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EXTERNAL MAGNETIC PULSE STRAIGHTENING – NEW TECHNOLOGY CAR BODY REPAIR

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Abstract. *Innovative equipment of external contactless magnetic impulse straightening developed by the laboratory of Electromagnetic Technology of Kharkiv National Automobile and Highway University is presented in this paper. The effect of metal hyper-plasticity at magnetic impulse acting is described. Suggestions concerning practical testing of advanced technology of damaged car body panels by external contactless magnetic impulse straightening are presented. The processing route of external contactless magnetic impulse straightening process is specified.*

Key words: *external straightening, dents removing, body repair, magnetic-pulse metal working, car body panels.*

ВНЕШНЯЯ МАГНИТНО-ИМПУЛЬСНАЯ РИХТОВКА – НОВАЯ ТЕХНОЛОГИЯ КУЗОВНОГО РЕМОНТА АВТОМОБИЛЕЙ

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Аннотация. *Описано разработанное в Лаборатории электромагнитных технологий ХНАДУ инновационное оборудование внешней бесконтактной магнитно-импульсной рихтовки. Описан эффект гиперпластичности металлов при магнитно-импульсном воздействии на них. Представлены предложения по практической апробации новой прогрессивной технологии внешней бесконтактной магнитно-импульсной рихтовки поврежденных элементов кузовных панелей автомобилей. Описан технологический маршрут операции внешней бесконтактной магнитно-импульсной рихтовки.*

Ключевые слова: *внешняя рихтовка, удаление вмятин, кузовной ремонт, магнитно-импульсная обработка металлов, кузовная панель.*

ЗОВНІШНЄ МАГНІТНО-ІМПУЛЬСНЕ РИХТУВАННЯ – НОВА ТЕХНОЛОГІЯ КУЗОВНОГО РЕМОНТУ АВТОМОБІЛІВ

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Анотація. *Описано розроблене в Лабораторії електромагнітних технологій ХНАДУ інноваційне обладнання зовнішнього безконтактного магнітно-імпульсного рихтування. Описано ефект гіперпластичності металів під час магнітно-імпульсному впливу на них. Подано пропозиції з практичної апробації нової прогресивної технології зовнішнього безконтактного магнітно-імпульсного рихтування пошкоджених елементів кузовних панелей автомобілів. Описано технологічний маршрут операції зовнішнього безконтактного магнітно-імпульсного рихтування.*

Ключові слова: *зовнішнє рихтування, видалення вм'ятин, кузовний ремонт, магнітно-імпульсна обробка металів, кузовна панель.*

Introduction

Number of cars in the world grows at a huge rate year by year. Unfortunately, quantity of road traffic accidents in which car body panels are damaged in a varying degree, but imminently, grows at the same time. Therefore, car body panels repair and restoration related operations are relevant and in increasing demand. And, as statistics shows – up to 80 % of the damages are small and medium. Half of them are dents not requiring replacement of the entire element and removable by straightening. Over 50 % of these damages are in the areas with difficult or completely closed reverse access. As a result, car body recovery methods, which allow you execute the so-called external straightening without the necessity of disassembly of car body elements and existing protective paint damage, are of special interest [1–6].

Publications analysis

The implementation of magnetic-pulse technology in repair and recovery of transport vehicles body elements led to creation of a whole new direction, which can be formulated as development of repair and recovery of transport vehicles body methods, based on the energy of electromagnetic fields.

These methods have variety of advantages (in comparison with conventional methods):
– ecological cleanliness and resource-saving;
– no mechanical contact with processed object;
– low self-cost of equipment (in comparison with the existing analogues);
– possibility of dents removal from vehicle body panels on their surface without dismounting and dismantling;
– possibility of protective covering retention;
– controllability of straightening process;
– utilization flexibility – usability for other manufacturing operations (crimping, distribution, stamping, etc.).

It should be noted that while working with metal by conventional mechanical methods (straightening, pressing, stamping etc.) metal becomes thin and stretched. In such case top metal layer undergoes a deformation that leads to its structure disruption [4, 7]. Magnetic-pulse straightening methods are devoid of these drawbacks because the interaction of the magnetic field with the induced current (full-thickness of processed metal) initiates a metal stretching by attraction forces that act throughout its full-thickness [1–3, 5, 6].

The aim and the formulation of the problem

Description with practical testing of the new advanced technology of external non-contact magnetic-pulse straightening of car body panel damaged components without their dismounting and dismantling which was proposed by the Electromagnetic technology laboratory of KhNAHU.

Metal hyper-plasticity

Important factor in favor of the repair magnetic-pulse technology is Metal hyper-plasticity effect which was discovered by professor of the Ohio State University Glenn Daehn and described in the scientific periodical publications in 2000-2004 [8].

It should be noted that the effect acts both in case of massive conducting work piece and in case of thin walled sheet metal which are used as car body panel plating. In the latter case hyper-ductility allows to do non-destructive stamping and straightening (without breaks) of geometrically quite thin products.

The essence of the effect is as follows. Under the action of short pulse loadings the relative deformations of metal samples can be up to 200% (Fig. 1). From a practical standpoint, this effect is interesting because the new metal alloys have arisen in the modern automobile, aircraft and shipbuilding industries and the processing of these metal alloys is impossible by known production methods. For example, the body part molding of these alloys is possible only in hyper-ductility mode [1,5,8]. In practice, this mode can be implemented only by brief heavy influence of magnetic fields. In other force impacts (conventional mechanical methods) there are breaks of processed metal (Fig. 1b).

According to Glenn Daehn, the hyper-ductility effect enables magnetic-pulse processing both in combination with conventional methods - to bring the work piece to the required level of the given product accuracy of manufacturing, and individually as an independent method of high-speed stamping (straightening) [8]. The mover of a proposal says that due to the hyper-ductility effect the processed object doesn't get wrinkled and there are no other negative effects of defor-

mation process. In this regard, the leading global producers have considered that it's expedient to apply magnetic-pulse methods in manufacturing industries and approach to their implementation from the perspective which is different from the sixties and seventies of the 20th century perspective. For example, PSTproducts company (Germany) is engaged in magnetic-pulse processing of metals (stamping, distribution, crimping) for the production demands of industrial sector of different areas [9]. Ford Motor Company (US) is introducing such process step as filling angles in the manufacture of car body elements (Fig. 1d). Leading European carmakers Volkswagen and Audi perform a large variety of technological operations, including cold and weldless connection of car frame structures elements through magnetic-pulse technologies [1, 5].

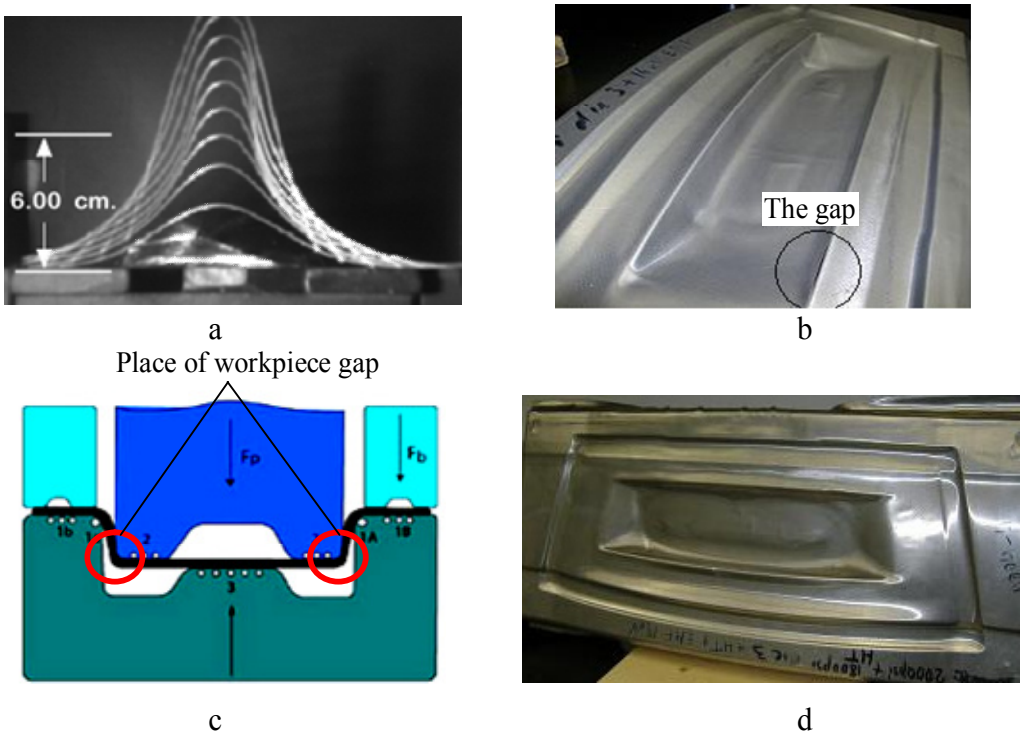


Fig. 1. The deformation of sheet metal: a – high-speed magnetic-pulse deformation of aluminum sheet, photographic recording of the process under sequential force impact (the interval between pulses is 30 ms); b – forming of sheet metal with conventional method; c – back panel of Ford after forming with conventional method; d – magnetic-pulse forming

Complex of external magnetic-pulse straightening

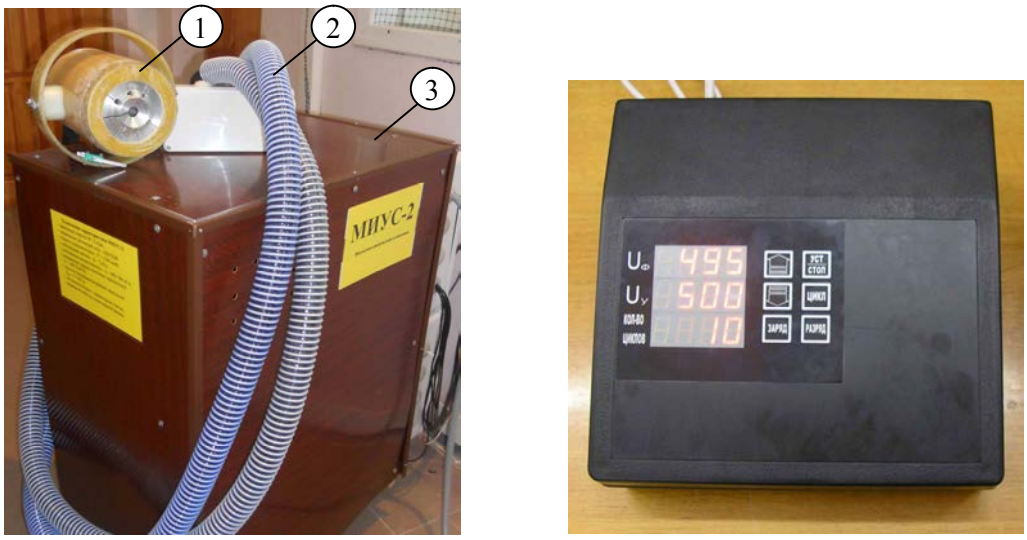
Complex of car body panels external magnetic-pulse straightening, Fig. 2, consists of the power source, which is powered by a set ~ 380/220 V (Fig. 2a, position 3), the control system (control made by the operator through the control panel, Fig. 2b): the tool (Fig. 2, a, the position 1), whereby the operator performs an external noncontact restoring of damaged car body panel metal surface: a flexible cable supply (Fig. 2, a, position 2), which connects the power source with the tool.

The experimental version (prototype) of the complex of car body panel external magnetic-pulse straightening was designed at the Electromagnetic technology laboratory of the Kharkiv National Automobile and Highway University (KhNAHU) Fig. 2 [10].

The specifications of magnetic-pulse installation MIUS-2: stored power W = 2 kJ; mains voltage ~ 380/220 V; capacity of condensers C = 1200 uF; self frequency f_0 = 7 kHz; self-inductance L = 440÷500 nH; charge voltage of capacitive storages U_c =100÷2100 V; repetition rate of discharge pulses f_i =1÷10 Hz.

Processing route of straightening operation

Processing route of external noncontact magnetic-pulse straightening operation is illustrated with photos of conducted experimental studies



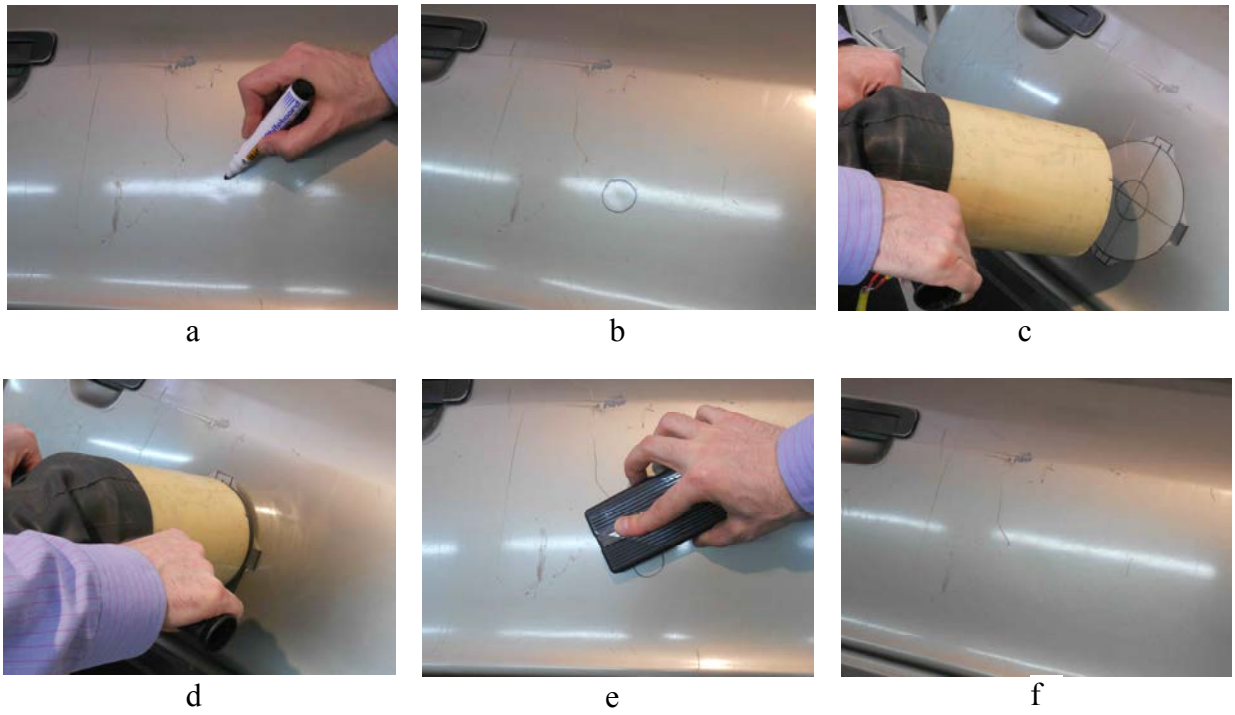
a b

Fig. 2. The prototype complex of external magnetic-pulse straightening: a – appearance of the complex; b – complex control panel: 1 – the magnetic-pulse straightening tools; 2 – the cable supply; 3 – the magnetic-pulse installation MIUS-2 (power source)

(Fig. 3), which are posted on the website «Electromagnetic technology laboratory» KhNAHU [10]. Car body panel of «Audi» door is taken as surface which is straightened on these illustrative photos (Fig. 3). It should be noted that samples of car body panel metals of almost every modern automakers were tested during the experimental testing of the developed complex and researches of the external magnetic-pulse straightening process.

Processing route

1. External examination of the car body surface elements for damage assessment as objects for elimination (Fig. 3, a). Geometrical dimensions and nature of the dents which were identified determine the level and intensity of the required force action.



a b c

d e f

Fig. 3. Illustrative photos of the processing route: a – dent definition; b – marking its edge dimensions; c – fixing tool over the dent; d – magnetic-pulse straightening; e – erase marker drawn objects; f – car door panel after straightening

2. The dent measures and its geometry are defined and fixed by dry-erase marker (Fig. 3, b).

3. Special dielectric pad, the purpose of which - rigid fixation of the external magnetic-pulse straightening tool working area relative to outer edges of dent for elimination is placed on the surface of the car body panel above the dent (Fig. 3, c).

4. The desired energy level, which is set by the operator on the control panel, is selected (Fig.2, b).

5. The required number of force action discharge pulses is selected.

6. The operator fixes the external magnetic-pulse straightening tool over the dent area on the car body panel (Fig. 3, c).

7. The operator brings the system into action, carries out the external magnetic-pulse straightening of the car body panel (Fig. 3, d). Excited forces pull the metal of the car body panel in the tool working area to a level of smooth surface.

8. After the straightening and correction operations the tool and dielectric pad are removed, drawn by marker objects are erased (Fig. 3, e).

If necessary, the operations of the processing route of external noncontact magnetic-pulse straightening are performed several times until the full restoration of the damaged surface. In dents with large geometrical dimensions recovery an integrative process approach is taken. If you remove a few dents, for each of them the straightening processing route is carried out separately and according to the above-described principles.

In fact, the basics of the scientific direction of car body panel restoring, which is different from the existing ones in that straightening is performed outside of the car body panel using the energy of pulsed magnet fields were proposed and formulated by the Electromagnetic technology laboratory of KhNAHU team.

Conclusions

Ever-increasing relevance and perspective of magnetic-pulse technology implementation in the methods and techniques of repair and restoration of vehicle body elements were shown.

Proposals of the Electromagnetic technology laboratory with practical testing of new advanced technology of external noncontact magnetic-pulse straightening of car body panel damaged elements without their dismantling and disassembly were described. The processing route of external noncontact magnetic-pulse straightening operation was brought.

Hyper-ductility effect of metals by magnetic-pulse action on them was described. It was demonstrated that due to this effect the processed object doesn't get wrinkled and has no other negative effects of metal deformation (straightening).

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