

A Historical Review Of High Speed Metal Forming



Gunter Zittel

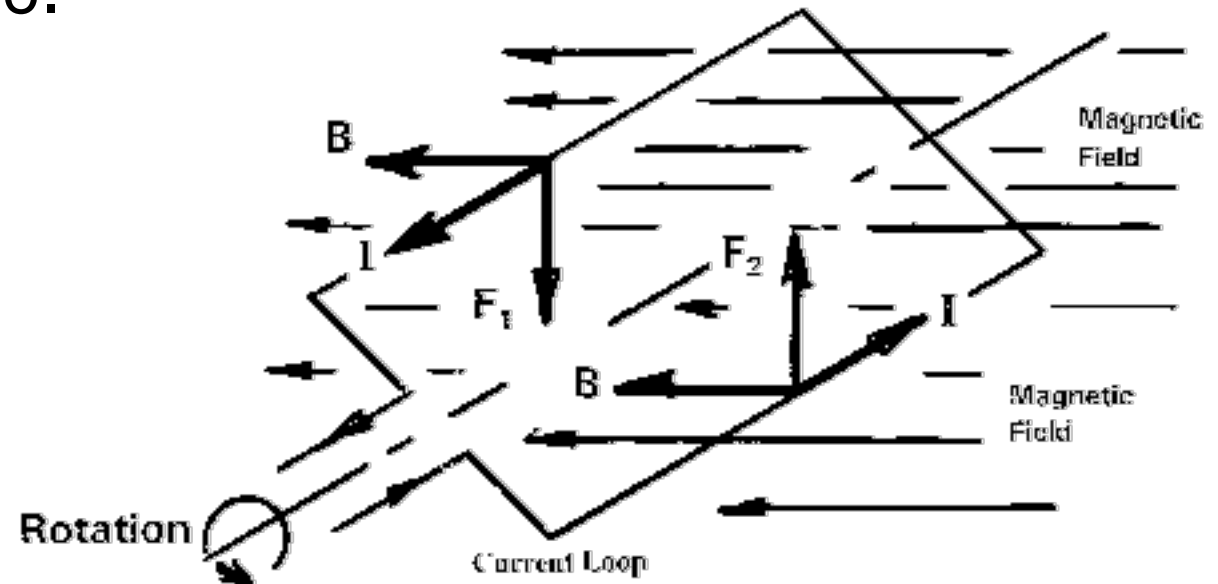
Elmag, Inc., San Diego, CA, USA

Discussion

- Cover The Evolution Of High Speed Metal Forming (HSMF)
- Show Technology Was More Or Less The Result Of Turning An Undesired Nuisance Into A Practical Useful Metal Forming Tool
- Discuss Requirements To Promote The Technology to Industry

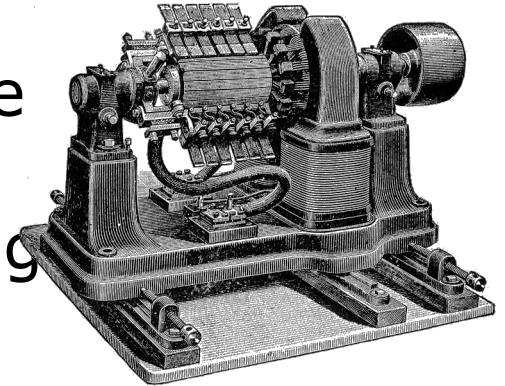
Basic Principle of HSMF

The basis for HSMF is the principle of the Lorentz force which has been known for a long time. However, its practical application for HSMF was more or less a by-product of fusion research 45 years ago.



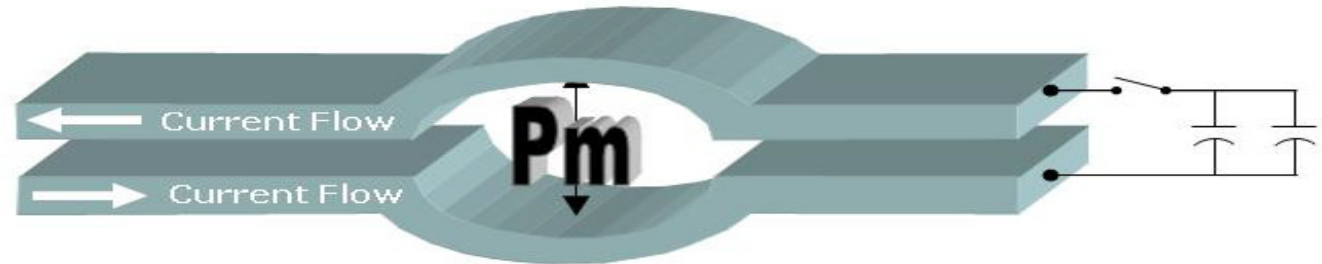
Early Attempts

- Experimenters In The Twenties Tried to make use of the Lorentz Force to Form Metal by Short Circuiting Large Rotating Generators.
- These Attempts Failed and the Experiments Were Discontinued.
- Not Much Happened In This Field Until 40 Years Later.



By-Product of Fusion Research Sparked Renewed Interest

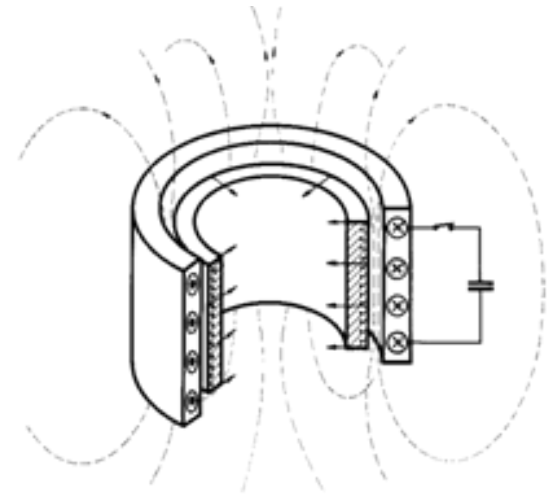
- GA Observation- Material Failures caused By Forces of High Intensity Electromagnetic Pulses Between Current Carrying Bus Works.



- Someone Then Had The Idea Of Using These "Undesired" Forces To Perform Useful Work.

Transforming Bus Works to an EMF Coil

Bus Work System Was Transformed Into A Coil Into Which An Electrical Conductive Work Piece Would Be Inserted And Subjected To An Electromagnetic Pressure Pulse.



First Introduction of EMF Equipment in Industry



Approximately 1963



The first introduction of EMF equipment in Industry was at GM for the banding of neoprene boots onto automotive ball joints.

Requirements to make HSMF an accepted production tool

- **Defining the Key Characteristics of the Process and Dissemination them to Industry**
- Acquainting Engineers and Product Designers with EMF
- Developing Reliable, safe and easy to use EMF Production Equipment



Key Characteristics

- Work Piece must be an electrical Conductor such as mild steel or better
- Work Piece must have a continuous electrical path
- Forming can be accomplished through an insulator, such as plastic or a finish on the material
- The forming speeds is as high as 100m/sec., the material turns plastic and closely conforms to any mating part
- Unlike rolling or spinning, no lubricants are needed and no consequential cleaning is required
- Once a machine is set up, it can be operated by unskilled labor

Requirements to make HSMF an accepted production tool

- Defining the Key Characteristics of the Process and Dissemination them to Industry
- **Acquainting Engineers and Product Designers with EMF**
- Developing Reliable, safe and easy to use EMF Production Equipment



Requirements to make HSMF an accepted production tool

- Defining the Key Characteristics of the Process and Dissemination them to Industry
- Acquainting Engineers and Product Designers with EMF
- **Developing Reliable, safe and easy to use EMF Production Equipment**

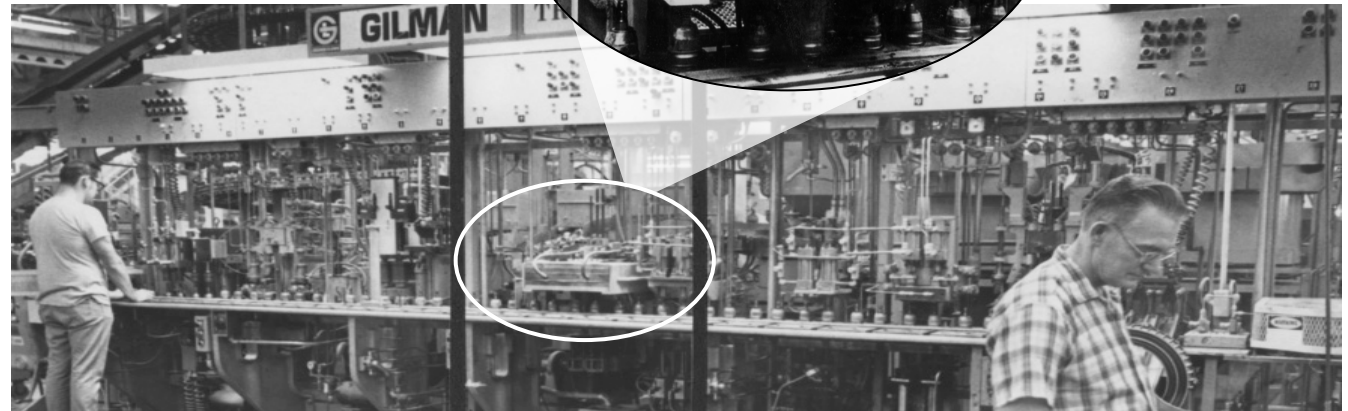
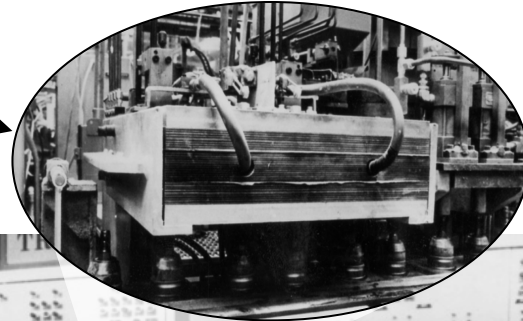


HSMF Equipment Development

- Meet Industrial Safety and Electrical Machine Tool Codes
- Has to be Absolutely Safe
- Be able to be repaired by routine maintenance personnel in case of a break-down
- Be easy to be operated by unskilled labor
- Be economical and capable of running millions of cycles with minimum failures

Ten years later!

Water
Cooled
EMF Coil

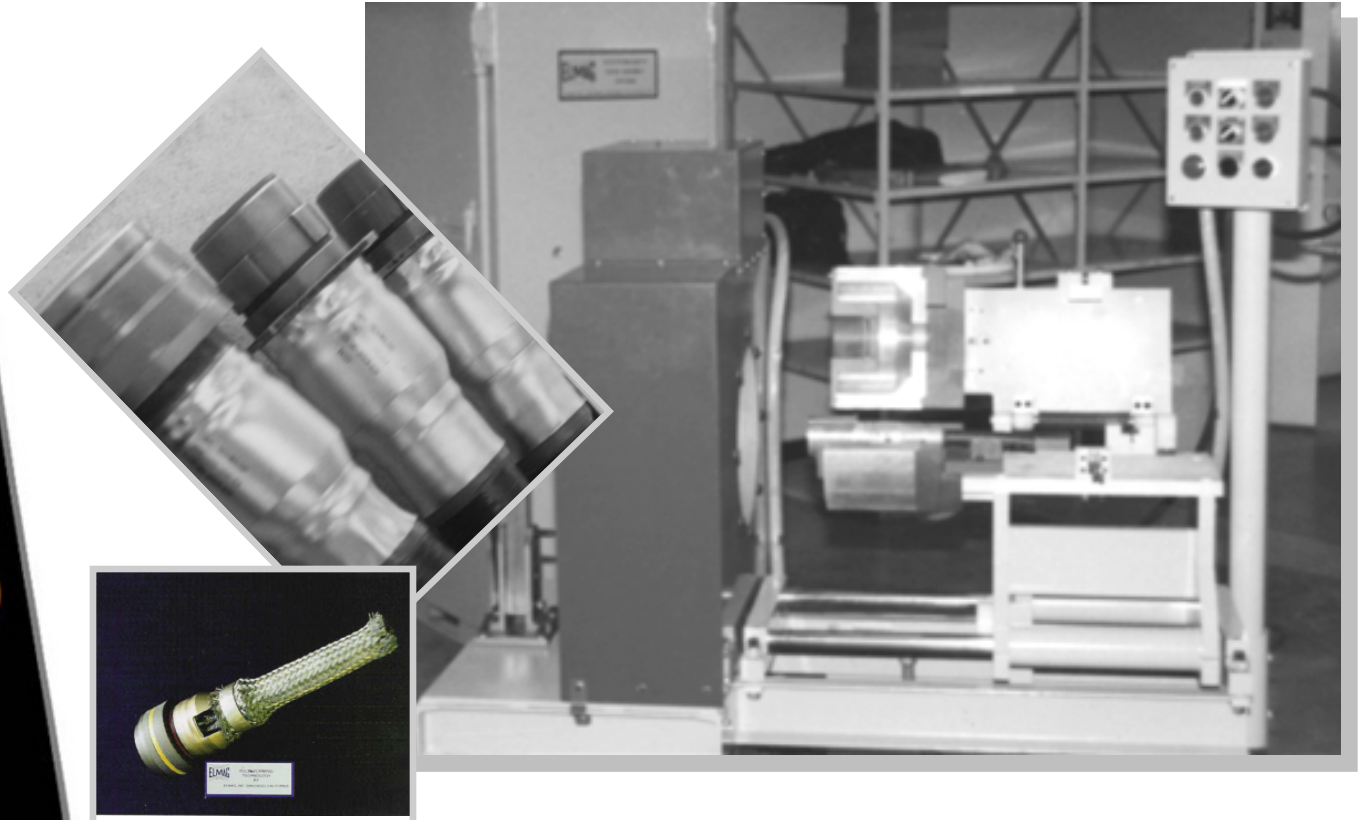


Third Generation EMF Machine at General Motors for final Assembly of Ball Joints. The Machine was incorporated into a fully automated 28 station assembly line and produced several millions ball joint assemblies.

Typical Industrial HSMF Equipment consists of:

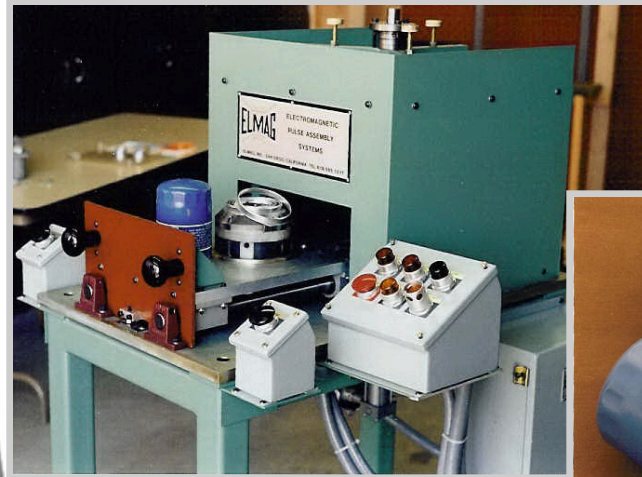
- Energy Storage and Control Unit
- An Electromagnetic Forming Coil
- A Work Station for Work Piece Handling

Simple Work Station with 16kJ Industrial HSMF Equipment



Split Coil To Accommodate Geometry
Of Connectors And Cables

12 kJ MAGNEPULS EMF Equipment with Work Stations



Single Station Semi-
Manual Work Station



Oil Filter
Assembly

Automated Turn
Table to Assemble
Oil Filters

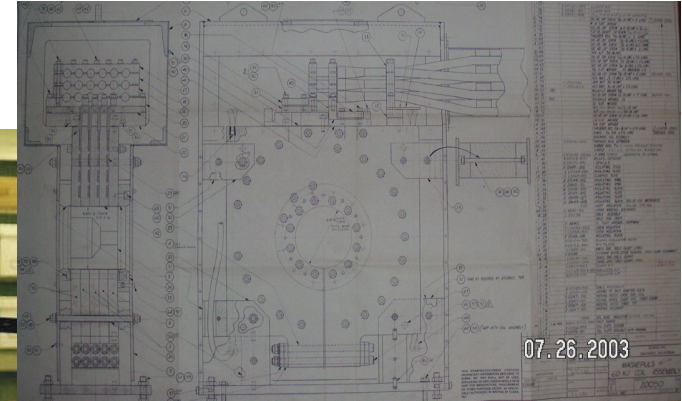


15kJ EMF Equipment with Work Stations



Automated turntable to assemble worm gear components for automotive power steering₁₇

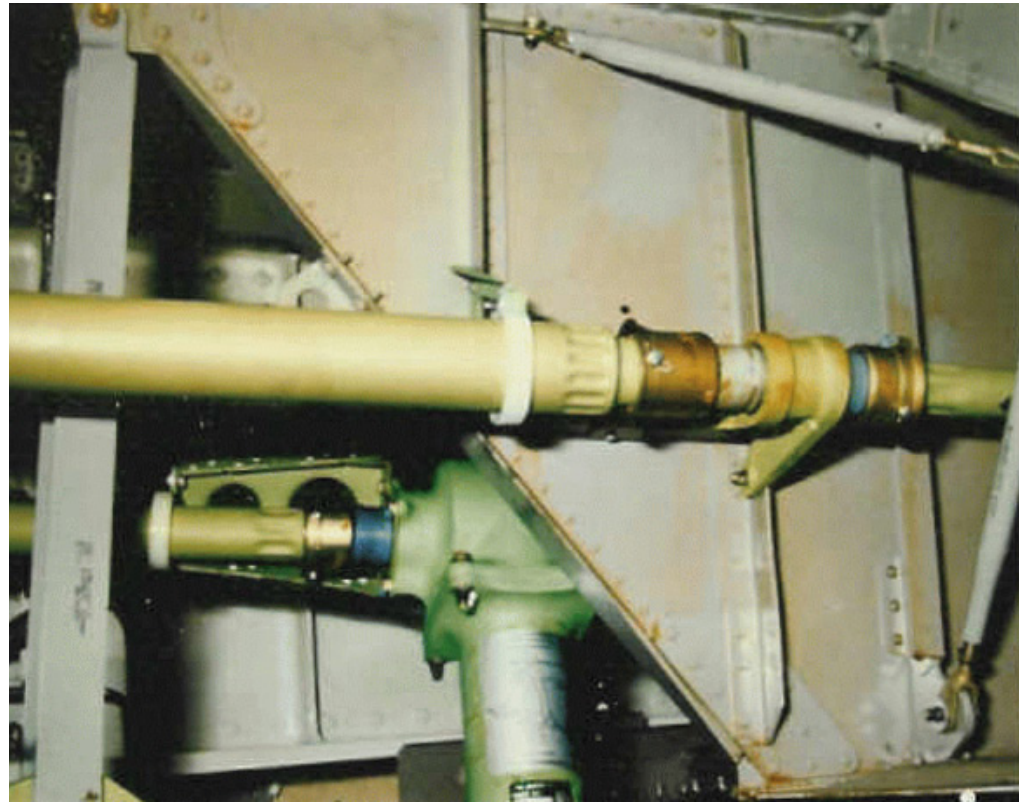
Assembly of Liquid Cooled 60 kJ Compression Coil



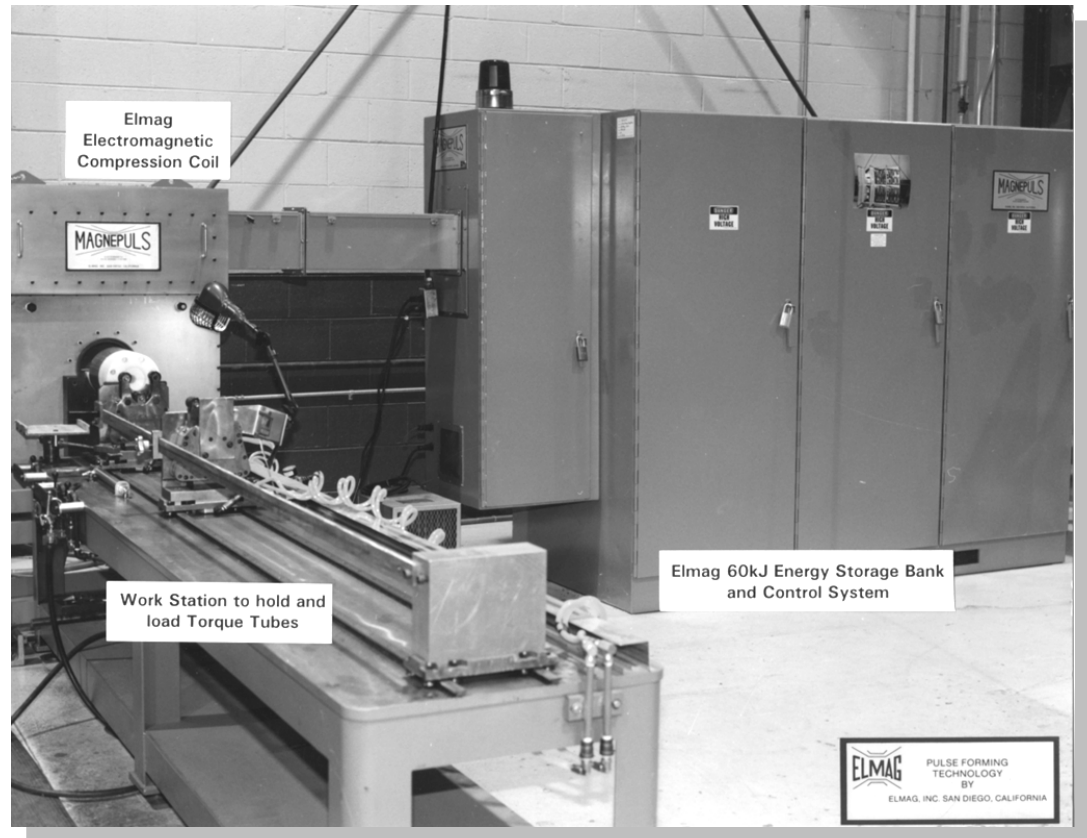
Aircraft Flight Control Tubes



Installed Flight Control Tubes in Commercial Airliner

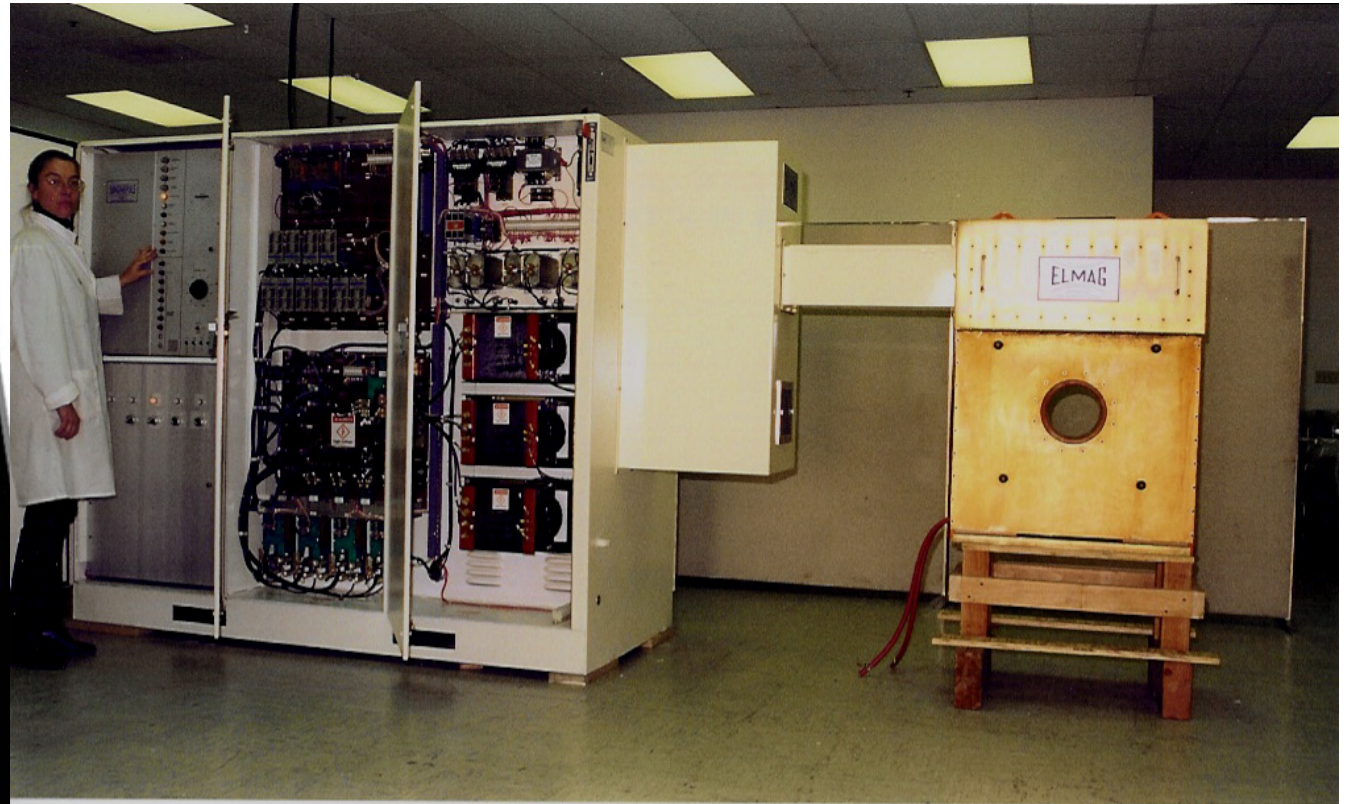


Typical Industrial HSMF Equipment

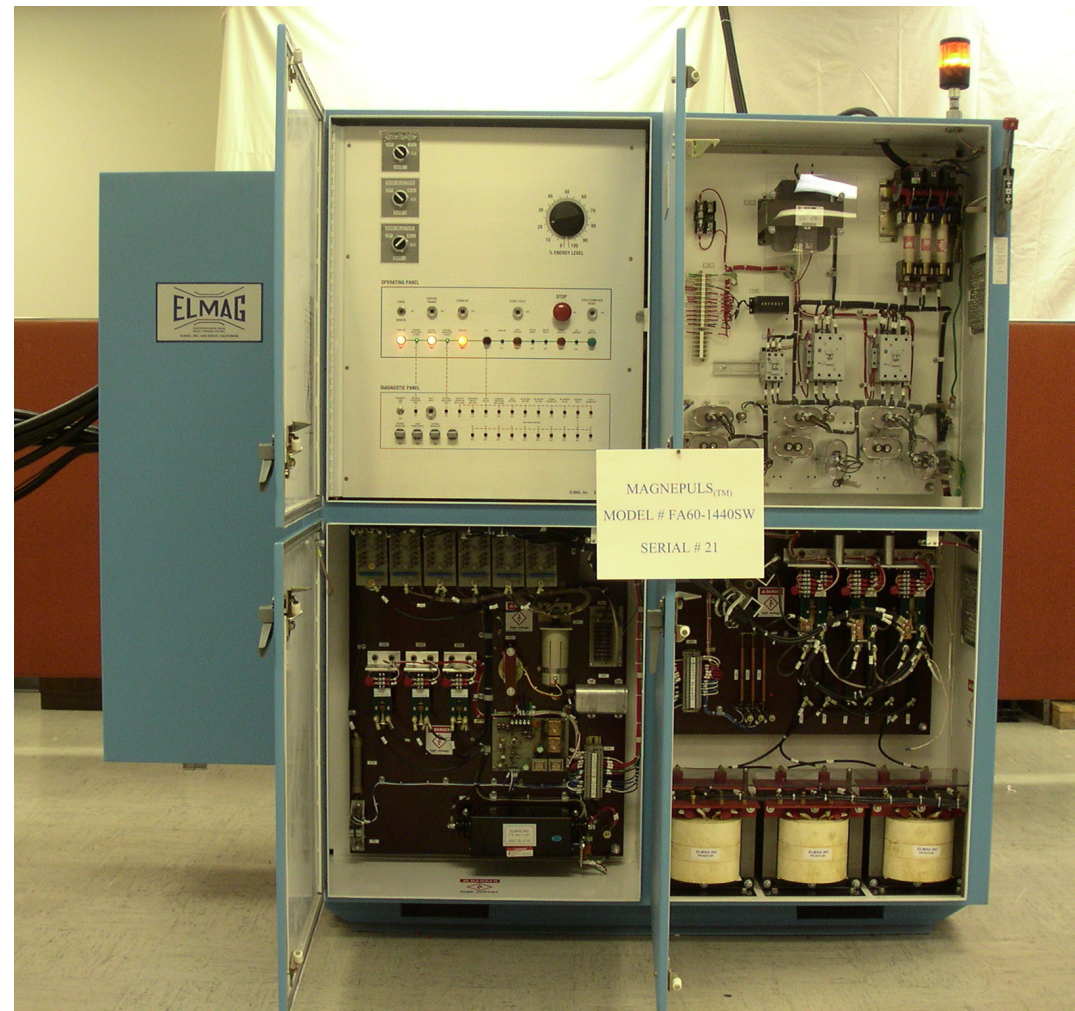


As used in the Aerospace Industry

60kJ Production EMF Machine for Aerospace Industry



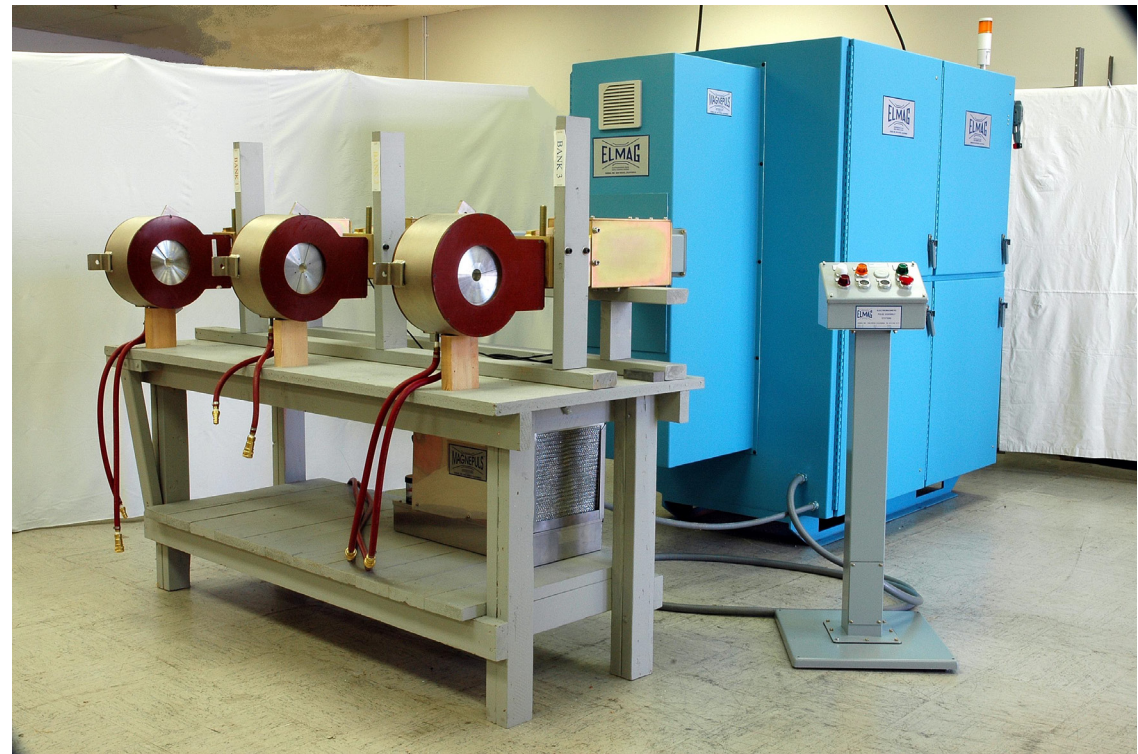
60 kJ EMF Machine Switchable into 10, 20, 30, 40, 50, and 60kJ



Energy Storage Compartment



60 kJ EMF Equipment switchable into three banks of 20 kJ each



Conclusion

- The Acceptance By Industry of The EMF Technology was Directly Related to the Improvement in Reliability and Safety of the EMF Equipment.
- EMF Technology Is Unique and allows designs which cannot be solved with conventional processes. Yet, it does not replace them but rather complements them.





Thank You

