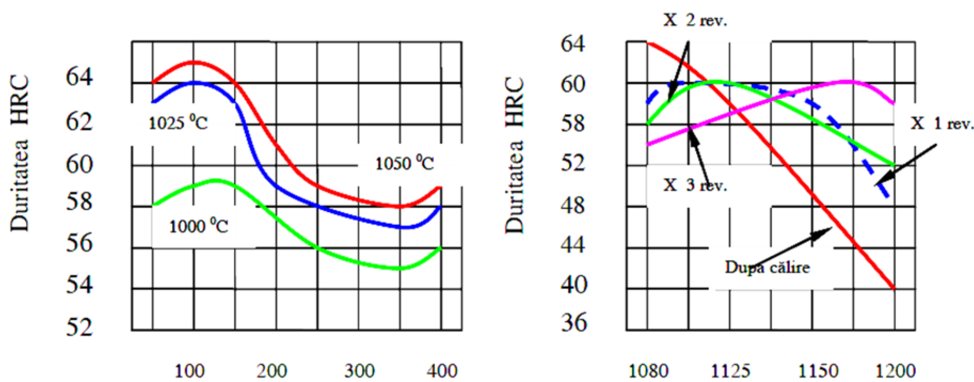

Fig 1.. The hardness of the alloyed steel 12, 5% Cr şi 0,8 % V depending on the hardening temperature, respectively of the reversible temperature: a – reverse transformation at 100 – 400 0C ; b – repeated reversible transformation at 520 0C [5]

From the fig 1.b it results that increasing the heating temperature for hardening (so the proportion of austenite remained untransformed - the rezidual one) the number of reversible transformations for the maximum hardness value obtained, increases from one to three.

Hardening under zero degrees is applied, instead of the repeated reversible transformation, for transforming the residual austenite and the dimensional stabilization of the tools. After the previous hardening, tools are processed during an operation of strenghtening and then, (after a while as low as posibil after the hardening) during a cooling operation under zero degrees (at – 75^{o}C), with a sufficient maintaining for the equalization of the temperature on the section. The transformation of the residual austenite determines the apparition of some structural tensions. That's why, the hardening under zero degrees is not recommended for the tools with complex configuration, for tools that have been heated for austenitization at temperatures within the superior prescribed interval.

3. EXPERIMENTAL RESEARCH

The studies were performed both on samples with circular section and straight on tools (punches) of hot plastic deformation when used in the hot drilling operation of the sheets used for the automotive springs (fig. 2). In a fully automated line, the spring steel blanks are pre-cut on length. With the help of an automated installation, with a conveyor, the tape blanks with a thickness of 37 mm are heated only locally in the area where the drilling is carried out. The used materials for manufacturing such punching drifts are the following: steel W1.2343 (EN ISO 4957) or X 38 CrMoV 5-1 (DIN) and W1.2379 (EN ISO 4957) or X155CrVMo 12-1 (DIN).

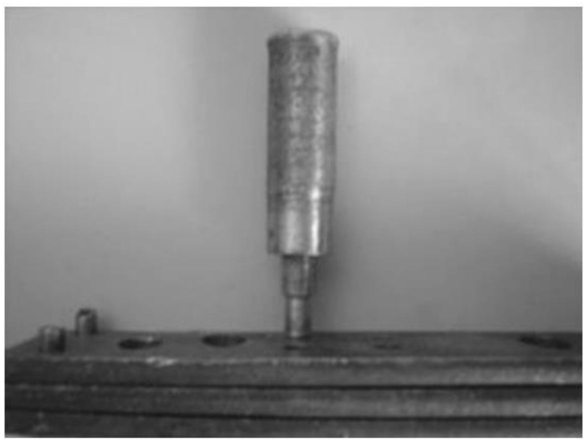

Fig.2. Punching drift for the semi manufactured spring sheets

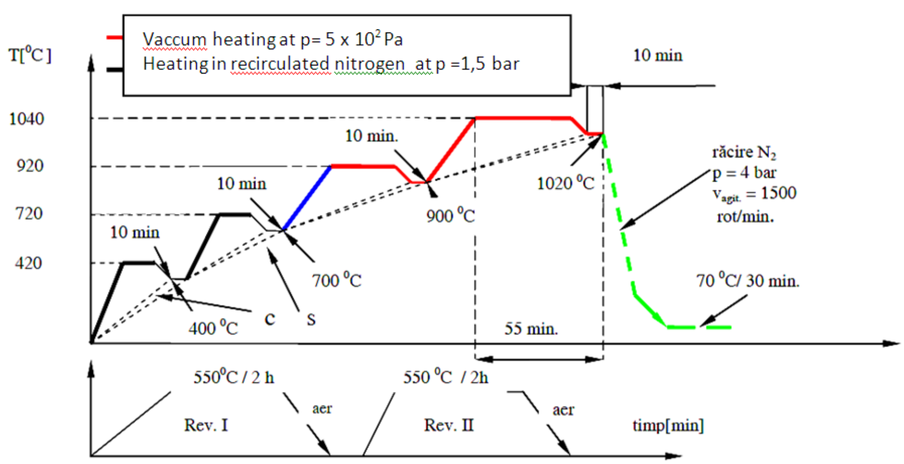

Fig.3. A Variant of thermic treatment previously applied to the nitridation in plasma / nitrocarburation

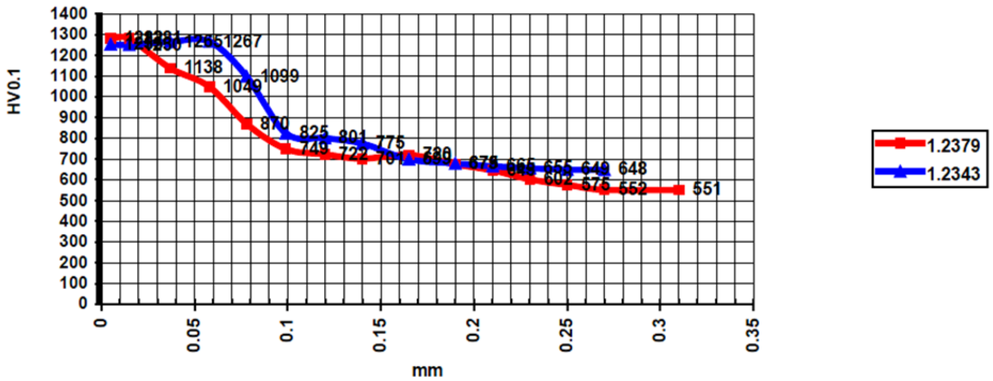

Fig.4. Variation of the microhardeness for the steels W1.2343 si W1.2379, nitided in plasma at 520° C

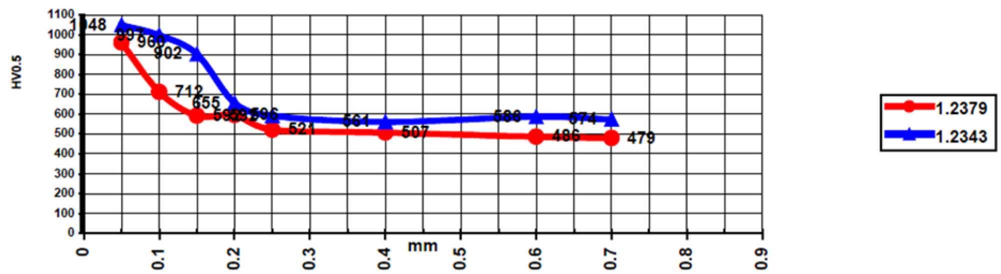

Fig.5. Variation of the microhardeness for the steels 1.2343 and 1.2379, nitrocarburated at 540° C.

The hardness obtained not only on samples but also on drifts after the hardening and the 2 reversible transformations was of 53-55 HRC (steel W 1.2343)(EN ISO 4957) and 56 - 57 HRC (steel W 1.2379) (EN ISO 4957) according to the graphs from the figures 4 and 5.

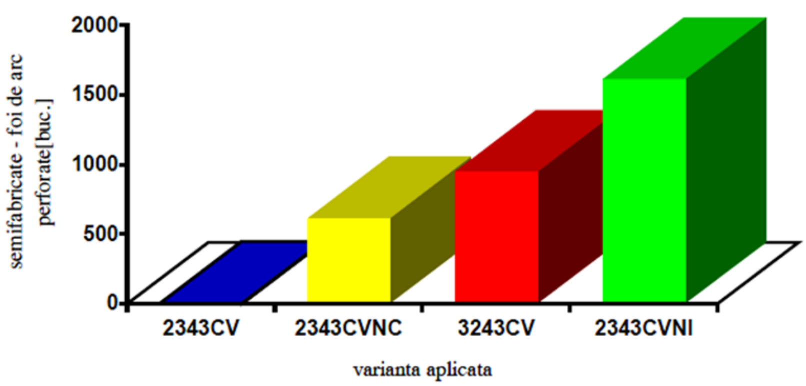

Fig. 6. Graph of the durabilitaty of the drift -punches during the hot drilling operation

Legend:

drift punch 2343 CV – **Variant 1**: hardened in vacuumt +2 reversible transformations

drift punch 2343CVNC – **Variant 2** : hardened in vacuumt +2 reversible transformations + nitrocarburation

drift punch 3243 CV – **Variant 3** : fast hardened steel in vacuum+ 3 reversible transformations i

drift punch 2343 CVNI – **Variant 4** : hardened in vacuumt +2 reversible transformations + ionic nitridation

4.OBTAINED MICROSTRUCTURES

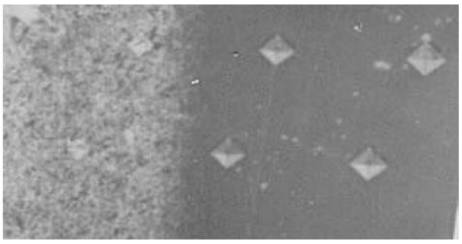

Fig.7. Coating **1.2343CVNI ionic** nitrurated at 520 0C , surface hardness 1281 HV1 ; 500 : 1 white coating 5-10 microns,

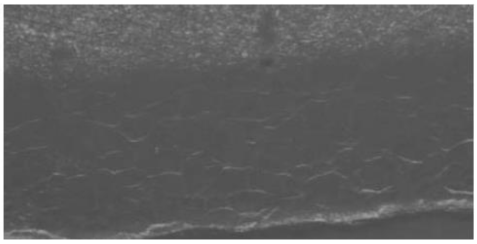

Fig.8. Coating **1.2343CVNC** nitrocarburated at 540 0C, surface hardness 1120 HV1 500: 1 ;

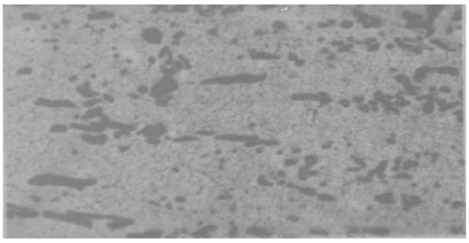

Fig.9. Core **1.2379CVNI** after ionic nitridation at 520 0C , 500:1

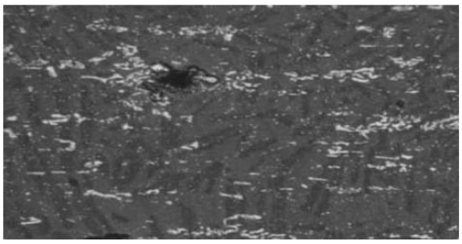

Fig.10. Core**1.2379CVNC** after nitrocarburation at 540 0C, 500:1

The samples were attacked with Nital 3%, 15 sec. for revealing the diffusion coating . – the sample of W 1.2343 (φ10x 60), ionic nitrated prezints a uniform diffusion coatimg on the whole surface, with a thickness of 0,12-0,15 mm, without visible nitrides sludgings, respectively with very fine coats. The combined coating is thin, under 5 µm (discontinuities are caused first of all by the sample preparation) – the sample of W 1.2379 (φ10x 40), nitrocarburated – the diffusion coating isn't clearly distinguished and has a thickness of 0,08-0,1 mm. It is noticed on the superficial zone the apparition of nitrides as "roots". The combining coating is not observed. The core is specific to the steel, with carbides deposited, uniformly distributed in the fine reversible transforming martensite matrix The samples were attacked with NITAL 3% for15 sec. to highlight the diffusion layer. – The Sample of W 1.2343 (φ10x 60), the ionic nitriding diffusion layer evenly over the surface with a thickness of 0.12 to 0.15 mm, with no rush visible nitrides, or very fine precipitates. The combination layer is 5 mm thin (the discontinuities are caused mainly by the sample preparation) – the sample of W 1.2379 (φ10x 40) nitrocarburated - diffusion layer does not specially distinguish and is 0.08 to 0.1 mm thin. It is observed in the surface the appearance of the nitrides in the form of the "roots". The coating the mixture is not observed. The core is specific to the steel with carbide precipitates uniformly distributed in the matrix of martensite of fine reversible transformation.

5.CONCLUSIONS

-The use of the rarefied gas discharge (luminescent discharge) containing nitrogen when nitriding steels, leads on one hand to the acceleration compared to the conventional nitriding and on the other hand, to obtaining layers with superior characteristics of hardness and toughness, fatigue resistance, contact pressure, wear, etc.

-The tools made of steel W 1.2343 (X38CrMoV5 -1) of hot processing and

improve their mechanical features after applying the ionic nitriding treatment .
-Higher hardness values were obtained by ionic nitriding due to the lower temperature and shorter nitriding duration compared to the nitro-carburetion .
-No defects were found in the structure of the marginal layers or coatings.
- After the durability test, as a following of the ionic nitriding of the drift punch made of steel W 1.2343 it was found that it is 1.6 times higher than for the drift punch made of high speed steel (W 1.3243) hardened and tempered in vacuum and 400 times higher than for steel W 1.2343 quenched and tempered in vacuum.
-The overall robustness of the hot deformation tools is given by the existence of the core tools of martensite type and bainite constituents.
-The experimental studies and comparative research, performed directly on tool on two types of steel (1.2343CV - hardened and tempered in vacuum, hardened 1.2343CVNI, ionic nitriding and reversible transformed in vacuum and W 1.3243CV - speed steel quenched and tempered vacuum) show that by applying conventional thermal treatments combined with thermo-chemical treatments can be obtained significant structural changes in the surface layer with direct consequences on physical and mechanical characteristics which are considerably improved.
- The unique property of high speed steels and certain "red resistance" allows keeping the core hardness (by the test end) and even on the active front, on the punch surface made of 1.3243 W of 63-64 HRC, compared to the drift punch of 1.2343 CVNI , which in the active core part decreased from 53-55 to 51-52 HRC under the action of the thermical factor , corresponding to the steel if it si applied a reversible transformational 570 - 580 ^{0}C.
- From the point of view of the economics issues: - after nitriding were not observed deformations of the tools, not being necessary any additional lapping or light polishing operations. – The perforating drift punches made of high speed steel can be replaced with cheaper steel (W 1.2343, W 1.2344) which will be then thermal treated after hardening and the reversible transformations, plus a thermo-chemical treatment (one reversible transformation) plus a ionic nitriding as a thermo-chemical treatment or a nitro-carburizing

6.BIBLIOGRAPHY

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