INVESTIGATION OF MAGNETIC PULSE DEFORMATION OF POWDER PARTS

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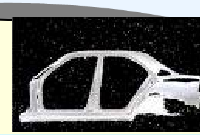
WHZ Zwickau: Research Focusses – Metal Forming Technology

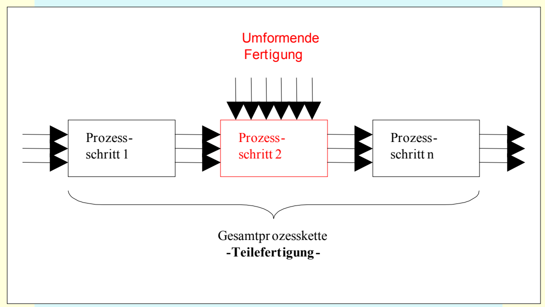


Automobile industry

Automobile suppliers

Optimisation of metalforming manufac-turing

Technology
Processes
Tool



Tool manufacturing industry

Developments to ...

- Sheet metal forming
- Innovative forming processes
- Bulk metal forming
- High speed forming by elektromagnetic impulse
- explosive energy supported forming
- Investigation of material

-component oriented research-

-basics oriented research-

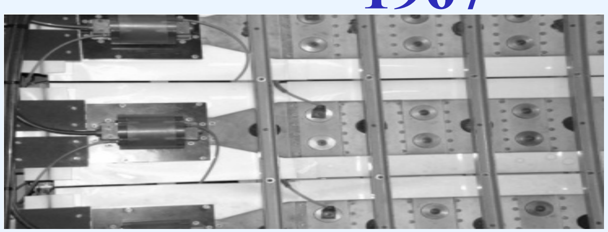
Selected Equipments - Metal Forming Technology

7 Presses for sheet-/ bulk- metal forming, Equipment for materialtesting

Magnetic impulse forming machine

BBC, 60kJ

1967



Poynting 30kJ

2010

poynting

Riga Technical University. Powder Materials Laboratory

Main Research Areas

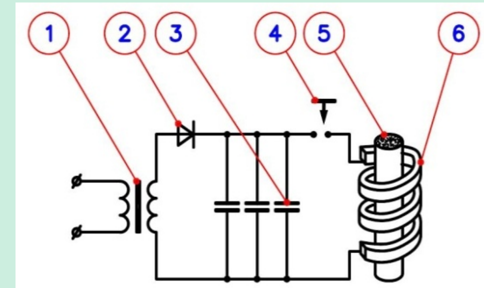
- Metals Electromagnetic Forming
- Powder Materials Compacting and Forming
- EM transport of powder materials
- New Compozit materials (Al-W-B, Fe-C-Cu)
- Infiltration of PM materials

Generator of impulse currents for compaction by electromagnetic pulsed field (Riga, RTU)

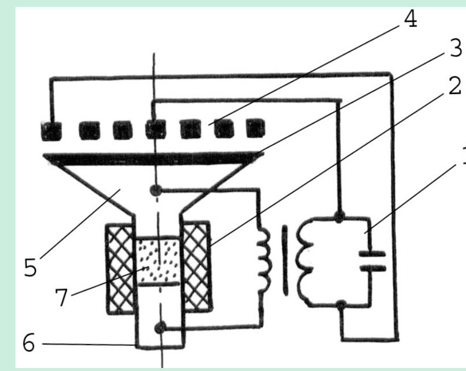
MIU-6
W = 6 kJ
U = 1-6 kV

Processes and products developed at RTU

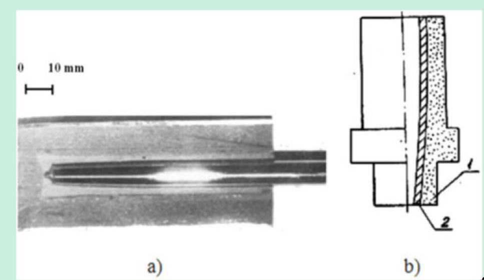
Powder forming and deformation of powder parts



Powder sintering with applied force impulses



Multilayer parts produced by magnetic pulse compaction of Fe-Cu powder materials



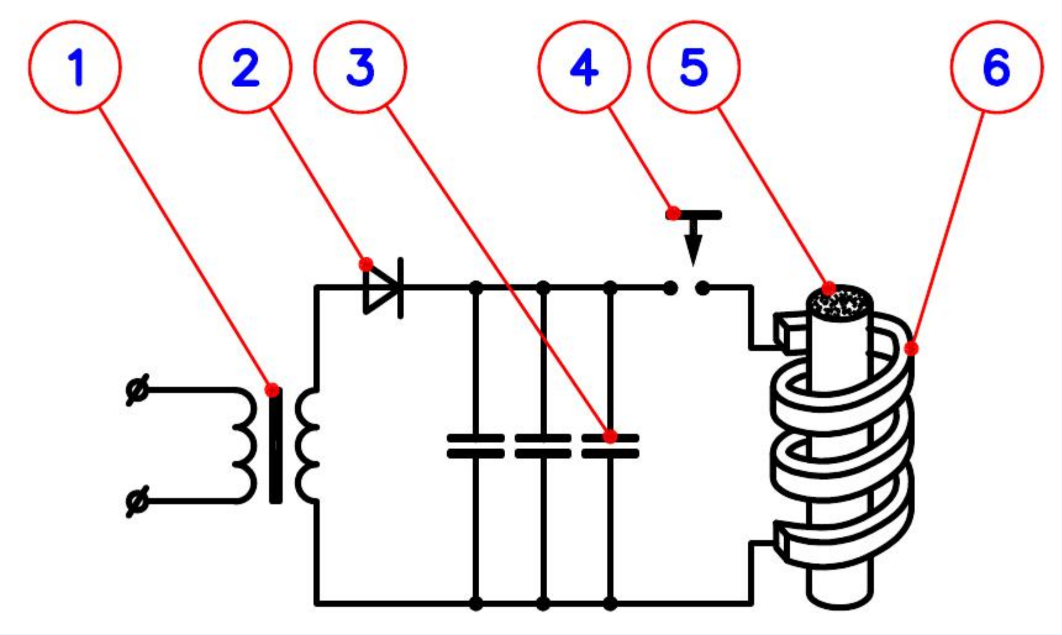
Various permeable powder materials obtained by TEMIF process (RTU, Riga)

Multilayer element made of titan powder. Ø = 40 mm, H = 125 mm.

Permeable element made of bronze powder, fixed in a copper holder.

Permeable elements made of iron powder in copper shell. Ø = 10-40 mm, H = 30-160 mm.

Schematic of treatment by electromagnetic impulsed field (TEMIF process)



1 – transformer
2 – rectifier
3 – battery of capacitors
4 – discharger
5 – powder part
6 – coil

Compaction of powders by electromagnetic impulse

- V. Mironov, "Pulververdichten mit Magnetimpulsen," *Planseeberichte fur Pulvermet.,* 1976,
- H. Wolf, V. Mironov "Verdichten von Metallpulvern durch elektromagnetische Kräfte," Zwickau: 1979.
- N. Dorozhkin, V.Mironov, V.Vereshchagin, and A.Kot, *Electro methods for coating of metal powders,* Riga-Minsk,, 1985.
- V. Shribman, *Svetsaren, a Welding Review,* 2001,
- A. Mamalis, D.Manolakos, A.Kladas, and A.Koumoutsos, "Electromagnetic forming and powder processing: Trends and developments," *Applied Mechanics Reviews,*, 2004
- V. Mironov,V. Zemchenkov, and V. Lapkovsky, "Model *of the* Magnetic packings of dispersed materials," *Ostrava,* 2009,
- V.Chelluri and E. Knoth, "Powder *Forming* Using Dynamic Magnetic Compaction,", 2010.

Theoretical background of TEMIF process

Electromagnetic pressure

$$p(t) = \frac{H_m^{\;2} \mu\mu_0}{2} e^{-\beta t} \sin^2 \omega t$$

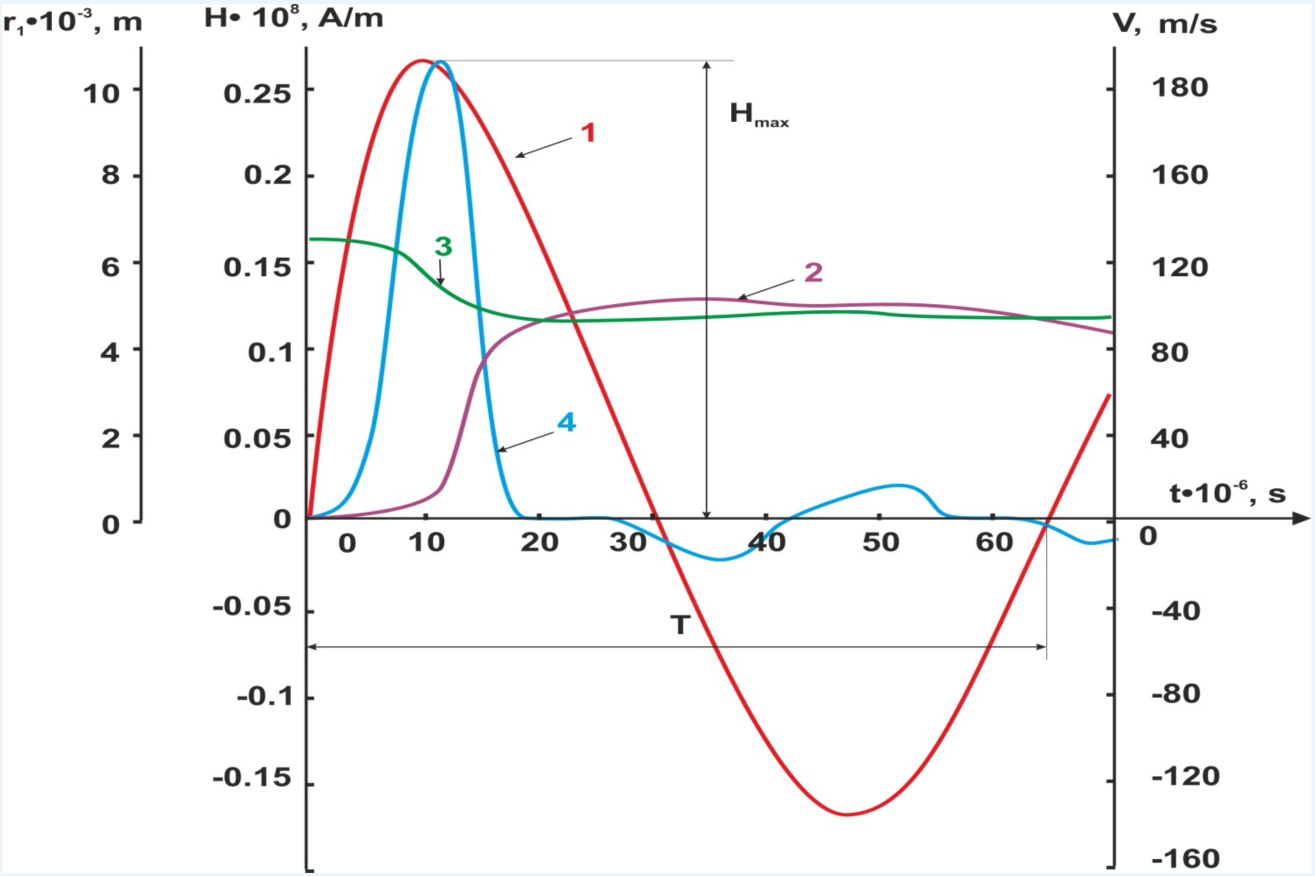
where:
H_m - magnetic field strength in the gap of the coil-workpiece,
μ - magnetic permeability of the workpiece material,
μ_0 - permeability of vacuum,
β - damping of discharge current,
ω - current' s angular frequency.

Pressure, required to compress the powder material

$$p_d = 2\sigma_s \ln\left(\frac{c_0}{c}\right)$$

where:
σ_s – tensile strength of powder workpiece,
C_0, C - initial and final density of powder workpiece.

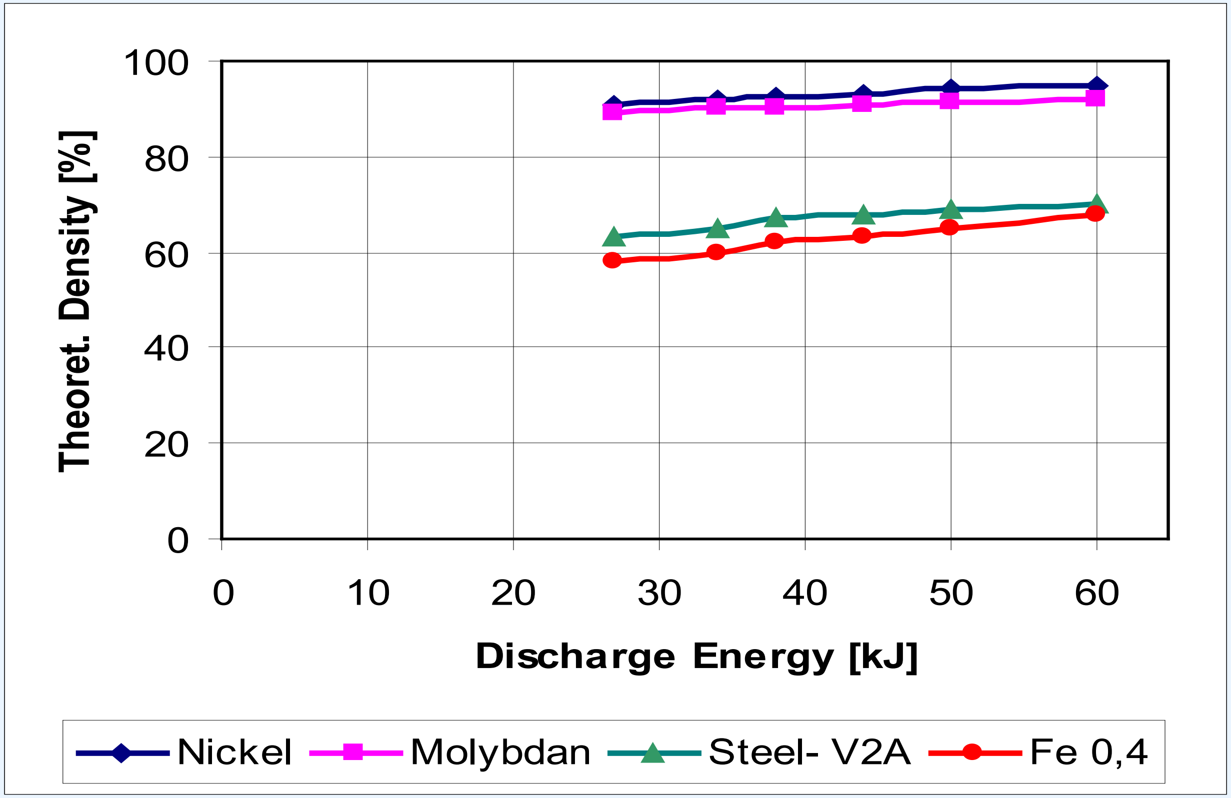
Change of magnetic field strength H_1 (1), H_2 (2); moving of powder part's wall r_1 (3); velocity Vr_1 (4) during the compression of powder material



H_1 , H_2 – magnetic field strength on the external and internal surfaces of powder part

D_{out} = 20 mm
D_{inn} = 18 mm
Length = 50 mm
Coil: w = 22,
R = 0,013 Ohm
U = 1,6 kV

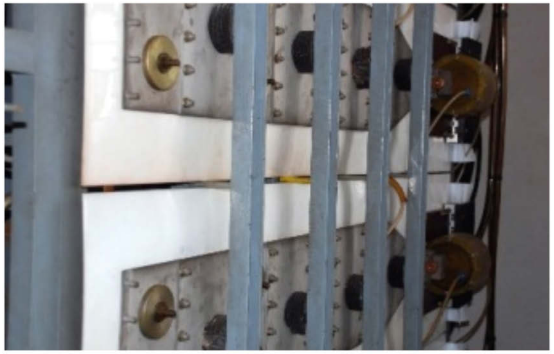
Density of electromagnetically compacted powder samples of different materials



D_{out} = 40 mm
D_{inn} = 25 mm
Length = 150 mm
Single action coil: copper
BBC- 60

Experiments. Deformation of PM Parts by Electromagnetic Field

Equipment used for TEMIF
Deformation was realized using the BBC-60 equipment.
Materials for TEMIF processing
The preliminary sintered at 1150ºC items made of Fe-C, Fe-C-Cu powders
Electromagnetic pressure
The pulse pressure 200-300 MPa.



Experimental parameters

Workpiece parameters	
workpiece weight	*100-300 g*
wall thickness	*2-10 mm*
workpiece diametrs	*20-50 mm*
workpiece length	*10-70 mm*

Electrical equipment parameters	
discharge energy	*1-20 kJ*
voltage	*10-20 kV*
frequency	*30-100 kHz*

Properties of the powder material	
material	*Fe-C, Fe-C-Cu*
particle size	*20-100 µm*
additives	*C (1,2%)*
porosity	*12-15 %*

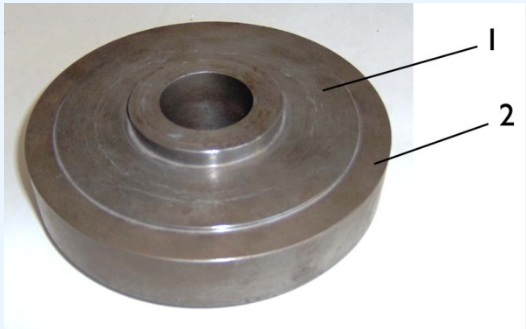
Joining	
coil wire	*Copper (3.5 mm)*
coil inductance	*0.04 µH*
gap between powders parts	*0.1-1.2 mm*

Experimental tasks

Powder parts on the steel mandrel

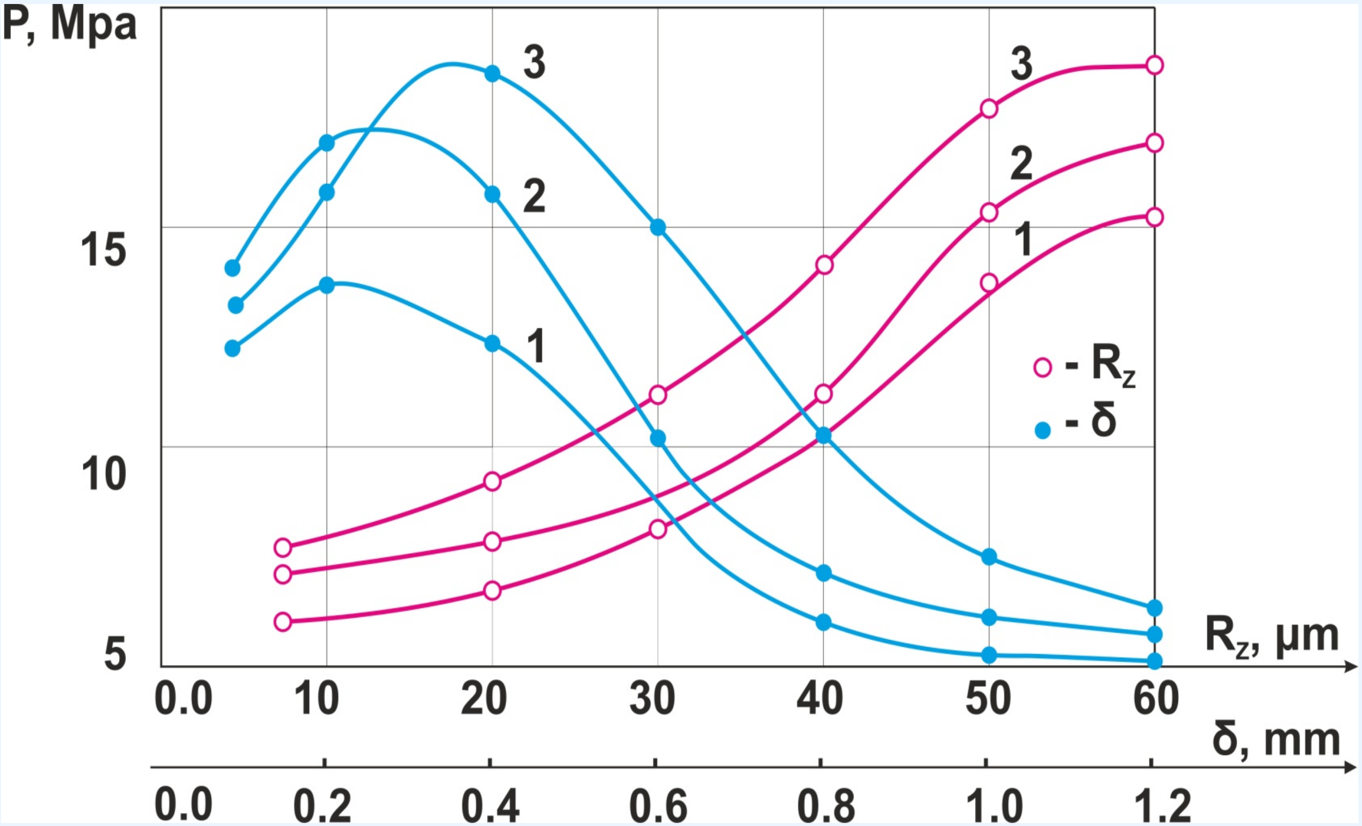
Two coaxially placed powder parts (Fe-C)

Single-action copper coil with powder parts inside



Two coaxially placed powder parts (1. Fe-C-Cu, 2. Fe-C)

Dependence bonding strength *P* on energy level of discharge *W*, rod surface roughness *Rz* and gap between details *δ*.



Energies:
1 – W=6 kJ/cm^3;
2 – W=8 kJ/cm^3;
3 – W=10 kJ/cm^3

Conveying of powder & powder parts by pulsed electromagnetic field

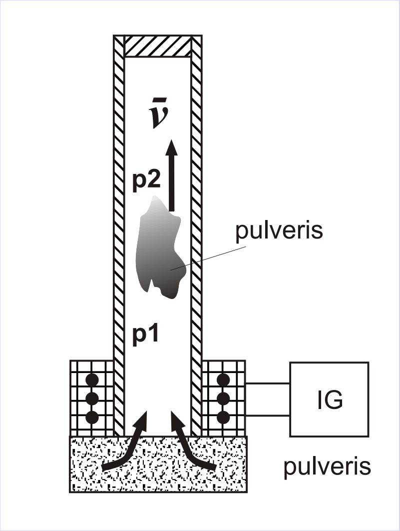
Recent patents and PCT application

V. Mironovs, A. Šiškins, V. Lapkovskis, J. Baroniņš. Magnetic stirrer. LR Patent application 14382 A , 14.06.2011.

V. Mironovs, V. Lapkovskis, A. Šiškins, J. Baroniņš. Method and device for mixing of powder materials. LR Patent application 14383 A, 10.06.2011 .

"Device for Dosing and Conveying of Ferromagnetic Powders“, PCT / IB 2009/055783. (!!! FOR PATENTING IN THE EU AND IN THE U.S.A. !!!)

Conveying of powders and powder parts by pulsed electromagnetic field (Riga, RTU)



Conclusions and future prospects

- TEMIF process can be used for compaction, deformation, joining, and conveying of powder materials.
- A degree of deformation depends on properties of powder, powder parts and mandrel materials as well as of equipment and coil's parameters.
- Experiments have shown that the gap between coil, powder part, and mandrel have significant influence on joining process.
- TEMIF process can be used in the following industries: ferromagnetic powders manufacturing plants, metallurgical plants, manufacturing of powder metal components, chemical plants, feeding systems, in fiber production.
- Further investigations are planed using the new electromagnetic power unit at the Zwickau University of Applied Sciences and in Riga Technical University.
- We invite you to cooperation for TEMIF process applications.

Thank you for attention !

Westsächsische Hochschule Zwickau
University of Applied Sciences

RTU

EIROPAS SOCIĀLAIS FONDS
EIROPAS SAVIENĪBA

In this work were also involved:

Dr. Manfred Maynel, emiritates professor of WH Zwickau

Vyacheslav Lapkovsky, a PhD student at Riga Technical University

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