

USE OF THE LORENTZ FORCE IN EMF TECHNIQUE

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Among the main problems of our time, ecology, resource conservation and energy stand out the most. Solving these problems will determine the future of humanity. Tools that allow processing of both ferromagnetic and non-ferromagnetic metals without direct contact with the material being processed can help in solving such problems. Such tools include induction induction systems (IIS) [1].

The principle of operation of IIS is based on the use of Ampere's law, according to which conductors with collinear currents in the same direction are attracted to each other. The actual name "induction inductor system" was proposed by the authors of this invention [1, 2]. The name, according to the authors, reflects the principle of action based on induction effects (law of electromagnetic induction) and the phenomenon of force interaction of induced currents (Ampere's law).

In contrast to inductor systems based on the natural attraction of ferromagnets, when reducing the operating frequencies of active fields (that is, using the physical effect in its pure form), induction inductor systems are a technical solution. Here, in addition to the actual inductor-source of the magnetic field and the sheet blank, an additional structural element is introduced. This is the so-called additional or auxiliary screen. It is located parallel and symmetrical to the plane of the inductor of the sheet metal being processed [2]. If the screen and the workpiece are identical, then the same currents are excited in them (we are talking about the magnitude of the time dependence and direction). Their interaction leads to mutual attraction, but the screen is rigidly fixed, so only the sheet blank is deformed. Its section in the region of the inner window will be attracted to the inductor [3].

One of the most important issues when choosing a specific structure of the IIS is the study of electrodynamic processes in it with the determination of the forces that are excited, since their nature and flow in accordance with the design features determine the effectiveness and efficiency of the IIS as a whole.

Therefore, the purpose of this work is the analysis of electrodynamic processes in the induction inductor system with the determination of the main components of Lorentz forces.

The efficiency of the IIS is determined both by its geometry, and by the electrophysical and geometric characteristics of the screen and the workpiece, as well as by the amplitude-time parameters of the current pulse in their relationship.

We use the analysis of electrodynamic processes in the calculation model in the cylindrical coordinate system [3]. In the presented calculation model, Maxwell's equations for the excited components of the electromagnetic field vector ($E_{\varphi} \neq 0$, H_r , $z \neq 0$) are formulated and solved by well-known mathematical methods [1]. Since in the low-frequency mode of the operating fields, in addition to the tangential one, the normal component of the magnetic field intensity vector becomes significant, a force vector with normal and tangential components is excited in the metal of the sheet blank. The first corresponds to the force of magnetic pressure, which ensures the result of magnetic pulse processing of metals in the mode of sharp surface effect [1], the second acts in the radial direction. Its importance is manifested in the case of even small deformations on the surface of the sheet blank. In this case, tangential forces multiplied by the shoulder -

normal deformations should excite rotational mechanical moments. The action of the latter must affect the process of deformation of the processed object as a whole. Mathematically, the normal component of the Lorentz force (z-component) is described by the relationship [2]:

$$F_{Lz}(t, r) = \mu \cdot \int_0^d j_{\varphi}(t, r, \zeta) \cdot H_r(t, r, \zeta) d\zeta. \quad (1)$$

The tangential (radial r-component) component has the form [7]:

$$F_{Lr}(t, r) = \mu \cdot \int_0^d j_{\varphi}(t, r, \zeta) \cdot H_z(t, r, \zeta) d\zeta. \quad (2)$$

It follows from the results of the calculation using expressions (1) and (2) that:

- amplitudes of excited forces in magnetic metals slightly increase compared to non-magnetic ones;
- normal forces (repulsion) are concentrated under the coil of the inductor;
- tangential forces are also concentrated under the turn;
- under the center of the coil, the direction of tangential forces changes to the opposite.

The practical use of the energy of pulsed electromagnetic fields opens up exceptional prospects for the creation of advanced technologies for processing materials of a magnetic and non-magnetic nature. The use of such technologies is seen as effective in the equipment for the repair of means of transport. Here, a complex combination of all the attributes that determine the progressiveness of technical solutions to various production problems, such as ecological cleanliness, high productivity, saving of material and energy resources, is possible.

Accordingly, the obtained results regarding the fact that the amplitudes of the normal component of excited forces in magnetic metals in comparison with non-magnetic ones increase by more than two times justify the use of materials of a magnetic nature. The design values of the coil width in the inductor (its reduction) increase the amplitudes of the excited Lorentz forces by almost 2 times compared to other sizes of inductors.

Conclusions

1. The analysis of electrodynamic processes in the induction inductor system with the determination of the main components of the Lorentz forces was carried out.
2. Obtained analytical expressions for the normal and tangential components of the excited Lorentz forces.

References

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