

Joining Sub-Platform

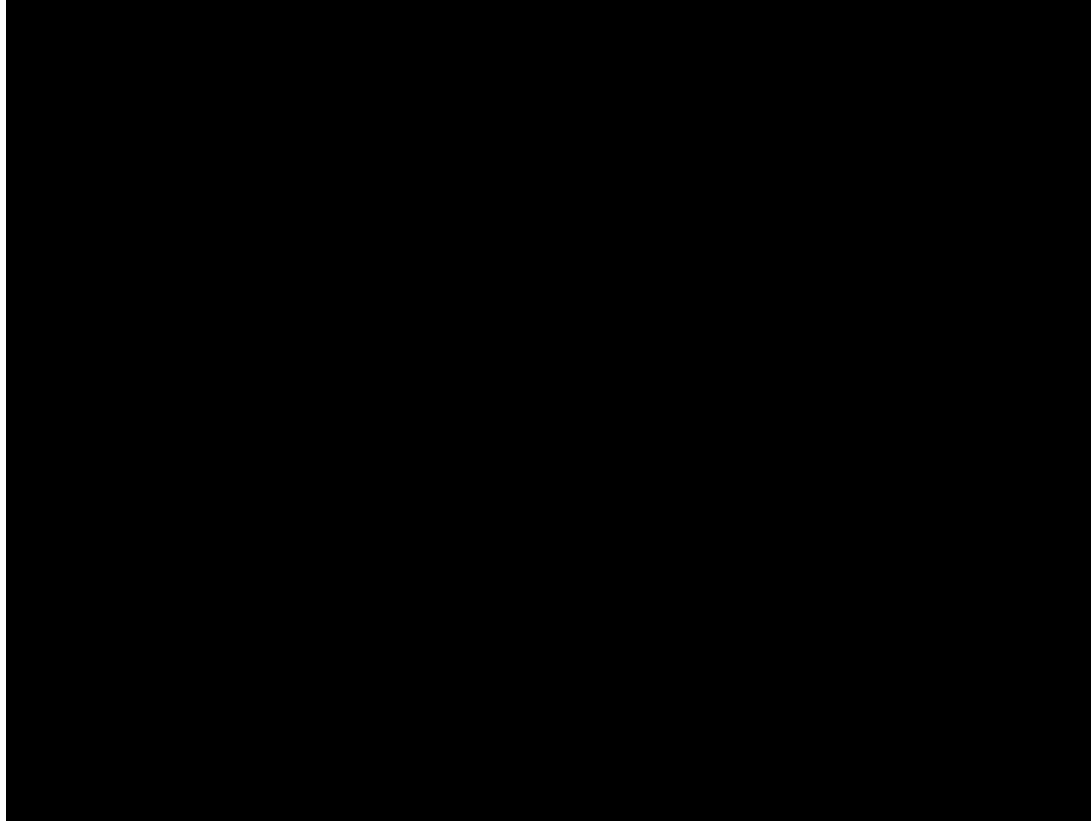
Industry 4.0 in Welding

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VISION ANNO 2005: WELDING IN 2145



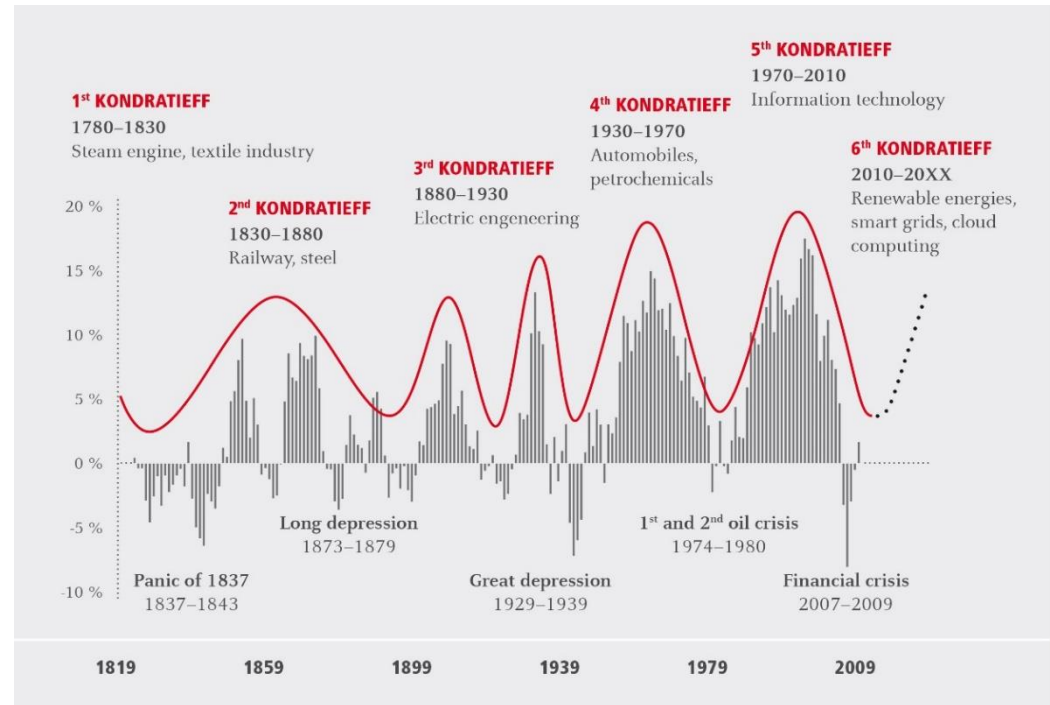
OUTLINE

- / Kondratieff Cycles / Internet of Things / Industry 4.0
- / 4th Industrial Revolution – Factory of the future
- / Industry 4.0 and its implication on Gas Metal Arc Welding
- / Digitalization of welding knowledge
- / Microprocessor-based welding power sources
- / Data communication, storage & security
- / Human / welding machine interaction
- / Virtual Welding
- / Metal Additive Manufacturing
- / Conclusions




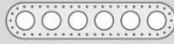


KONDRATIEFF CYCLES – TECHNICAL INNOVATIONS

- / Nikolai Kondratieff (1892-1938):
Monitoring of trend-setting technical achievements in relation to economic development; starting in 1780`s
- / Findings: Cyclic behavior; Cycle time: 40-60 yrs
- / 5 cycles recognized; now: 6. cycle
- / Current trend-setting achievements:
 - / Renewable energies
 - / Smart grids
 - / Cloud computing



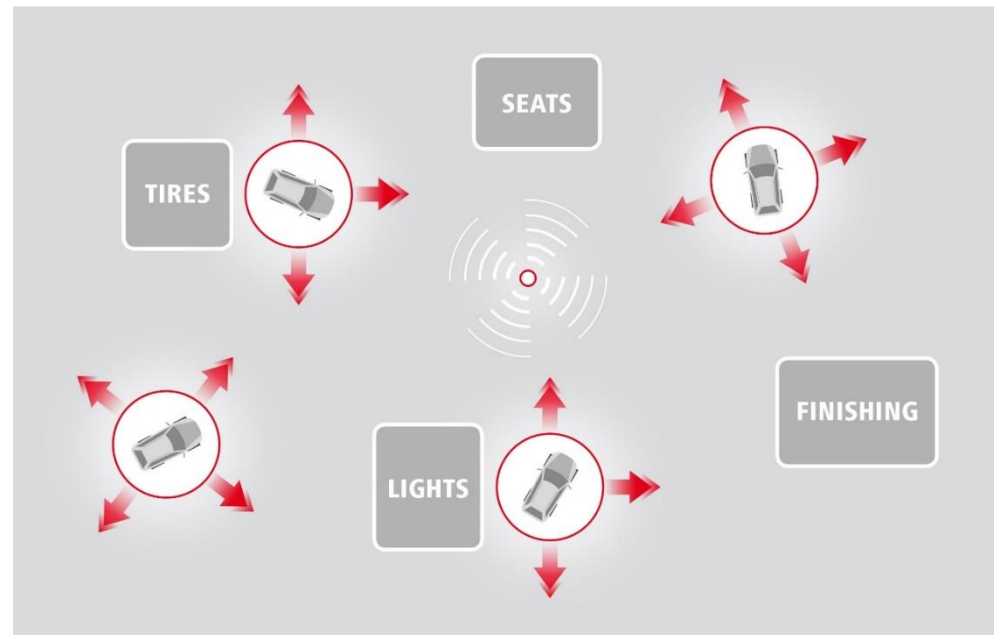
THE 4TH INDUSTRIAL REVOLUTION – „INDUSTRY 4.0“

- / Application of IoT in industrial environment
- / German synonym: “Industrie 4.0”
- / 3 key areas:
 - / Use of IoT and digital services within value chain
 - / Change in hardware design: mechatronic → cyber-physical
 - / Realtime data generation

 Steam engine	 Conveyor belt	 Computer, NC, PLC	 Cyber Physical Systems
1st INDUSTRIAL REVOLUTION	2nd INDUSTRIAL REVOLUTION	3rd INDUSTRIAL REVOLUTION	4th INDUSTRIAL REVOLUTION
Quality of life Engineering sciences	Mobility	μ-electronics	Information and communications technology
late 18 th – early 19 th Century	late 19 th – mid 20 th Century	Second half of 20 th Century	Early 21 st Century

FACTORY OF THE FUTURE - SMART FACTORY

- / Shift from conveyor belt driven manufacturing to modular assembly (much higher flexibility)
- / Master control unit: „digital mastermind“: decision, which manufacturing cell takes over next assembly step, based on reported data
- / Various manufacturing cells: high end production units with digital quality control
- / Focus: efficient manufacturing data reporting



INDUSTRY 4.0 AND ITS IMPLICATION TO WELDING, ESPECIALLY GAS METAL ARC

Thinking in „Industry 4.0“ following topics will play a mandatory role in achieving an „autonomous welding cell“:

- / Digitalization of welding knowledge
- / Microprocessor-based welding power source
- / Data communication
- / Welding parameter selection & data storage
- / Data security
- / Welding torch position identification
- / Communication human / welding machine
- / Virtual welding



DIGITALIZED WELDING KNOWLEDGE

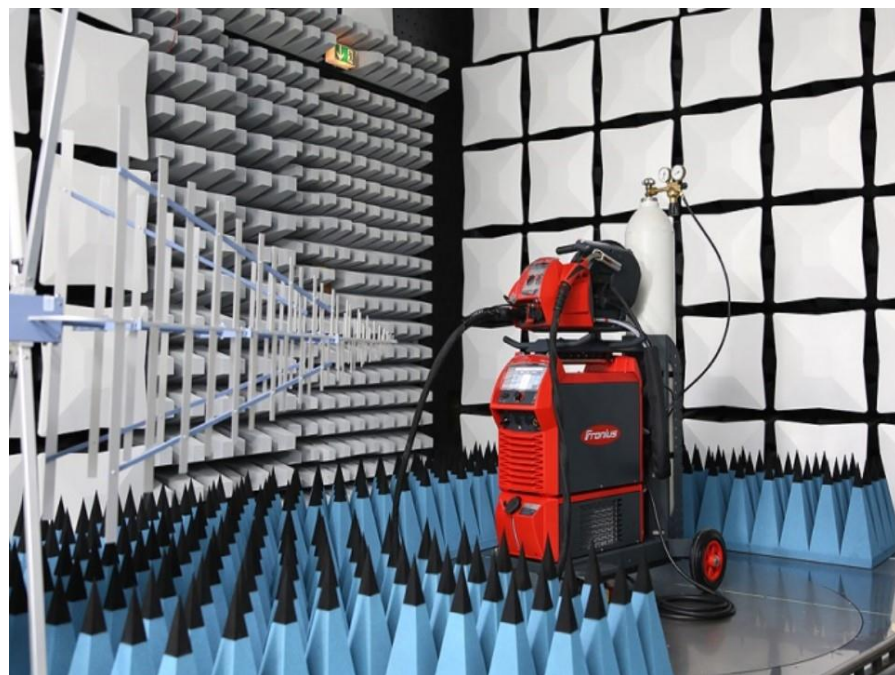
- / The perfect seam is a result of a perfect technology, a perfect process and a perfect filler metal
- / Much knowledge about welding is needed, to define and to choose the best options
- / Till now the welding technologist takes over this responsibility
- / If the welding cell should run autonomously, this knowledge has to be digitalized “somewhere in the cloud“, accessible by a master control unit



MICROPROCESSOR-BASED WELDING POWER SOURCE

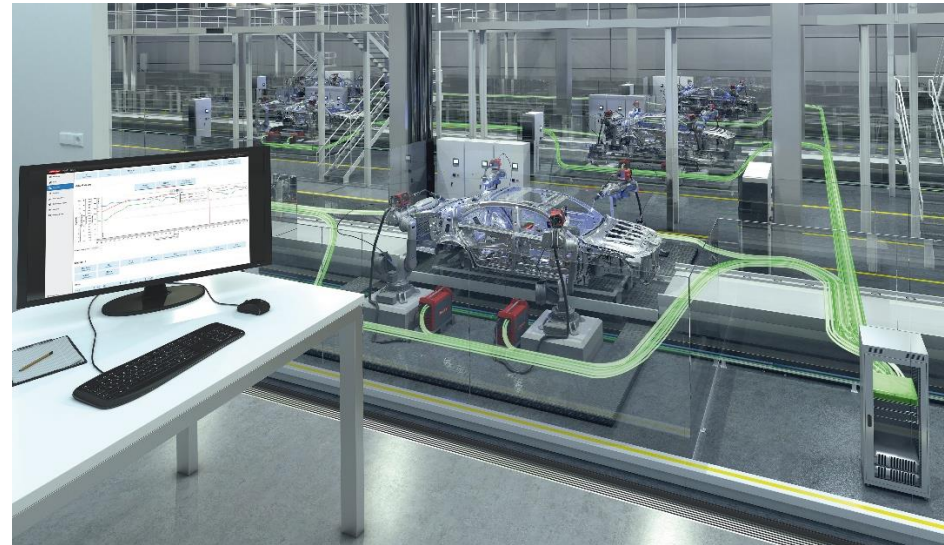
14.0 ready machines are equipped with a powerful microprocessor. Requirements:

- / Self-detection of installed components
- / Restriction of the welding power based on the „weakest“ installed component
- / Providing all network functions
- / Welding data measurement and storage
- / Welding parameter control algorithms
- / Very fast synergic line processing
- / Electromagnetic compatibility



DATA COMMUNICATION

- / Mandatory: real time communication
- / Communication time between the arc and the processor for best possible modulation of the metal transfer: $<30\mu\text{s}$
- / Including measuring & digitalization
- / Including data processing & parameter control
- / Huge set of data has to be handled
- / Unrestricted functionality also under harsh, dirty and dusty industrial surrounding



WELDING PARAMETER SELECTION & DATA STORAGE

- / A powerful and fast data management is mandatory to digitalize, monitor, record and control the welding parameters
- / Fast and reliable data storage concepts are needed
- / Establishing an adequate data base for meaningful data analysis
- / Algorithm-based knowledge for e.g. weld imperfection prevention or economic spare part management, has to be developed and implemented
- / An autonomous parameter selection is limited by the digital accessible knowledge



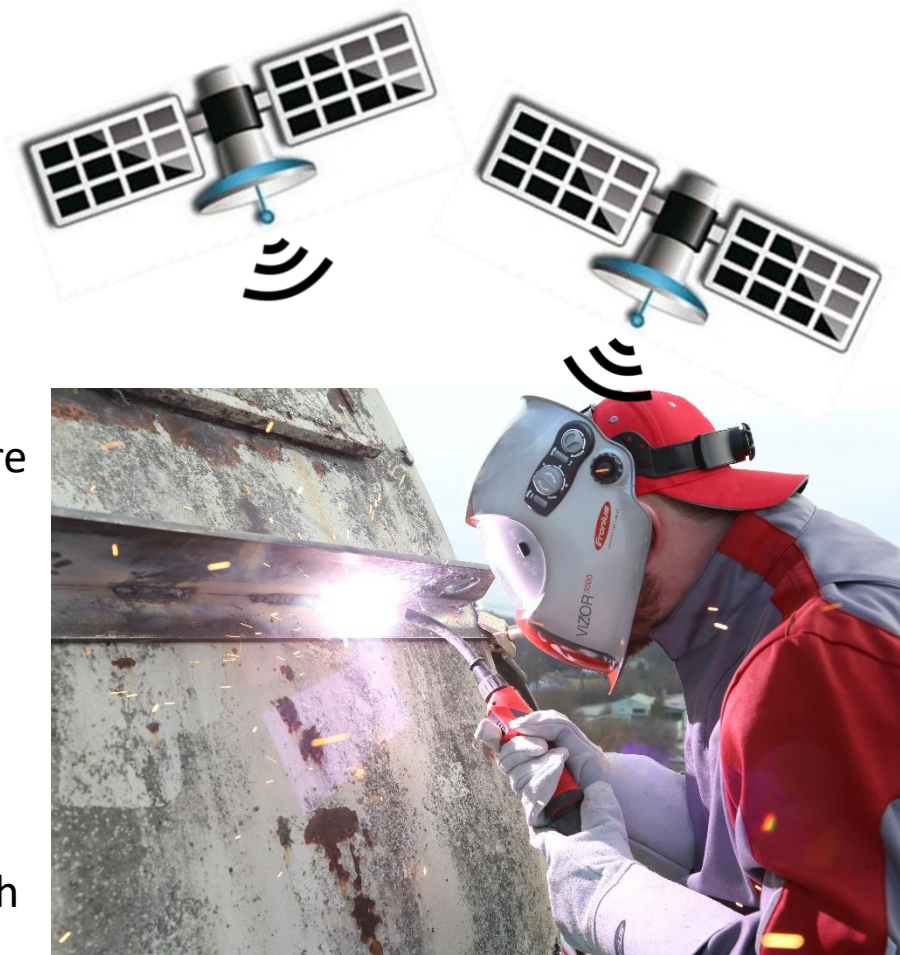
DATA SECURITY

- / Idea of I4.0 and IoT:
Providing and sharing big data via the „net“ to the „cloud“ enables a more efficient data analysis and leads to more economic solutions
- / Therefore common data standards and interfaces are needed, which make also intranets, which host the welding machines, vulnerable against cyber crime
- / Highest levels of cyber security have to be developed also for the welding power source (security hardware+software)



WELDING TORCH POSITION IDENTIFICATION

- / Knowledge of welding torch position is essential for:
 - / Autonomous welding cell
 - / describing the influence of welding on the material (heat input)
 - / Selection of proper welding processes and parameters
 - / Optimization of torch positioning procedure before and after welding
 - / Weld documentation
- / Absolutely challenging:
 - / Sensors near the arc necessary (radiation, temperature)
 - / „Positioning satellites“ (similar to GPS) with „free sight“ to torch necessary



COMMUNICATION HUMAN / WELDING MACHINE

- / Humans will stay the responsible operator of welding machines within the next decades
- / To facilitate communication human / machine: a similar operation as for modern telecommunication devices (e.g. smartphone) is required but it has to be suitable for harsh industrial conditions
- / Integration of the welding helmet into the communication network (for voice control, as a „monitor“ of welding data, improved obscuration of the protection glasses,...)



VIRTUAL WELDING

- / For training of welder, robot operator and robot off-line programmer
- / Before going into autonomous welding the welding process has to be virtually mapped for:
 - / Checking of digitally predefined welding procedures
 - / Checking of the correctness of robot off-line programming
 - / Optimizing of parameter settings
 - / Adjusting welding speed, torch position and movement
 - / Online control

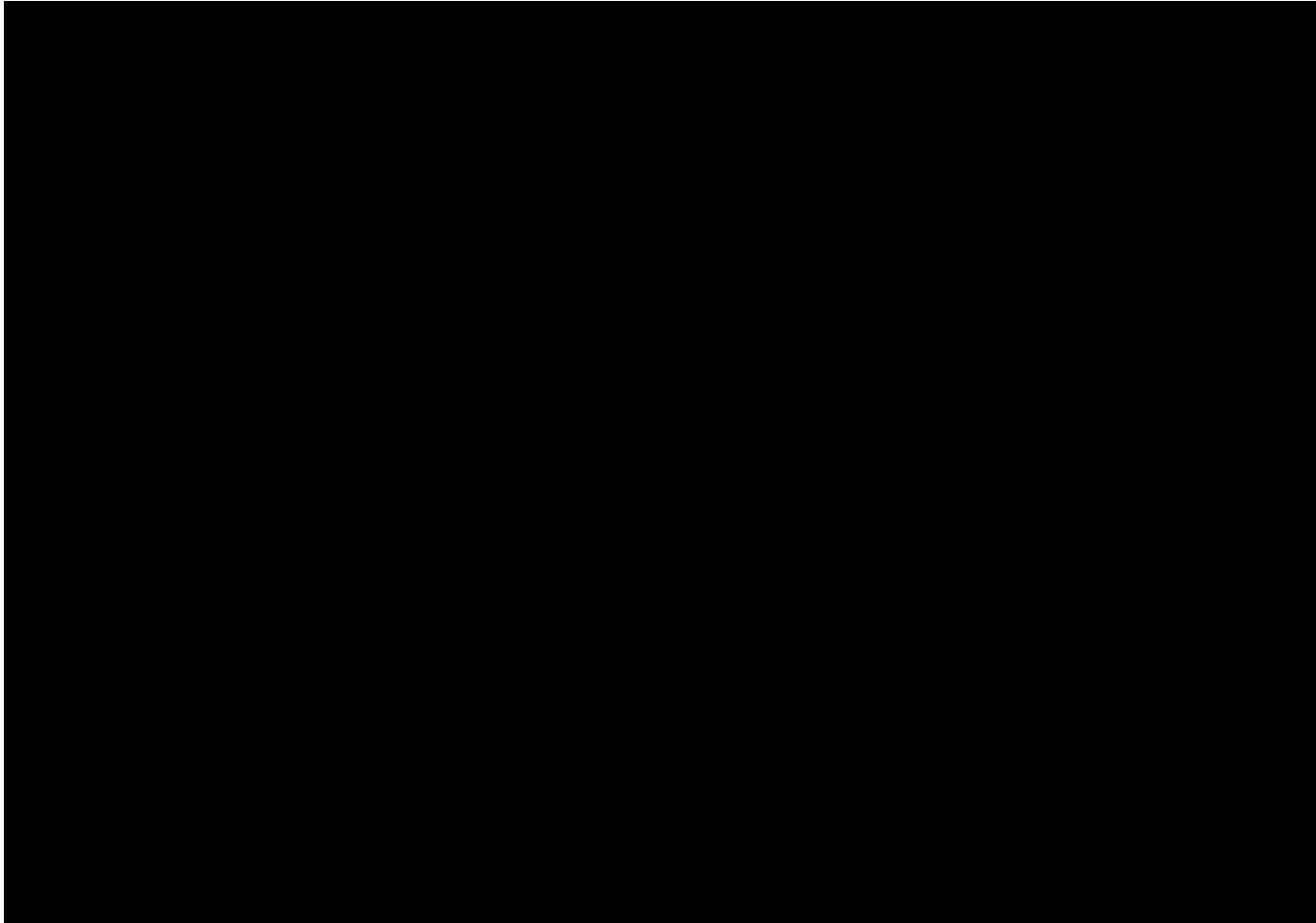


CONCLUSIONS

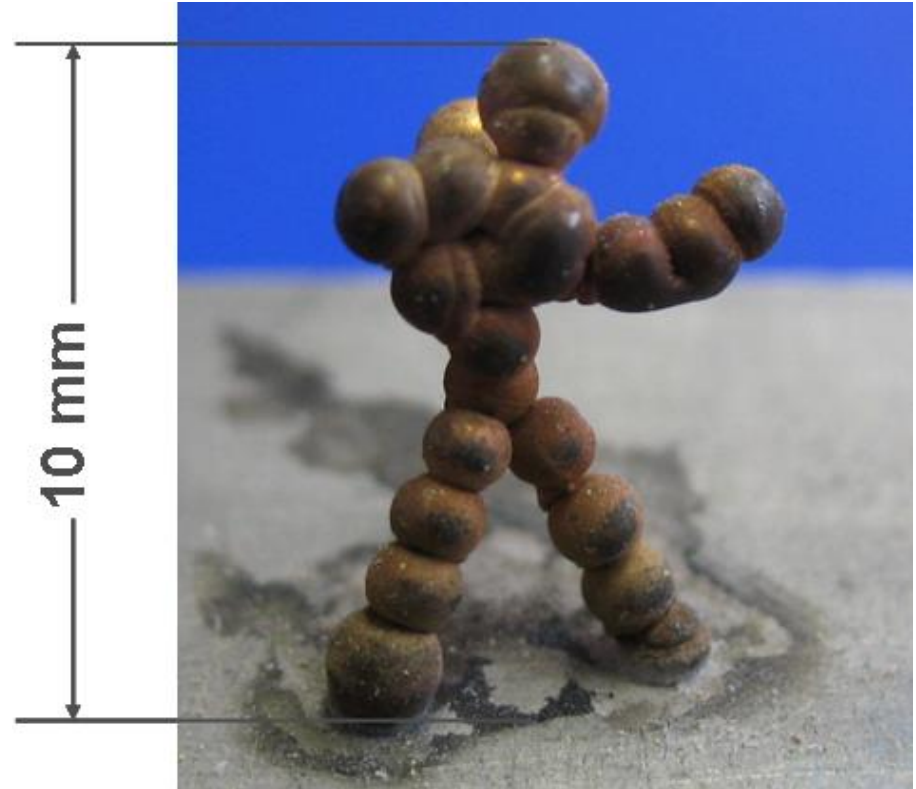
- / „Internet of Things“ & „Industry 4.0“ are at the moment one of the most used technical terms
- / Vision of I4.0: **Digitalization provide valuable data; sharing it to a larger community can enable new, more economic solutions**
- / Overall goal of I4.0: **Autonomous working smart factories based on digital information, which comes from the „cloud“**
- / Impact on Welding:
 - / Digitalization of welding knowledge and welding data is a basic requirement
 - / Welding machines get computerized (powerful microprocessor, software controlled, network capability, remote controllable,...)
 - / High-speed data and intelligent human / machine communication is a necessary requirement
 - / Virtual welding will be an essential piece of the puzzle



VISION 2015: WELDING IN 2025



**Thank you for
your attention!**



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