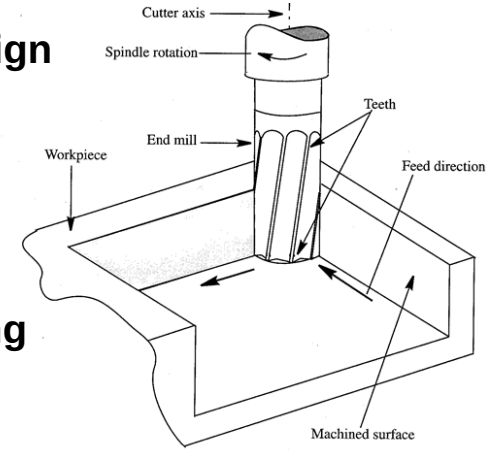
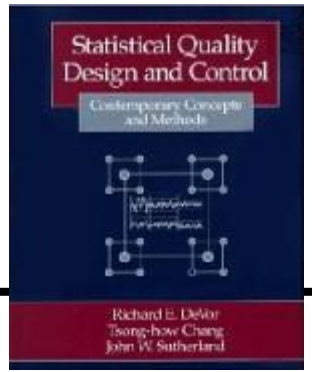
Sutherland Background

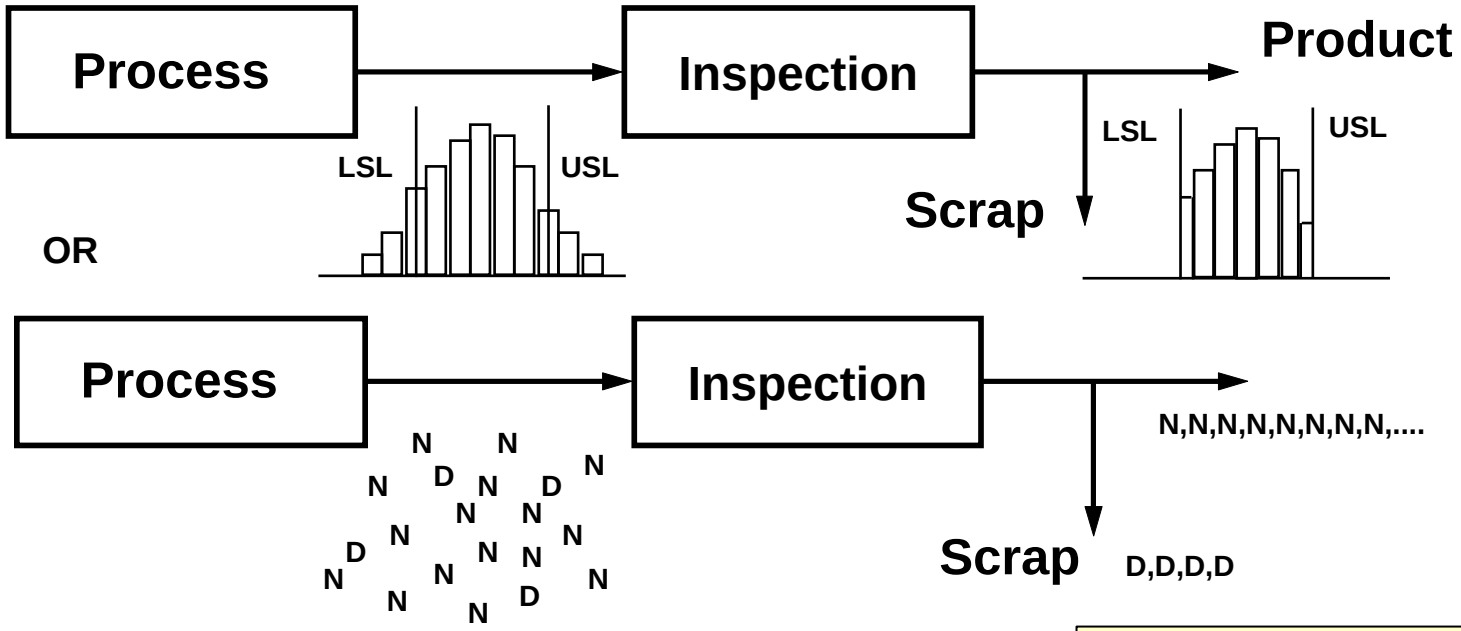
- **Academic preparation: University of Illinois at Urbana-Champaign**
  - **BS and MS in Industrial Engineering**
  - **PhD in Mechanical Engineering (manufacturing focus)**
  - **Dissertation: “Dynamics of peripheral milling”**
- **Launched business (late 1980’s)**
  - **Industry workshops on quality – covered teachings of Deming**
  - **Manufacturing consulting**
  - **Software**
    - **SPC and DOE**
    - **Machining Process Simulations**
- **Quality Engineering text developed based on workshops**
- **Faculty position at Michigan Tech (1991)**





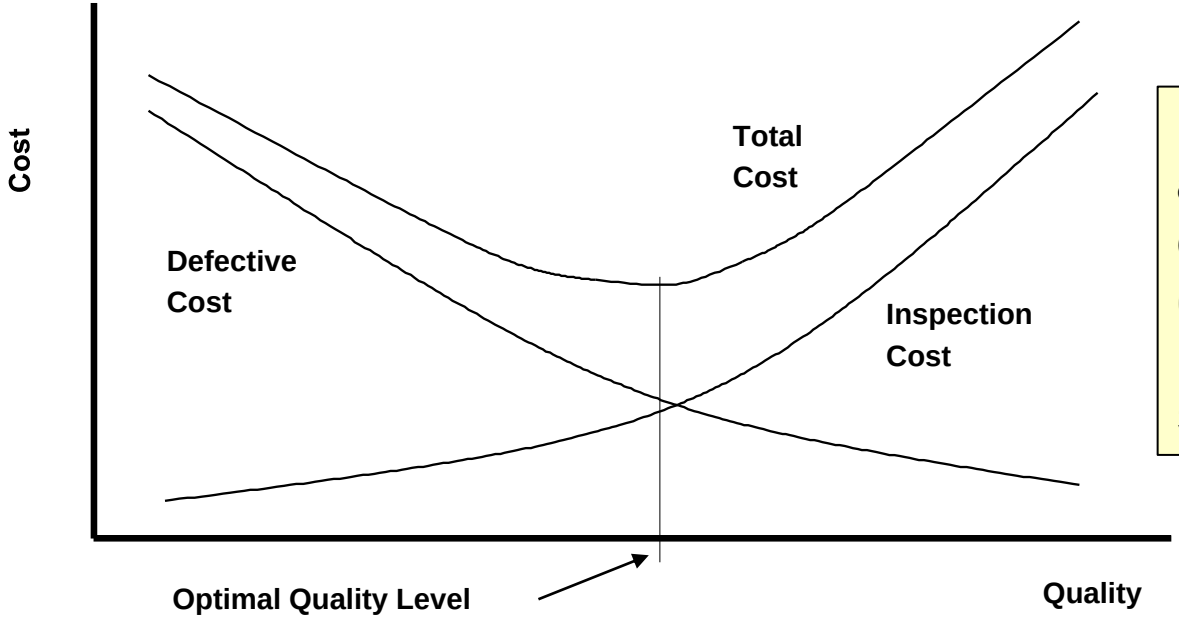
Traditional Approach to Quality

Use inspection to ensure customers receive good products



Product Control

Quality, Cost, & Productivity

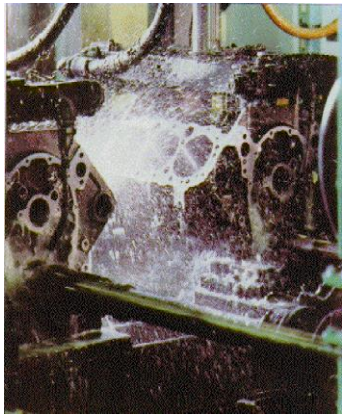


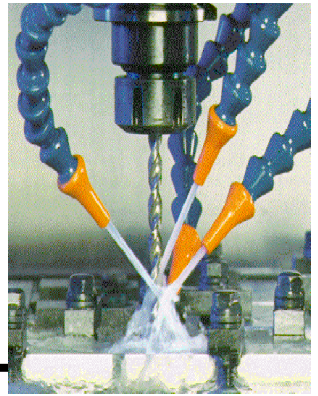
Deming called for attacking root causes of problems (*Process Control*) rather than focusing solely on products

This means there is an optimal level of defective parts
Quality and Cost/Productivity become *competing* goals

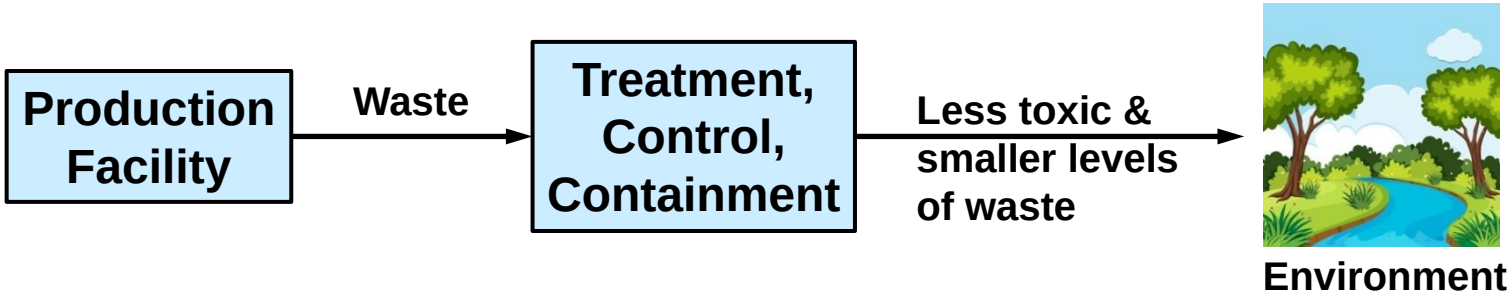
Cutting Fluids

- Spoke with environmental engineers in auto industry about cutting fluids
- 100 million gals. of fluid used annually in U.S.
- Claimed functions & benefits
  - Cooling & Lubrication
  - Corrosion Inhibition & Chip Flushing
  - Increased Tool Life
  - Improved Surface Finish
  - Increased Dimensional Accuracy
  - Reduced Cutting Forces
  - Improved Machine Tool Life and Function
- Concerns: Negative effects on health and environment, and high cost





Classic Environmental Engineering

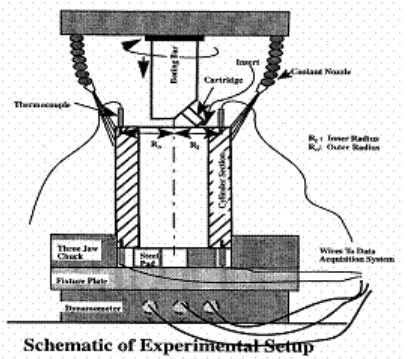


- Environmental engineering traditionally relegated to containing, treating, diluting, controlling, and mitigating waste streams, i.e., addressing a problem that already exists.
- Adopt Deming philosophy: anticipate and avoid/reduce waste in the first place, i.e., identify and eliminate root causes of waste streams (product → process control).

Cutting Fluids: A "Process Control" Approach

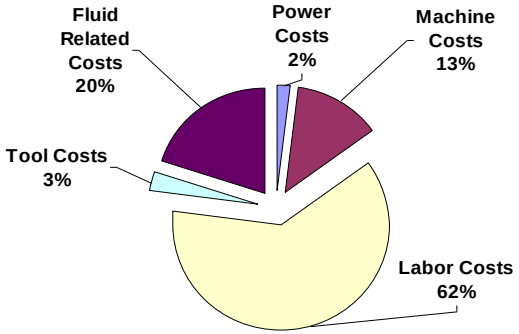
- **Role of Cutting Fluids in Machining**
  - **Experimental component**
    - **Performed hundreds of tests**
    - **Processes (Cylinder Boring, Milling, Drilling, Tapping)**
  - **Analytical component**
    - **Created models for heat transfer, lubrication, and thermal distortion for the processes**
    - **Predicted effect of fluids on performance (forces, temperatures, surface error)**
- **IMPACT: Environmental and health benefits PLUS substantial cost savings.**

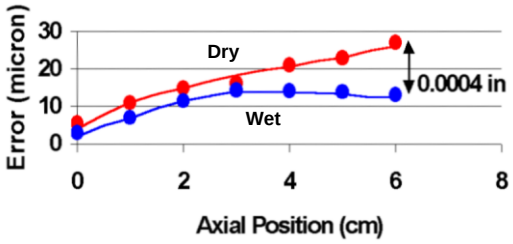
Develop data & models to support dry/nearly dry machining applications



Schematic of Experimental Setup

Feed (mm/rev)	Spindle Speed (rpm)	Fluid	Heat Source Strength (W)	% of Heat Entering Work	Conv. Coef. (W/m^2K)
0.100	1000	off	858	77%	6
0.254	1000	off	896	47%	6
0.100	2000	off	1597	43%	6
0.254	2000	off	1496	27%	6
0.100	1000	on	858	77%	2014
0.254	1000	on	896	47%	1561
0.100	2000	on	1597	43%	1496
0.254	2000	on	1496	27%	1575





Takeaways from Cutting Fluid Story…

- **Need: How to best deal with waste and conspicuous resource consumption??**
- **Approach: Focus on the sources of waste and consumption. Innovate. Engineering changes.**
- **Impact: Less waste produced and less energy/ resources consumed. Reduced environmental impact and improved economic competitiveness.**

- **Sustainable Manufacturing**

Environmental and Ecological Engineering

- Joined Purdue in 2009 as EEE Head.
- EEE Need: modern approach lacking for engineering research and teaching on issues related to the environment
- EEE Approach:
  - Seamlessly integrate Classic Environmental Engineering and Industrial Sustainability. We are unique.
    - Management of waste within water, soil and air
    - Create engineering system that can exist in harmony with the environment
- EEE Impact: Quickly grown to one of the largest environmental engineering programs in nation

358
BSEEE Degrees Awarded Since 2013

50+
Graduate Students

170+
Undergraduate Students

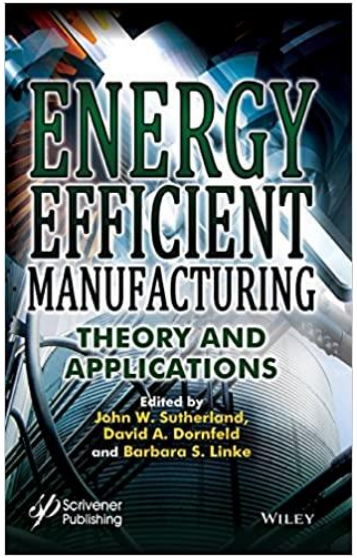
Over 50%
Female Engineers

21
Faculty Members

Read EEE Insights Newsletter Summer 2023!

Recent Research Activities

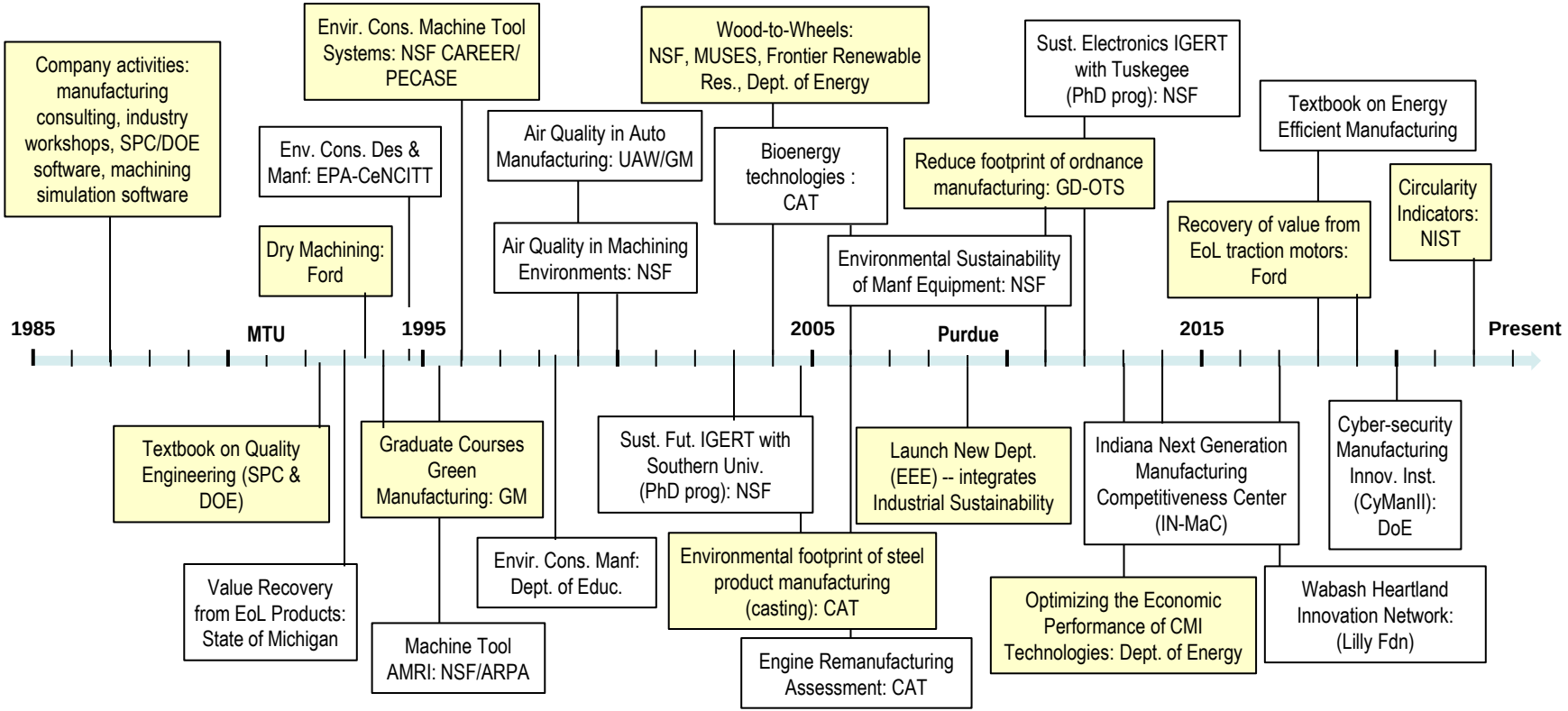
- **Topics:**
  - **Circular economy, reduce waste/efficient resource use, environmental/economic assessment of technologies/processes/systems, life-cycle engineering, social impacts.**
- **Support:**
  - **Smart manufacturing (Lilly Foundation, IN-MaC)**
  - **Clean energy technologies (DoE – Critical Materials Inst.)**
  - **CyManII, ONR, Cummins, IN-DoT, NIST, DARPA, ARL, NSF**



Summary of Contributions

- **Environmentally responsible design / manufacturing**
  - **Reducing environmental impact of manufacturing processes / systems AND improving competitiveness**
  - **Clean energy technologies (wind turbines, EVs, etc.) – support via LCAs and TEAs**
  - **Closing material loops via recycling and remanufacturing – circular economy**
  - **Green manufacturing planning**
  - **Eco-design of products**
- **Worked with 30+ companies on improving manufacturing environmental performance.**
- **Service: EEE Head plus ASME, SME, CIRP, and AEESP activities**
- **Began offering courses on green manufacturing in 90s**
- **Impacted 1000s of students via courses on manufacturing, quality, and sustainable manufacturing**
- **Mentored over 100 graduate students including ~40 PhD students and 40+ scholars/post-docs**

Timeline of Industry and Other Key Activities



Thank You
for Your Attention!!

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