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NEW TRENDS IN THE BENDING OF COATED SHEET METAL

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ABSTRACT

The article deals with new experimental equipment for effective test of adhesion for selected coating STEEL, applied cold on the coated sheet metal with Al (aluminium). In the experiments with new test equipment it was shown that for bending radiuses from R11 to R35 there is a change of deposited coating STEEL from original coating Al and this coating was part of test sheet metal of thickness 1.5mm. Steel coating has significant anticorrosive properties and it is resistant for main oxidizing agents such as acids, alkalis, salt vapours etc. It is very simple to apply to metallic and non-metallic surfaces. Broad application is in automotive industry to modify the surfaces of block vehicle, car-body repairs, welds needing protection, in heating industry (i.e. boilers), in air condition with heat exchangers and in shipping industry.
In the next stage of investigation, technological process was developed, which allowed the increase of adhesion of coating STEEL for bending up to or maximum 180° (shape U). Result of a new technology is documented in article. Experiments were implemented in cooperation with the Masaryk University in Brno, Czech Republic.
Key words: a*dhesion, metal sheet, aluminium coating, bending, plasma*

1. INTRODUCTION

Field testing and evaluation of adhesion of coated sheet is characterized by great diversity of methods and procedures [1,2,3,4].In addition to the testing proceduresused to test the adhesion to metal and other coatings such as coatings adhesion test grid cut, the resistance test of the coating in Erichsen device can be found in [5,6]. In addition to determining the resistance of coatings made against cracking or peel, the coating characteristics from steel sheet after surface- treatment was done by (making) bend test in laboratories in the 180° cylindrical mandrel [7].For testing of steel plate with coat Al and STEEL according to DIN EN 327/EN 101143 with ultimate tensile strength.

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Rm = 307 MPa, proof stress Rp0, 2 = 154 MPa, tensibility A80 = 43% anda thickness of 1,5 mm (Fig. 1) new graduated bending jig (Fig. 2) developed in the Institute of engineering Technology in BUT (Brno University of Technology)was used [10,11,12,13,16].
New graduated bending jig and its design allows testing of coated sheet (plate) of greater thickness than the currently test jig recommended from norm ČSN ISO 1519.
The JIG allows simultaneous bend five samples in the range of values of angles up to 180° by using rollers through (over) cylindrical segments. They can make a ”U” bends with inner radiuses of R11, R17, R23, R29 and R35 mm.
Cylindrical segments can be easily changed for different radiuses. Bent sample is distinct in the case when coating damage is assessed visually and if there is no apparent damage of coat using all segments; otherwise the close examination of the functional coating cracks under the microscope should be performed.
The aim of the experiment was to test the new graduated bending jig adhesion of selected steel samples with dimensions in the range of lengths from 98 to 181 mm and a uniform width of 18 mm. All samples were with Al coat, to which was additionally applied coat STEEL in cold conditions.

Fig. 1 - Selected samples before bending

The JIG was designed as an assembly unit and the pulley and segments are fixed to BEND-JIG by screws and their possible reassembling capabilities on the different range of radiuses are very simple and can be done in a short time interval.
Design solutions with segments gave a worse prediction of evaluation of the quality of coating on a steel plate. Therefore, segments were replaced by rollers, Fig. 2.

2. TEST ADHESION OF COATING

Experiments were divided into two stages. In the first stage, samples were tested at five pieces without previous treatment of surface by Al coating by plasma jets before coating steel was applied. Thickness originally deposited Al coating from supplier for all samples was measured by Thickness Elcometr 456 and measurement results are documented in the sample (Fig. 3). Measurement of thickness was also applied to the coating Steel which was applied on the Al coating (Fig. 4).

Fig. 2 - Photo of graduated bending jig with rollers

Steel coating serves as a surface treatment of steel (heat resistant up to 600°C, the aesthetic effect, and increased corrosion resistance).
Steel coating was subjected by chemical analysis and was found that coating contains 13,6 wt. % Si, which strengthens the coating and contributes to the deterioration of plastic properties in shaping sheet metal (plate).

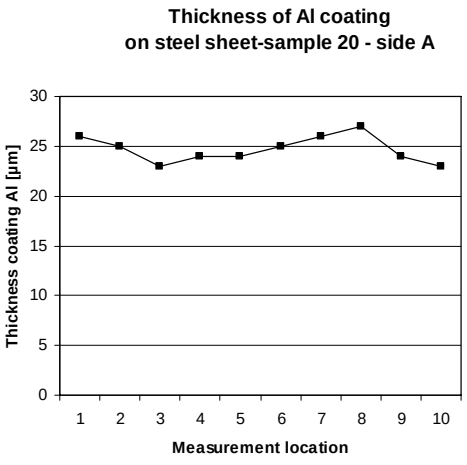

Fig. 3 - The thickness of Al coating on steel sheet – sample 20 – side A

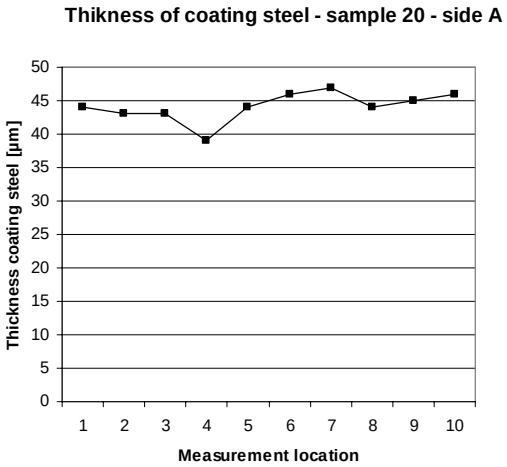

Fig. 4 - Thickness of coating STEEL – sample 20 - side A

According to the supplier (company Faren Ltd.) this coating resists acids, salt vapours and is resistant to corrosion and atmospheric effect as well. It can be used for adjustment of welds in stainless steels in place of traditional pickling methods.
On the basis of the bending tests in the test preparation it was concluded that the adhesion of coating STEEL is unsuitable. When forming the bend into the shape of "U" in the test preparation was performed, a breach in the coating occurred in the interval of radii of curvature from R11 to R35 mm (Fig. 5).

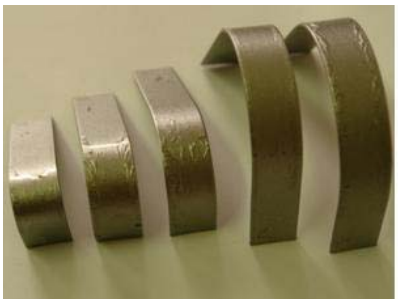

Fig. 5 - Photo of damaged coating STEEL after the bending without application of plasma

In the second stage of the experiment a conjunction with MU Brno multi-jet plasma system (Fig.6) was performed with a width of 100mm with nineteen jets providing low-temperature and non-isometric discharge at atmospheric pressure.
The physical nature of the phenomenon of plasma multi-jet system consists of generating plasmas at atmospheric pressure [15].

3. THE PRINCIPLE OF HIGH-FREQUENCY HOLLOW CATHODE (13.56 MHz)

As basis of nozzles dielectric capillaries made of silica glass were used, which flow through the argon, including any additions. The resulting plasma jets from the mouth cavity of the plasmic-jet flows into the external environment, which acts on the coated steel samples. Discharge for the entire length of plasma channel active was generated. Multi-jet device absorbed power of the plasma channel according to selected working conditions in the range from 10^2 to $10^3 Wcm^{-2}$.

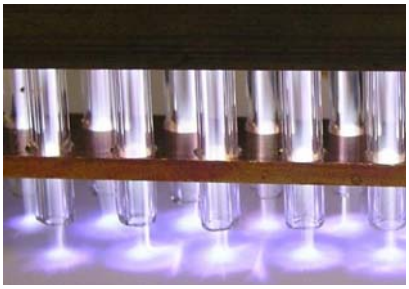

Fig. 6 - Sample of multi-jet system used in the experiment [14]

Unlike welding, electron beams have the power density at the point of welding up to 10^9 W.cm^{-2} [1]. Thermal effects on the surface of samples can be in the range from 30° to 1600°C while maintaining non-isometric character of discharge (temperature of energy particles of 10 000K).
Based on these properties, plasma-jet system can provide a highly reactive compound with high efficiency for the chemical and physical modification of the surface material.
A suitable grouping of nozzles (jets) in linear or other formations allows cutting of large areas of test samples of semi-finished steel in industrial practice [7, 11].
The result of the application by multi-jet system on the test specimens with Al coated on the set of optimal parameters of plasma jets flowing out of nineteen, (know-how process), was afterwards subsequently processed by coating STEEL, which had no signs of damage after bending the sample on the graduated bending jig (Fig. 7).

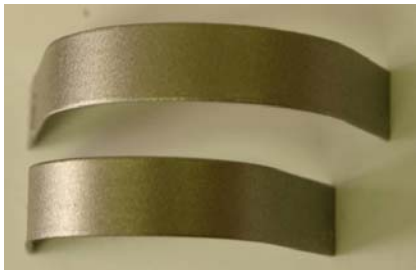

Fig. 7 - Photo of functional coating STEEL after the bending with the application of plasma made in graduated bending jig with rollers at BUT BRNO

Sets of 20 specimens were prepared in the same size and bent in the jig under the same conditions as specimens of coated STEEL discussed above in the article. The thickness of the applied coating BIG TRUCK was measured afterwards at ten places (50± 10μm). The difference was only in the fact that for new experiment steel sheets without Al coating were used. Effect of plasma parameters were set as well as for coated sheet steel with Al+STEEL.
Comparison of the quality coating BIG TRUCK after bending in the jig is in the Fig. 8 and Fig. 9. InFig. 8 a photo without application of plasma - coating BLACK BIG TRUCK is presented. Fig. 9 shows a photo with application of plasma – coating BLACK BIG TRUCK.

Fig. 8 - Photo without application of plasma - coating BLACK BIG TRUCK

Fig. 9 - Photo with application of plasma – coating BLACK BIG TRUCK

Fig. 10 shows graduated bending jig with rollers with specimens without the application of plasma. The last specimen is damaged.

Fig. 10 - Photo of graduated bending jig with rollers with specimens without application of plasma (coating BLACK BIG TRUCK)

This method is based on surface treatment and exactly defined parameters for low-temperature plasma at atmospheric pressure. Positive results as well as multi-coating Al+STEEL on the steel base were obtained. Surfaces after bending were fully functional and there is no paint damage after bending into U shaped sample with the radius R29 – R33.
This method can be extended to the application of paint without using interlayer (directly on the metal base plate).
Other methods for testing adhesion of coating are for example Bulge test [8, 9]. Range of application is very broad. In the field of ground machines, cabs, cradle, machines which are working in the worse terrain etc.

3.1 Preparation of coating on set of specimens

In paint shop basic coating with thickness of 25±5mm was applied on steel specimens and after drying top-coat to non-stick was subsequently applied in thickness up to 5mm at temperature of 170±10°C. Despite very thin top coating, the pressing plate is destroyed.

For this reason top-coat was treated by plasma and these parameters and conditions of the experiment are shown in table 1, see below.

Table 1 Conditions of the experiment

SELECTED SAMPLES	PERFORMANCE OF PLASMA [W]	FLOW Ar [l/min]	SAMPLE FEED [m/min]	NUMBER OF PASSES UNDER PLASMA
21-25	550	50	3	2

4. CONCLUSION

Based upon bending experiments of steel samples with a nominal thickness of 1,5mm, width 18mm and lengths in interval from 98 to 181mm of low-carbon steel according to DIN EN 327 (with sprayed coatings Al thickness of 25±5μm and STEEL 47±7μm),it was concluded:

- Performing of the bending on the cylindrical thorns with radiuses R11, R17, R23, R29 and R33 without application of plasma with a functional surface of tested coatings is impossible without their defects.
- After application and optimization of plasma parameters using the plasma system, functional coatings were made for cylinder radiuses R29 and R33 in the test graduated bending JIG.
- For smaller radiuses of test cylinders, there were slight defects in the coating Steel.
- Graduated bending test JIG used for experiments was newly developed and introduced for testing by bending sheet metal into the shape of "U" at the Institute of engineering Technology in BUT (BRNO UNIVERSITY OF TECHNOLOGY).

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NOVI TRENDOVI U SAVIJANJU LIMOVA SA NANEŠIM POVRŠINSKIM SLOJEM

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REZIME

Ovaj rad se bavi novom eksperimentalnom procedurom za test adhezije limova sa nanešenim površinskim slojem. Površinski obrađen lim ima veoma dobra anti-korozivna svojstva i otporan je na najzastupljenija oksidaciona jedinjenja mnogih kiselina i soli. Novi eksperimentalni postupak se veoma jednostavno primenjuje na metalne i nemetalne površine. Širu primenu ima u autoindustriji za modifikaciju površina blokova motora, šasije, zavarenih spojeva, kao i u npr. proizvodnji bojlera ili klima uređaja. U ovom radu u okviru eksperimentalnih istraživanja na lim debljine 1,5mm i širine 18mm nanesen je sloj dodatnog aluminijuma debljine 25±5μm ili čelika debljine 47±7μm.Savijanje takvog lima na radijusima od R11, R17, R23, R29 i R33 R11, R17, R23, R29 i R33R11, R17, R23, R29 i R33 bez upotrebe plazma tehnologije rezultiralo je u površinskim defektima. Upotrebom plazma tehnologije uspešno je izvršeno savijanje na radijuse R29 u R33. Na manjim radijusima došlo je do oštećenja prilikom savijanja lima na koji je nanesena prevlaka od čelika.U sledećem koraku je razvijen tehnološki postupak koji je povećao adheziju za savijanja do maksimalno 180° (oblik U). Rezultati ovog postupka su dokumentovani u radu. Ekspermenti su izvedeni u saradnji sa Masaryk Univerzitetom u Brnu, Češka Republika.

Ključne reči: a*dhezija, metalni lim, prevlake kod aluminijuma, savijanje, plazma*