FINAL REPORT

THE IMPORTANCE OF NICKEL COMPOUNDS:

ELECTROFORMING

Prepared for

European Nickel Institute

5 October 2007

THE WEINBERG GROUP LLC
Le Val Duchesse
360 Boulevard du Souverain, box 5
1160 Brussels, Belgium
e-mail science@weinberggroup.com

BRUSSELS
EDINBURGH
WASHINGTON
SAN FRANCISCO

TABLE OF CONTENTS

THE IMPORTANCE OF NICKEL COMPOUNDS: ELECTROFORMING

1. INTRODUCTION

A highly specialised metal forming process, electroforming uses electro-deposition to fabricate metal parts that meet demanding requirements for extreme tolerances, complexity, precision, wear resistance, accuracy and light weight. When used with nickel, electro-forming delivers to users additional benefits of economy, versatility, and resistance to heat, corrosion, and abrasion. Electro-forming is widely used in two important industrial processes: manufacturing of high precision durable moulds – used to produce complex parts based on a range of different, and often advanced, materials and production of complex sieves and meshes – supporting specialist and high volume production in a wide range of low and high-tech industries. Many of these applications involve high precision replication. Nickel compounds play an essential and critical role in nickel electro-forming: the most widely used form of this important enabling technology.

2. NICKEL AND ELECTROFORMING

The nickel electroforming process consists of an electrolyte bath based primarily on nickel sulphamate solution. The nickel sulphamate provides the nickel ions used to deposit nickel onto a conductive patterned surface such as glass or stainless steel. Once the plated material has been built up to the desired thickness, the electroformed part is stripped off of the master substrate.

Nickel sulphamate solutions are widely used for electroforming because of the low internal stress of the deposits, high rates of deposition, and superior throwing power. Throwing power is the relationship between current distribution and uniformity of coating thickness, as influenced by geometric factors (the shape and relative positioning of anode and cathode), and by the electrochemical characteristics of the solution (conductivity, cathode polarization, and cathode efficiency). Throwing power is a measure of the extent to which a solution will produce deposits that are more uniform than those that would be produced in the absence of cathode polarization and cathode efficiency effects. Because of the very high solubility of nickel sulphamate, a higher nickel metal concentration is possible than in other nickel electrolytes, permitting lower operating temperatures and higher plating rates. A small amount of nickel chloride is usually added to nickel sulphamate solutions to minimize anode passivity, especially at high current densities.

Modern applications of nickel electroforming are diverse. The largest group of nickel electroformed based products are molds and dies. Another large group of products are the electroformed nickel mesh products. The reasons for its popularity include the fact that electrodeposited nickel can be strong, tough and resistant to corrosion, erosion and wear. Its mechanical properties can be varied when necessary by changing plating conditions, by alloying with other elements and incorporating particles and fibers within the electrodeposited nickel matrix.

The highly specialized use of nickel plating process for nickel electroforming is the only technique which results in the manufacture of tools and products that are unique and often impossible to make economically by traditional methods of fabrication. These tools are indispensable for operations in the aerospace, textile, automotive and other industries.

3. IMPORTANCE OF ELECTROFORMING FOR THE EU

3.1. Economic Impacts

Nickel electroforming helps underpin the competitiveness of a number of major sectors in the EU, including aerospace, textiles, automotive, banking, and optical media.

Aerospace – large electroformed moulds, principally based on nickel, are used by aerospace companies to manufacture complex, light weight precision parts using advanced composite materials. On a modern passenger aircraft, such parts include wing edges, tail rudders, nose cones, nacelle cowlings, radomes, waveguides, antennae, and fairings. Effective use of advanced composite materials is a key technology for the competitive performance of the aerospace industry. They reduce weight (hence improving fuel efficiency); increase operational life; and cut maintenance costs. Taken together, these benefits help EU companies match global standards of cost and quality. In the EU, the aerospace industry has a turnover of more than Euro 80 billion; employs 435,000 people; and supports a further 1.2 million jobs elsewhere in the economy. It is also a strategic industry, supporting innovation, key skills, and key technologies.

Textiles – modern nickel electroforming is used to produce rotary screen printing drums. Rotary printing is the principal technology used to print textiles, wallpapers, and carpets world-wide. It enables manufacturers to achieve very high levels of precision and accuracy and to produce materials using extended production runs. More than 30 billion square metres of printed textiles, with a value of more than Euro 150 billion, are produced worldwide using rotary screen printing. Despite extensive competition, the EU remains a major centre of textile production, particularly in the newer Member States. Nearly 15% of world-wide production takes place in the EU, supporting more than 2.5 million jobs and generating turnover of over Euro 225 billion in the textile and clothing industries. Innovative use of rotary printing technologies, alongside newer digital ones, helps EU-based companies remain competitive.

Automotive –there has been a substantial increase in the use of non-metallic materials in the automotive sector over the last decade. This has enabled vehicle manufacturers to reduce weight (cutting fuel consumption and emissions); to improve interior and exterior quality; and to develop new, innovative vehicle designs. Nickel electroforming plays an important part in this process. It is used to develop large-scale moulds for the production of high-end, complex vehicle parts, such as lorry and tractor cabs, bonnets, door panels, headrests, steering wheels, bumpers, and armrests. This technology also facilitates the use of advanced materials, providing further

scope for innovation. The EU produces over 18 million motor vehicles each year, more than 25% of global output. Vehicle manufacturing generates annual sales worth more than Euro 560 billion; employs over 2.3 million people; and supports more than 12.6 million jobs indirectly.

Banking – confidence in the integrity of cash and non-monetary transactions are essential pre-conditions for the operation of a sound banking system. Nickel electroforming technology helps banks and other financial intermediaries achieve these conditions. High precision moulds enable bank note manufacturers to use the complex 'Intaglio' process, limiting the scope for counterfeiting and extending the life of banknotes. Similar mould-making technology is used to produce very large numbers of small, highly detailed holograms, one of the security features embedded in payment cards and banknotes. Despite the rise of non-monetary payment systems protection against counterfeiting remains important. The use of cash continues to grow in the EU: in the Euro-area, 11.3 billion banknotes worth more than Euro 600 billion were in circulation in 2007. Moreover, identity theft and other attacks on payment integrity are estimated to affect over 10% of all holders of payment cards.

Optical media – the optical media sector meets the needs of customers for high quality data storage, replication, and retrieval. It is an integral part of the entertainment industry (music, films, and computer games) and the IT industry. The sector encompasses the production and sale of hardware based on CD and DVD technology, and the production and sale of associated hardware. High precision replication technologies, based on nickel electroforming and the production of highly accurate moulds, underpin the competitiveness of the industry. In the EU, the value chain for entertainment applications of optical media generates sales of Euro 40 billion, and supports 400,000 jobs. Further wealth and jobs are supported through IT applications.

Other industries also benefit economically from nickel electroforming technologies. Producers of intellectual property (in sectors such as software, car parts, films, music, and pharmaceuticals) use holograms, produced from electroformed moulds, to guard against counterfeiting, for instance. Highly accurate sieves and meshes, manufactured in nickel-based materials using electro-forming, support high volume production in a range of industries including sugar and starch, powder metallurgy, pharmaceuticals, food and drink, and waste water treatment.

3.2. Other Impacts

Nickel electro-forming also creates additional benefits for the EU:

Efficiency – across a wide range of applications and sectors, nickel electroforming helps improve economic efficiency. In the aerospace and automotive sectors, manufacturers are able to use lighter non-traditional materials for large complex parts, reducing energy consumption and greenhouse gas emissions. For the IT and entertainment industries, DVD and CD technologies help reduce the costs of data storage and retrieval. In the textile sector, durable, advanced rotary printing screens, again derived from nickel electroforming, help manufacturers increase operating cycles, reducing unit costs. Producers of intellectual property and financial

intermediaries benefit from nickel electroforming too. Reductions in counterfeiting cut costs and maximise revenues. Finally, complex sieve and mesh technologies increase the accuracy of a number of major industrial processes, cutting waste and costs.

Innovation – nickel electroforming is a platform technology: it provides a basis, grounded in know-how and experience, for incremental and radical innovation. In the entertainment industry, for example, advances in DVD technology facilitate the use of Blu-Ray and other new recording processes. Other advances in software complexity, video game sophistication, and recording quality have made similar use of electroforming technologies. Producers of aircraft and motor vehicles have also benefited from nickel electroforming: it has provided a basis for the innovative use of new non-metallic materials. In turn, these have been used to improve performance and to increase differentiation.

4. CONCLUSIONS

Nickel electroforming is an important enabling technology that supports the competitiveness of some of the largest industrial and service sectors in the EU. Moreover, it provides a platform for continued improvements in efficiency; for greater innovation; and for increased sustainability. More efficient operation of industrial processes, combined with greater use of non-traditional materials, reduces resource and energy consumption. Nickel compounds play a critical role in the nickel electroforming process.