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EMF FLATTENING FOR RESTORING A CAR DAMAGED BODY

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Abstract. This paper is dedicated to experimental study of pulsed electromagnetic attraction based upon recently developed tool design – “Inductor System with an Attracting Screen (ISAS)” for the repair technology of the external dent removing on a car body.

Key words: electromagnetic forming, electromagnetic attractive force, repair technologies, dent removing.

МАГНІТНО-ІМПУЛЬСНЕ РИХТУВАННЯ ДЛЯ ВІДНОВЛЕННЯ ПОШКОДЖЕНИХ АВТОМОБІЛЬНИХ КУЗОВІВ

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Анотація. Робота присвячена експериментальному вивченню магнітно-імпульсного притягання за допомогою нових конструкцій інструментів – «індукторних систем з екраном, що притягає (ІСПЕ)», призначених для ремонтних технологій зовнішнього рихтування вм'ятин в автомобільних кузовах.

Ключові слова: магнітно-імпульсне рихтування, електромагнітна сила притягання, ремонтні технології, видалення вм'ятин.

МАГНИТНО-ИМПУЛЬСНАЯ РИХТОВКА ДЛЯ ВОССТАНОВЛЕНИЯ ПОВРЕЖДЕННЫХ АВТОМОБИЛЬНЫХ КУЗОВОВ

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Аннотация. Работа посвящена экспериментальному изучению магнитно-импульсного притяжения с помощью новых конструкций инструментов – «индукторных систем с притягивающим экраном (ИСПЭ)», предназначенных для ремонтных технологий внешней рихтовки вмятин в автомобильных кузовах.

Ключевые слова: магнитно-импульсная рихтовка, электромагнитная сила притяжения, ремонтные технологии, удаление вмятин.

Introduction

The interest to the magnetic pulse attraction of thin-walled conductors has a long-standing history. Some different suggestions allowing artificial transforming the natural magnetic pressure in the magnetic attraction had appeared during

first testing some field technologies. The practical side of the marked interest is initiated by the growing demand upon production operations by the effective restoration of the airplane and vehicle bodies with the dents [1]. The process has to be realized from a body external side. It has to be flattening without disassembling and without

damaging existing protective cover. Precisely Electromagnetic Forming (EMF) technologies satisfy to all listed requirements [2–5]. The objective of this paper is representing some experimental results for a new manufacturing process of the sheet metal attraction through the recently developed experimental system. It's the main feature is what a source of the pulse magnetic field (inductor) is positioned behind the additional accessory screen. This process is one of the few suggestions generating attracting forces with much higher capabilities than vacuum forming, for example [6–10].

Literature review. Problem formulation

Historically and chronologically, USA can be considered as “pioneer” and a leader in a field of the technical system creation for the external removing dents in the sheet conductors. Trustworthiness of this fact is confirmed by Web-Sites of the well-known Americans companies “ELECTROIMPACT” and “FLUXTRONIC”, for example. They have been representing some EMF equipment for the exterior restoration of aircrafts wings and fuselage when access from the inside of the panel is very problematic if not impossible [2, 3].

The European leader in area of the creation of the modern repair equipment is the well-known concern “BETAG INNOVATION”. The Web-Site of the concern contains many suggestions of the different modern technologies for flattening a car body [4]. Among them there is so named “Magnetic Dent Remover” claimed by Meichtry R., Kouba I. (2008) [5]. This device permits eliminating dents by attraction of the designated parts of magnetic steel blanks only. Non-magnetic metals can not be restored. But undoubted advantage of “Magnetic Dent Remover” is a possibility of restoration from the external side without disassembling of the components and without damaging of existing paint and protective coating. For justice sake should mark that the action principle of this device was taken from Batygin et al. (2004) [6]. The physical essence of mentioned action principle was justified theoretically and experimentally rather later. As it was shown by Batygin et al. (2013) [7] by the low working frequencies of the acting field the attracting forces become prevailing over the repelling forces which are well known forces of the magnetic pressure. The attraction is caused by the magnetic properties of the sheet billet metal. The nature of repulsion is caused by the Lorentz forces.

A new concept of electromagnetic attraction based upon force interaction between unidirectional currents (the well-known Ampere Law) in the blank and in the accessory screen was formulated for the first time by Batygin et al. (2006) [8]. Physical essence of the idea and its first technical implementation, named as “Inductor System with an Attracting Screen (ISAS)” were described later (2014). The first construction of the attraction tool consisted of the single turn inductor positioned between parallel plates of the screen and sheet metal blank which requires treatment by attracting forces. Identically directed eddy currents are induced in the metal of the screen and the sheet metal blank by the current flowing through the single turn coil. The proposed design requires rather low frequency of discharge to accomplish intensive penetration of the electromagnetic field through the thickness of the blank and avoid repelling Lorentz forces, which are the natural result of interaction of magnetic field with a conducting environment.

This construction of the electromagnetic attraction tool has an essential demerit: the exciting inductor is located between screen and work-piece. In connection with this, a strength of the system is falling down and the Lorentz repulsion is rather strong due to the proximity of the inductor and the sheet work-piece metal.

The further development of the theory and practice of the EMF attracting tools based on the Ampere Law have led to new ISAS – construction suggested by Batygin et al (2013) where the exciting inductor is moved out of the working zone and positioned on the external side of attracting screen. The new ISAS consists of parallel flat circular inductor, accessory screen and sheet metal blank. The induced whirl-wind currents in the screen and blank metals are being excited by penetrated pulse magnetic field being generated by the external source.

This research paper intends to represent the experimental test of the “Inductor System with an Attracting Screen (ISAS)”, as the tool of the external EMF flattening a car body with the dent when the magnetic field source – the circular flat inductor located outside of the accessory screen.

The production operation being modeled

The manufacturing operation by the external non-contact removing the dents on the auto car metal covering was chosen for the experimental

test of the “Inductor System with an Attracting Screen (ISAS)” being excited by the external circular inductor. The given choice was initiated by the information on Web-Site of the leading European concern “BETAG INNOVATION” about actuality of this production operation for the advanced repair technologies of the modern auto transport.

A principle scheme of the experimental modeling the chosen production operation is represented on Fig.1. It includes a sketch of the ISAS construction used in the test.

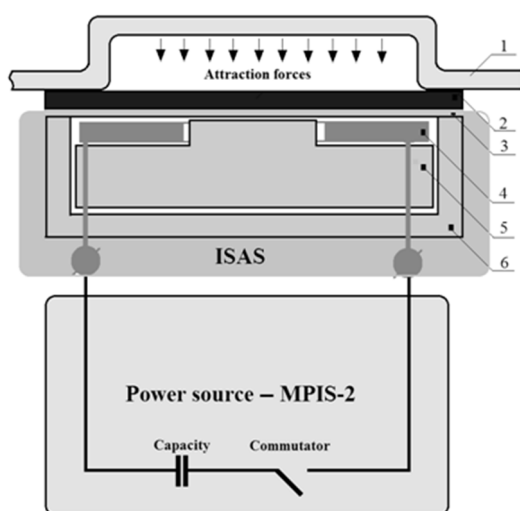


Fig.1. The principle scheme of the dent removing with help of the “Inductor System with an Attracting Screen (ISAS)”: 1 – is the sheet metal blank, ISAS; 2 – is the accessory attracting screen; 3 – is a dielectric insert; 4 – is the external exciting inductor, 5 – is a dielectric compaction; 6 – is the dielectric body; power source – MPIS-2 (Magnetic Pulse Installation Series with 2kJ energy stored): is a capacitor storage; is a block of thyristor switches

Should mark some features of the conducted experiment.

1. The outside straightening was being realized precisely from side of concavity.
2. The excitation of ISAS was realized by the outside source of the magnetic field. The circle inductor was positioned on the external side of the accessory screen.

Equipment. Experimental samples

The draft of the ISAS experimental construction is represented on Fig.1 (see a part named ISAS).

Its main components are the exciting circular inductor and the accessory attracting screen positioned parallel.

It should be noted that the proposed design of the ISAS by the result of the action is similar to the well-known electromagnet. But unlike it this tool permits to realize attraction of the designated parts not only ferromagnetics but as well metals of any physical nature.

The inductor of ISAS was connected to the power source. It was MPIS-2 (“Magnetic Pulse Installation Series” with 2kJ stored energy) created in the Laboratory of the Electromagnetic Technologies and described in detail by Batygin et al (2013, 2014).

The feature of the power source – MPIS-2 is its work in a serial regime as a generator of a designated quantity repetition of the current pulses which enter the inductor winding and excite pulses of the force attraction of the dent metal to the screen plane.

The main data of the MPIS – 2 in experiment are the following.

1. The stored energy is equaled to $\sim 2,4$ kJ, the voltage is ~ 1500 V, the current in pulse is equaled to ~ 12 kA.
2. The working frequency in discharge is ~ 1500 Hz.
3. The frequency repetition of the current pulses is ~ 5 Hz.
4. The quantity of the force attraction pulses what was necessary for the sheet blank flattening is $\sim 18\dots 20$.

The separate plates of the sheet metal body covering automobiles “Subaru” and “Citroen” were taken as the experimental samples. Their dimensions were $\sim 0,15$ m $\times 0,15$ m. The thickness of the samples was $\sim 0,0008\dots 0,001$ m. The depth of the dents which were created artificially was $\sim 0,0018\dots 0,002$ m. Their external diameter was $\sim 0,05$ m.

Besides the separate sheet samples an object of the experiment was as well a door of the automobile “Audi” represented on Fig. 2. The thickness of its steel covering was $\sim 0,001$ m. Dimensions of a natural dent were $\sim 0,02$ m.

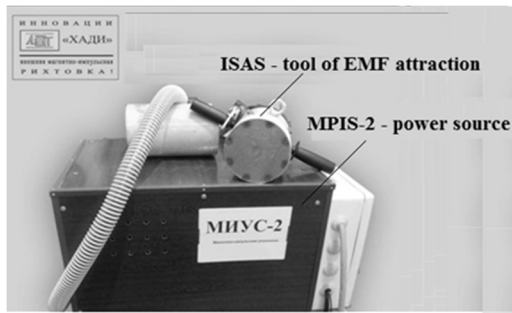


Fig.2. The equipment for EMF removing the dents in the whole

Experimental test. Results

After switching on the mains voltage was given on the force step-up transformer primary winding. Charging the capacitors was carried out through the rectifier till a specified level of stored energy. After this the discharge circuit was being closed automatically by a block of the thyristor switches and the current pulses being generated entered in winding the exciting inductor (ISAS).

A cycle “charge – discharge” and the force EMF attraction was repeated several times till removing the dent on the object surface of the experimental investigation. Some results of the external non-contact EMF removing the dents in separate samples of the sheet covering the Japanese and European automobiles are represented on Fig.3.

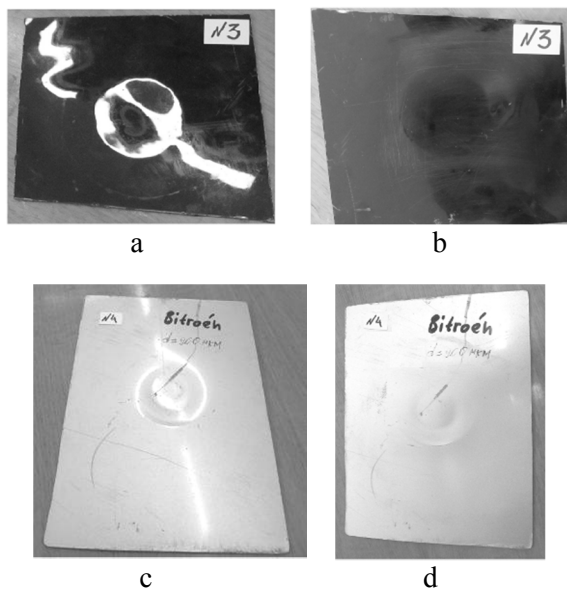


Fig.3. The experimental samples of the different automobile steels, “Subaru”: a – before force action; b – after attraction; “Citroen”: c – before force action; d – after attraction

The first what is necessary to mark as an experimental positive result is a level of the force attraction what provided high effectiveness of the fulfilled production operation. Should remind, a flattening quality was not a problem in this case. The aim of the conducted experiment was only practical test of the ISAS as the tool of the EMF attraction.

The second positive result is saving the protective paint-and-lacquer coating. Though a quite important remark has to be done. As it follows from practice saving the paint-and-lacquer or other protective coating depends on many factors immediately not connected precisely with EMF attraction of the deformed metal.

Fig.4 illustrates a course of experiment by flattening the steel covering the “Audi” automobile door with natural dent.

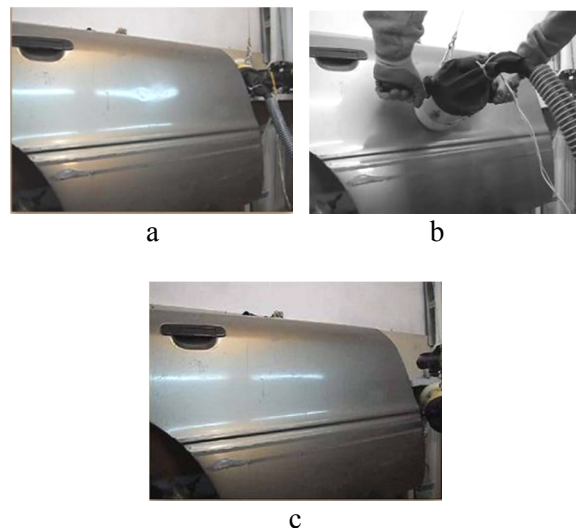


Fig.4. The external EMF flattening in real repair process: a – the door before flattening; b – the tool ISAS in action; c – the door after flattening

Conclusions

1. The “Inductor System with an Attracting Screen (ISAS)” being excited by external source of the magnetic field is successfully tested in the actual repair production operation by the out side non-contact EMF removing the dents.
2. Removing the dents was successfully realized not in idealized conditions for separate steel samples only but in real situation of the element restoration of the automobile body.

3. The got results have demonstrated the high effectiveness of the suggested tool in the principle new advanced repair technology with usage of the pulse magnetic field energy.

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