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BASIC DIAGRAM AND PRACTICAL ALGORITHM REMOVING DENTS ON THE BODY OF VEHICLE BY THE PULSED ELECTROMAGNETIC ATTRACTION

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ABSTRACT

The paper is dedicated to the electromagnetic attraction process (this is a development direction of the EMF technology!) which can deform thin-walled sheet metals and remove the dents on the covering body of the modern vehicles using low frequency discharges. The basic diagram of technical system implementing the electromagnetic removing dents is given. The main feature of this system is that the working tool is placed from the external side of the dent on the metal surface of the vehicle body. The removal of the dent does not require any disassembly and dismantlement. The practical algorithm of the electromagnetic repair technology is described. The conducted tests have shown a high effectiveness of the suggested electromagnetic attraction for the non-contact external flattening a car body in real production conditions. The represented work was done in the Laboratory of the Electromagnetic Technologies of the Kharkov National Automobile and Highway University, Ukraine.

KEYWORDS: Electromagnetic Forming, Electromagnetic Attractive Force, Repair Technologies, Removing Dents, Car Body..

INTRODUCTION

The well known applications of the Electromagnetic Forming (EMF) are based upon excitation of the repelling Lorentz forces between the EMF tool (this is a coil) and conductive blank. In such configuration the tool is positioned from opposite side of the blank [1]. But another configuration of EMF processes is possible where the blank is attracted to the tool. The first application of this process is expected to be in automotive repair shops where an attracting one sided distributed force may enable low cost exterior panel damage correction [2].

The present article supplements the experimental material of the publication [2]. But unlike cited work the objective of the present article is to describe the principle acting scheme and the practical testing the process algorithm of the external removal of the dents on the car body with help of the pulsed electromagnetic attraction. Additionally, the experiments described in this work have been directed to checking and confirming the main fundamental concepts on which the workability of the present suggestion is based.

BRIEF LITERATURE REVIEW ON EMF ATTRACTION PROCESSES

Analysis of the real life examples indicates that a great number of damages on a body vehicle are the dents in the areas where access from the inside of the panel is very problematic if not impossible. These cases include aircraft wings and fuselage components as well as doors, hoods, roofs, fenders and bumpers of cars and trucks. From this perspective, there is a practical interest to devices allowing restoration of sheet metal parts by eliminating the dents on the surface from the external side without disassembling of the components and avoiding damaging of existing paint and protective coating. In this connection, the new repair technologies using the electromagnetic attraction are becoming quite actual.

Historically, an electromagnetic attraction of the designated areas of panels manufactured from sheet metal blanks is motivated by the restoration needs of exterior panels of aircrafts. The first repair technology like that was suggested and implemented by concern "Boeing". Later, this work was continued by American firms "ElectroImpact" and "Fluxtronic"

[3,4]. Physics of the process proposed by their engineers consists in generating two frequencies of discharge: slow and fast. The fast discharge eliminates the slow field from the side of the blank facing the coil while the slow field diffused through the thickness of the sheet metal deforms the blank. This physical principle was incorporated in a number of technical designs and configurations: it was suggested a method and apparatus for electromagnetically removing dents from conductive materials by introducing a slow discharge through a multi-turn coil and a rapid pulse of counter current; they further developed the coil system by introducing a flux concentrator which is also known in the literature as a field shaper. Also specialists of these firms introduced a system of two coils and portable pulse generator generating both repelling and pulling forces to correct both concave and convex areas of the dent. At last what has to be marked surely as improvement of the tool for flattening they introduced a crow bar system capable of shaping the pulse comprised of fast and slow frequencies in most favourable way for the dent removal process. But the main essential demerits of all suggested systems with two frequencies of the excited fields are the complicated and expensive devices of the high-voltage electronics. From our opinion this is the main reason why these systems have found no usage for the ground vehicle flattening.

The concept of a single frequency sheet metal attraction was introduced by Batygin et al for ferromagnetic materials [5]. This concept was discovered during EMF experiments with steel sheet metal material deformed by electric discharges with different frequencies. The suggested concept quickly found its practical application in dent removal devices for automotive applications where majority of exterior panels are fabricated from low carbon steel. The specific coil designs as well as practical aspects of dent removal in automotive panels were used in creation of the "Magnetic Dent Remover" of the European concern "Betag Innovation" (the previous name "Beulentechnik AG") [6].

A recent review in the work [7] described the initial concept of electromagnetic attraction based upon creating unidirectional currents in the blank and in

the attracting screen was formulated by Batygin et al. [8]. The physical concept of the proposed coil design is based upon the Ampere law. In order to create unidirectional parallel currents, an additional conductive screen was added to a traditional single turn inductor design. A well-known single turn coil design is employed to create attraction forces in a new process: the inductor is 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.

The experiments by the electromagnetic attraction and effective removing of the dents on thin-walled sheet metals with help of the before described physical principles are illuminated in the materials of report at the 6th International Conference under High Speed Forming [9].

Finally, more detailed information about advanced elaborations in the area of the modern field technologies is represented on the Web-site of the Laboratory of The Electromagnetic Technologies of the Kharkov National Automobile and Highway University [10].

Concluding the brief review of the methods of the electromagnetic attraction should mention their main advantages which explain the interest to usage energy of the pulsed fields for the advanced repair technologies of the modern vehicles.

In comparison with the well known traditional ways of removing the dents the methods of the electromagnetic attraction are distinguished by the following positive particularities.

- The external removing the dents on the body panels of the modern vehicles without any disassembly and dismantlement.

- The real possibility preserving a protective covering on the body panels.
- The absence of any mechanical contacts with metal of the body panels.
- The possibility of control of the process removing the dents.

The ecological purity and resources saving.

Endnote. The main advantages of our elaborations (with one frequency of the acting field!) in comparison with the American analogues (with two frequencies of the acting field!) are the more simple principle action and the essentially more low self-cost of the manufacture.

THE BASIC DIAGRAM THE SYSTEM FOR THE EXTERNAL REMOVING THE DENTS ON THE CAR BODY WITH HELP OF THE PULSED ELECTROMAGNETIC ATTRACTION

A workability of the elaborated complex for the external electromagnetic pulsed removing the dents on a body of the car can be explained with help of scheme on Fig.1. The complex was created in the Laboratory of the Electromagnetic Technologies of the Kharkov National Automobile and Highway University.

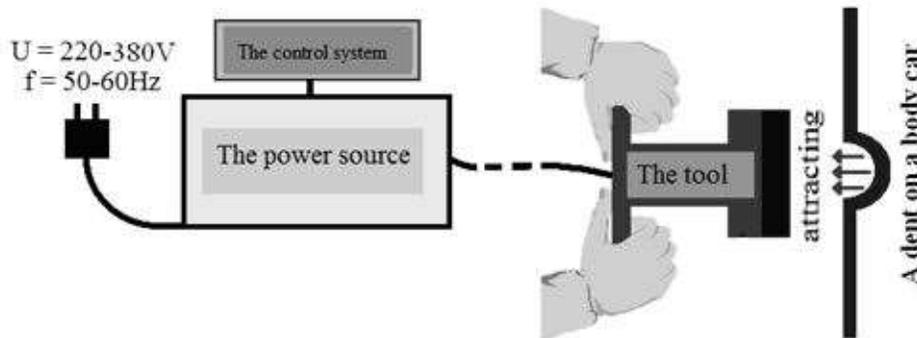


Fig.1. The basic diagram of the elaborated complex for the external electromagnetic pulsed removing the dents on a car body.

The technical characteristics of the “power source” (in the special literature “power source” this is a magnetic pulsed installation!) are the following: the voltage of the electric network is $U_0 = 220 - 380V$; the voltage of the charge of the capacitor bank is $U_C \approx 100 \div 2100V$; the maximum of the stored energy is $W \approx 2kJ$; the capacity of the bank is $C = 1200 \mu F$; the own inductance is $L = 440nH$; the working frequency in the current pulse is $f_w = 7kHz$; the frequency of repeating of the current pulses is $f_r \approx 1 \div 10Hz$.

The tool of the electromagnetic attraction of the steel covering



Fig.2. The technical implementation of the complex for the electromagnetic flattening the steel covering of the car body,
*a) the complex in the whole: 1 – is a tool for flattening;
 2 – is the cable connection;
 3 – is the power source
 (MPIS – 2, “the magnetic pulsed installation of the action series on 2 kJ”);
 b) the remote controller;
 c) the different tools for electromagnetic attraction of the dents on the steel covering.*

Description of the algorithm as sequence of the demanded operations.

1. An external survey of surface of a car body is being fulfilled visually.
 A purpose is to determine and estimate damage which is subject for repair. A shape and geometric dimensions of found dents allow choosing a level of the necessary force attraction and a value of necessary voltage of the capacitor bank.
2. The necessary voltage and quantity of the forces actions are being fixed by an operator on the remote controller.
3. On the surface of the body panel over the dent a special dielectric insert is being placed. Its destination consists in a hard fixation of working surface of the tool for effective removing the dent.
4. The operator fixes the tool over the dent, switches on feeding the voltage and implements the external flattening the body panel of the car.
 Result: the excited forces attract the dent metal till level of the initial smooth surface. A completion flattening is being determined visually.

5. The tool and insert are being taken away after completion of the force action. Removing the dent is successfully fulfilled. A protective paint covering remained without any damage.

In conclusion, the practical algorithm of flattening can be illustrated by photos on Fig.3 where the removing a dent on a body panel of the automobile “Audi” is shown. Though should mark that this operation has been worked off for the different steel coverings of the car body.

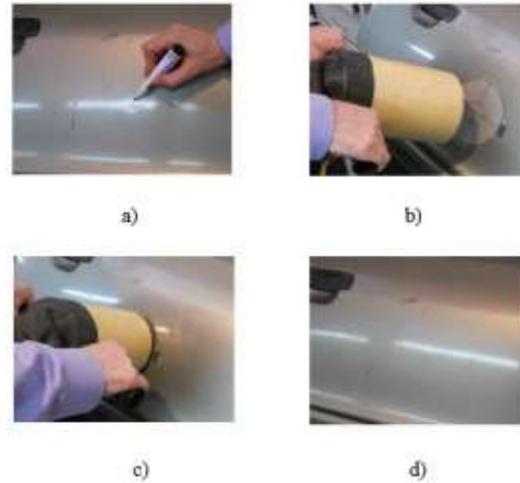


Fig.3. Photo illustrations of the algorithm of electromagnetic flattening,
*a) fixation of a dent which is an object of removing;
 b) centering the tool over the dent with help of a thin dielectric insert;
 c) realization of flattening (several actions of the attracting force!);
 d) the door of the car after removing the dent, protective paint covering is preserved without any damage.*

CONCLUSIONS

1. The electromagnetic attraction process for deforming ferromagnetic sheet metal materials such as low carbon steels, is suggested for the external non-contact removing the dents on the car body.
2. The basic diagram of the elaborated complex for the external electromagnetic flattening is represented.
3. The implementation of the external non-contact removing the dents on a car body is described in a shape of the practical algorithm of the sequence of the demanded operations.
4. The suggested method flattening allows preserving the paint covering without any damage what was confirmed experimentally

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