CII Welding conference
November 16, 2016
Contents

• Trends changing the world today

• AI & IoT-impact on welding
Global trends

- Environment concerns: Greenhouse gas (GHG) emissions
- Isolationism (Brexit, Trump), in developed nations, due to:
  - Recurring Global recessions
  - Increasing gap between rich and poor
  - Attributed to trade and immigration
- Terrorism & war: Nuclear, biological, Cyber
- Fourth industrial revolution
  - “Mass customization” through Additive manufacturing
  - Bio technology, nanotechnology and new materials
  - Virtual reality and augmented reality
  - Artificial intelligence and impact on jobs
  - Internet of things, “smart” objects, machines, homes, factories, grids, cities
Environment concerns

• Overpopulation sustained by extraction of natural resources
  • The first billion was reached by 1800
  • Second billion by 1930; third billion by 1960

• Natural resource depletion may prevent this in future
  • Earth may be able to sustain only 1 billion

• GHG emission leading to Climate change
  • Deforestation, ocean acidification, ozone layer depletion
  • Changes in water patterns—rising sea levels, floods, droughts
  • Water and air Pollution
Minimizing GHG impact: Green energy

- **Renewable energy**: Exponential increase
  - Solar energy & wind energy mainly

- **Power storage**: Cheaper, lighter, smaller, longer lasting, faster charging
  - New technologies- lithium air batteries vs lithium ion
  - Ultra capacitor batteries
  - Power generation and storage at point of consumption
  - Storage of grid energy: Compressed air reservoirs
Biotechnology

• Gene editing:
  • For curing leukemia
  • Can also be used for biological weapons

• Growing food artificially:
  • Genetically modified crops
  • Meat grown in labs

• Stem cell research:
  • Curing disease
  • Lifespan beyond 130 years
Materials technologies

- Life cycle - Cradle to cradle, not cradle to grave
- Carbon fiber: Stronger, lighter
- Bio inspired, biodegradable plastic
- Advanced materials
  - Nanotechnology
    - Graphene and carbon nanotube
  - Surface coatings
  - Bio chemically made materials
    - Bacteria to make graphene semiconductors
    - Bacteria to make “self healing” materials
Additive manufacturing

• “3D printing”: Not a technology of the future, but of today

• Not only for prototypes, commercial production today
  • Airbus “prints” cabin fittings on A350XWB airliner
  • “Printed” hearing aids customized to the individual
  • GE, in Alabama “prints” 40,000 nozzles/annum
    • for its LEAP jet engine
    • Alloy of cobalt, chromium, molybdenum

• However, cost considerations currently limit its use
  • Particularly for large and simple steel parts
Virtual reality and Augmented reality

**Virtual reality & Augmented reality**
- Changing the nature of shopping: virtual walk throughs
- Medical applications: Therapy - Getting rid of phobias
- For a pilot to “see outside” an enclosed cockpit
- Education & training - Surgeons, pilots, military

**Virtual reality & augmented reality in industry**
- Engineering - virtual prototyping
- Google glass can superimpose data on images
  - To tell where parts are to be placed or welded
- Welding:
  - Training
• Trends changing the world today

• AI & IoT-impact on welding
“Anything that could give rise to smarter-than-human intelligence – in the form of Artificial Intelligence, brain-computer interfaces, or neuroscience-based human intelligence enhancement - is doing the most to change the world.”

“Artificial intelligence will reach human levels by around 2029. Follow that out further to, 2045, we will have multiplied the human biological machine intelligence of our civilization a billion-fold.”
Artificial Intelligence

• Self driven cars
  • Singapore started trial of the first self driven taxis in August
  • Uber launched self driven cars in Pittsburgh, USA in September

• Medical diagnosis and surgery
  • Watson of IBM is the no.1 in diagnosis of cancer
  • STAR(Smart tissue anastomosis robot) –faster than surgeons

• Legal and para legal work(65% of legal work)
  • Document preparation and research/diligence

• Sales, Customer service, Translation/documentation

• And intelligent worker robots, including welders

“Replacement of humans by robots is a question of “when”, not “if” “
AI/machine learning

- Computers that *learn* without being *explicitly* programmed
  - Algorithms that learn from and make predictions from data.
  - Learning what the programmer himself may not know
  - To make data-driven predictions or decisions
  - *In order to achieve a task or goal*

- Is a terminator type of scenario possible?
  - Machines cannot become “self aware”

- Is an “I robot” type of scenario possible?
  - Self learning as to the best way to realize a goal
  - Like “Keep humans safe”

"By far the greatest danger of Artificial Intelligence is that people conclude too early that they understand it."

"The purest case of an intelligence explosion would be an AI rewriting its own source code"
Internet of things (IoT)

Data acquisition, storage, analysis and Sharing with other devices

Enabling Remote operation

- Smart objects (RFID)
- Smart machines (collecting, transmitting data)
- Smart grids (interacting with smart elements)
- Smart cities

“"It will be part of your presence all the time. Imagine you walk into a room, and the room is dynamic. And ...you are interacting with the things going on in the room." — Eric Schmidt, Google chairman,
Industrial Internet of things (IIoT)

- Intelligent assets: Products; machines
- Data acquisition & communication: interconnected machines
- Analytics and applications to act on the data
- Process control, Production control, Predictive maintenance
- GE has resolved 53% of issues in Power & Water by IoT
- Enables selling “product as a service”
  - Eg: Rolls Royce sells “hours in the sky”
  - Or “Arcing time” of a welding machine
- Key issue: Data security

"Smart homes and other connected products won't just be aimed at home life. They'll also have a major impact on business. And like any company that ignored the Internet at the turn of the century, the ones that dismiss the Internet of Things risk getting left behind."
VR & IOT in arc welding

• Virtual reality in training
  • Welding can be done in varied situations
  • Environments, parts, materials, modes

• IOT
  • Arc tracking software: Arcing time, productivity
    • Weld parameters, Heat input, Energy, consumables
  • In future,
    • Seam tracking: Variability in fit-up
    • Non destructive testing: Weld quality
    • Sharing of data across robots/machines
Key elements of *smart* robotic arc welding

- Software controlled waveforms
- Arc sensing
- Seam tracking
- In future: AI & Non destructive testing
Software developments in welding machines

• Until 2000, most improvements were in hardware

• Improvements in last two decades have been in software

• Waveform control is the main development
  • The Control Board has a Microprocessor, a RAM and a logic controller.
  • Also has a high frequency chopper circuit which receives the signal
  • And changes the current and voltage to get the required wave form.
  • The wave form program is designed to optimize application

• Waveform delivers the arc according to the application
Types of waveforms

• Waveform for higher productivity:
  • The current ramps up quickly
  • Then starts tailing off
  • The arc collapses
  • A plasma boost pushes the puddle away

• Specific waveforms can be programmed:
  • Thin sheets to avoid burn through
  • Puddle control for out of position welding
  • Aluminium welding
Out of position welding:
- Peak and background current
- At a fixed frequency
- Creates consistent droplet transfer.
- A shorter but more focused arc
- Helps increase puddle control.

Aluminum welding < 6mm
- Two distinct pulse types
  - (High Energy and Low Energy)
- Alternatively used to obtain a ripple weld bead.

Waveform
1. Pulse Ramp/Peak: A controlled current increase creates a motion droplet without disturbing the puddle and minimizes the size of the arc cone.
2. Tailout: Reducing current relaxes the plasma force as the droplet approaches the puddle, creating a clean droplet transfer.
3. Background: Lower background helps maintain control by minimizing the puddle heating.
4. Frequency: Frequency is a preset value. The UltimArc™ control allows the operator to fine tune the pulse frequency.
Arc Tracker- For acquisition of welding data

- Digital Control Board, Ethernet Board user Interface Board
- Connected to any conventional DC Power Source (for GMAW)
- to access a wide array information of the welding arc
- Accesses weld data & Communicates to the network via Ethernet.
- To access on any device – desktop, laptop, iPhone® etc
- Tracks: Equipment usage, Welding parameters
  - Energy, Consumable consumption, % rejection
- All production information real time on phone/laptop
- Latest welding machines have these built in
Seam tracker - Tactile vs laser

**Tactile**
- For GMAW/GTAW/SAW
- Probe (tactile sensor) touches the walls of the job
- Detects deviation
  - between an edge and the original coordinates
- Mechanically adjusts the wire to seam position

**Laser type**
- The Laser rays run along the seam in advance
- Detects deviation
  - between an edge and the original coordinates
- Wire is adjusted to required Seam Position
- **In future, may measure groove dimensions and**
  - **Acquire the data**
  - **self adjust parameters to compensate**
Non destructive testing:

Ultrasonic testing: contact vs non-contact

- UT is the preferred option for NDT, and the options are
  1. Piezo electric sensors
  2. Electro magnetic Acoustic Transducers (EMAT),
  3. Ultrasonic phased arrays (UPA)
  4. Laser Ultrasonic

- EMAT is non contact and may be the future for inline testing
The dumb robot VS the smart (AI) robot

- Programmed to carry out activity
- Programmed to complete a task
- Needs to be fed task specific data
- Needs to be “taught” every job

- Programmed to learn
- Programmed to reach a goal
- Needs only generic data
- Learns jobs by watching/analyzing

Dumbot VS. Baxter
AI in welding - Today vs Tomorrow

• Robot of Today (Dumb)
  - Robots programmed by “teaching” specific jobs
  - Human sets the program depending on component
  - QA data offline, used to “teach” what is a good weld

• Robot of Tomorrow (Intelligent)
  - Robots programmed to learn to become skilled welder
  - Robot “recognizes” the job and sets parameters accordingly
  - Acquires In line QA data, self correction of welding parameters
AI in welding- Today vs Tomorrow

• Robot of Today (Dumb)
  • Humans decide what is a good weld, robot evaluates and “scores”
  • Humans decide what parameters to change to achieve a top “score”

• Robot of Tomorrow (Intelligent)
  • Robot is programmed to “understand” what is a good weld
  • Robot *self corrects* parameters based on past “experience”
AI in welding - Today vs Tomorrow

• Robot of Today (Dumb)
  • When conditions change human intervention is required
    • Contours/positions/materials, variable quality of fit-up, etc.
  • Each robot is to be programmed individually for specific jobs
  • For developments, trial and error by humans using their own experience.

• Robot of Tomorrow (Intelligent)
  - Robot *analyzes and “learns”* how to make the best welds for all conditions
    » Contours/positions/materials, variable quality of fit-up, etc.
  - All robots become equally “skilled” through a common *intelligence*
  - For developments robot uses past *experience* for trial and error
On the cusp of a 4\textsuperscript{th} industrial revolution....... 

- New technologies will alter the future dramatically  
- Welding machines will change  
  - AI & IOT will be the main drivers of change  
  - And developments in machine software & NDT  
- Impacting capital costs, quality and productivity  

- \textit{And resetting customer expectations}
THANK YOU