Lead-free Electroless Nickel by Induction Heating

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Electroless nickel plating solutions traditionally operate at 80 to 90°C. The solutions are normally very active and therefore, much care must be taken to prevent spontaneous deposition on the tank walls and filtration equipment.

A method for heating steel parts by induction through the use of eddy currents in a cold solution was first introduced in the 1970's. This method was recently re-examined and is the subject of this paper. The results to be presented will show that the method, although promising, demonstrates that the overall deposition rate is not high enough and suffers from non-uniformity issues. Compared with traditional heating methods, phosphorous content is dependent on the local temperature at the part surface, as is the plating speed. A benefit from this type of cold process includes that stabilizers, typically lead containing, are not required for solution control. Thus, the process is deemed to be a lead-free, environmentally friendly process alternative versus other heating methods.

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Introduction

Due to the need to recycle parts at the end of a product's life, there is a large demand for lead-free process alternatives in both the electronics and automotive industries. Most electroless nickel formulations contain traces of lead as a stabilizer. Some electrolytes have organic or other metals as a stabilizer. Ongoing improvements to reduce this lead content have been and continue to be undertaken.

There is a proposal from the 80th to use eddy currents by induction for heating [1]. This concept is usable for cylindrical parts in a so called "reactor technology".

The principle is as follows: The electroless electrolyte is cold (ambient temperature) and does not need a stabilizer. Eddy currents heat part of its surface. (Note: Direct heating by AC or DC current is possible but needs two electric contacts on the part.) The area covered by the contact will not plate. In most cases, this is deemed to be a disadvantage.

The first investigations that utilized stabilized electrolytes to study the induction heating were presented at the Euro Interfinish Technical Conference in Padua 2003 [2].

Experiments & Results

Enthone has undertaken further investigations with lead-free and/or complete stabilizer free electrolytes to study this method.

The following scheme demonstrates the principle (Fig. 1, Fig. 2):

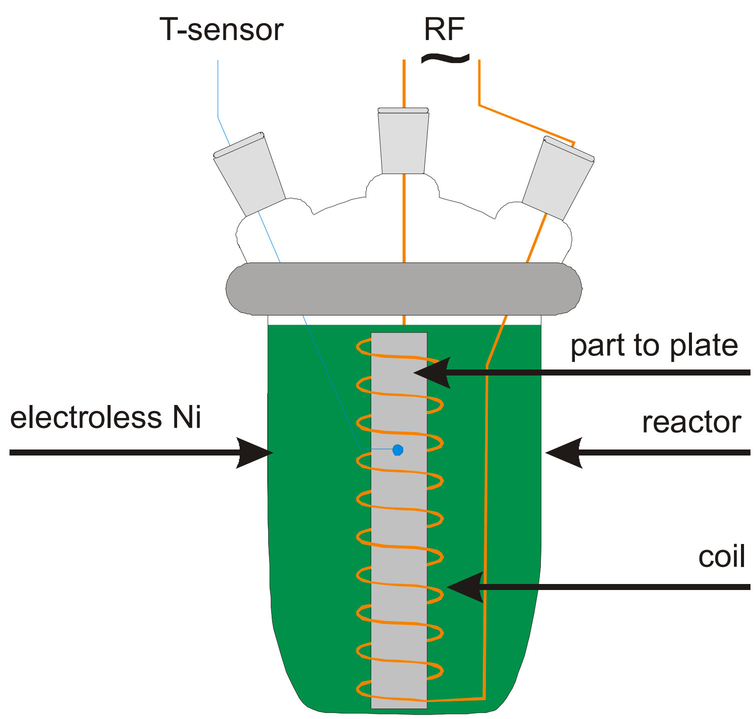

Fig. 1: Induction heating principle

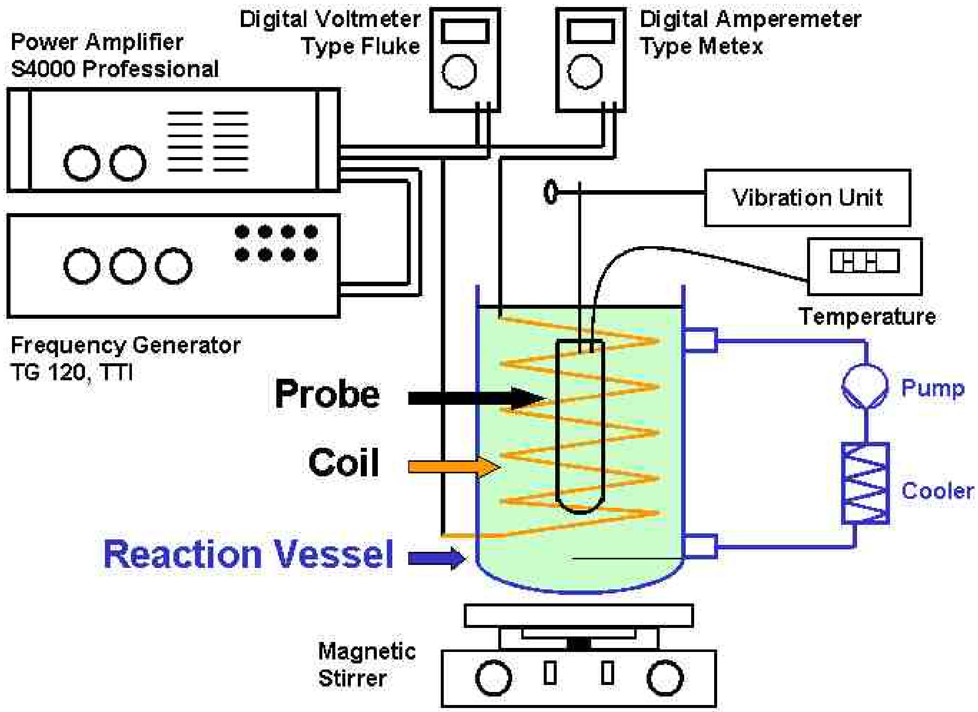

Fig. 2: Experimental set-up

The coil will feed with an alternating current of 1000 Hz and about 4 kW power (Fig. 2). The eddy currents (Fig. 3) will quickly heat the surface layers of the part.

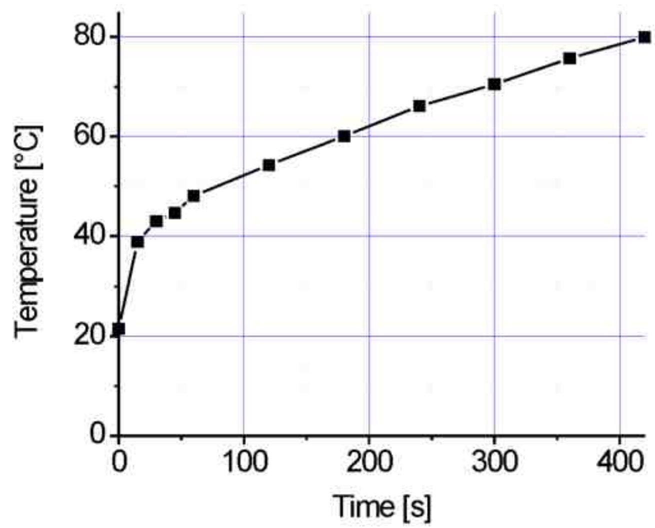

Fig. 3: Heating speed measured direct on the surface of the part

Surface geometry plays a key role in temperature distribution of the part to be plated. The eddy current follows the surface structure. Distance to the coil is also an important factor. The convection and the kinetics of the deposition process may also be influenced.
As a first step, a stationary electrolyte is placed in a small volume of electrolyte that is heated (Fig. 4). Next, a flow through cell is used with the inductive heating equipment (Fig. 5). The electrolyte is allowed to could cool down. Alternately, an isolated coil placed in a larger volume of electrolyte may also be used.

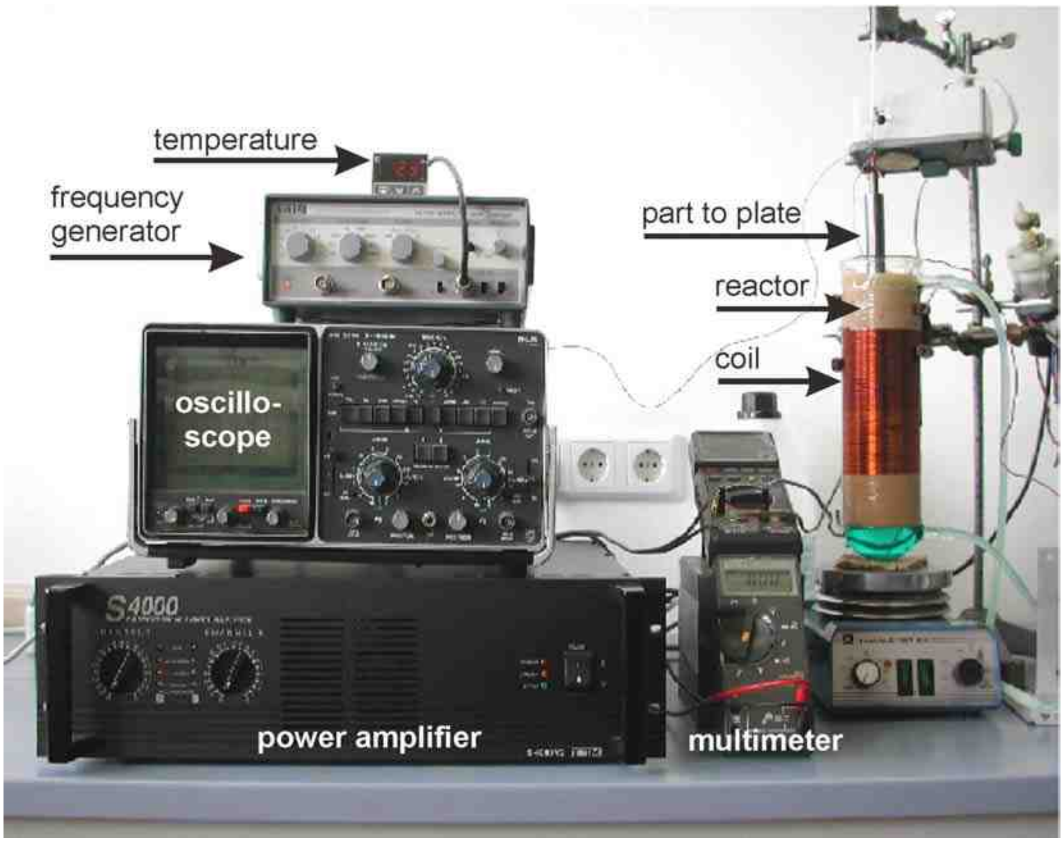

Fig. 4: Equipment with stationary electrolyte

Steel parts with 2-mm deep blind holes for positioning of the temperature sensor were used. The parts were grinded with sandpaper scale 500, degreased in an alkaline cleaner and dipped in 10% sulfuric acid prior to plating.

Fig. 5: Equipment with flow through cell

Target: Integrated Production
Electroless plating of similar parts

- Engine valve shafts, pistons, PWBs, wires, stripes (e.g. eliminate need to transfer production jobs to other plating shops)
- Open the window for Cadmium-free and lead-free systems
- Transfer results to other electroless electrolytes
- Use the system for stripes, PWBs and similar applications for heating in general

Tab.1: Plating speed and P- content depending on temperature and electrolyte type

Type	Temp.	Plating speed	P-content
ENPLATE 429	65°C	12 µm/h	4.1 %
ENPLATE 430	75 °C	25µm/h	4.5 %
ENPLATE 430	**98°C**	**60µm/h**	**9.2 %**
ENPLATE 430 nonstabiliz.	**98°C**	**66.4µm/h**	**4.94 %**
ENPLATE 612	75°C	2µm/h	13.3%
ENPLATE 612	90°C	9.4µm/h	11.9%

We found that the crystal structure of the metal deposit was much rougher without stabilizer. The lead traces had an influence on crystal size and shape. We are now evaluating if an organic stabilizer and non-hazardous metals will provide similar results. For compounds such as saccharine this fact is already well documented. Other grain refiners and additives from electrolytic nickel electrolytes also require testing.

Upcoming experiments are being designed as follows:

Tab. 2: Experimental Matrix for inductive nickel plating

P-Content	**Base Electrolyte**	**Stabilizer**
Low Phos	ENPLATE 430	Lead no stabilizer elements of 4^{th} 5^{th} and 6^{th} main group and organic stabilizers
Mid Phos	ENPLATE 425	Lead no stabilizer elements of 4^{th} 5^{th} and 6^{th} main group and organic stabilizers
High Phos	ENPLATE 612	Lead no stabilizer elements of 4^{th} 5^{th} and 6^{th} main group and organic stabilizers

The experiments are currently in underway.

References

[1] J. Hackerrott, C. Grunewald, H. Kotschy, G. Weimann, H.J. Schilling, DDR-Pat.: DD 249 495 A1 (1987).

[2] A. Möbius, W. Siegert, C. Fabijan, W. Geppl, "Electroless nickel plating with induction heating", EuroInterfinish 2003, October 23-24th 2003, Abbey de Praglia, Italy.

