MANUFACTURING & INNOVATION : 200YRS +
LESSONS WITH AN EYE TOWARDS TODAY'S COMPUTING
Tom Lange preparing for his first trip to Bay Area for P&G

Circa ~1987...
As told through one Manufactures 180 year view...by a retired story teller ;-)

FIRST SOME MANUFACTURING HISTORY...
How Historians Know P&G…
Founded in 1837

Founded on the Banks of the Ohio, Cincinnati

…one of the DOW 30
4th oldest on the Fortune 500
… one of the very few in top 50 in 1900 and in 2000
Why Cincinnati?

...Rivers & Pigs
“Porkopolis” a.k.a. Cincinnati, Ohio

Cincinnati was the U.S. chief hog packing center

Meat was stuffed in Brine Filled Barrels & shipped down the rivers

Salt Pork, Bacon, Sausage Were staple foods
The Great 19th Century Industrial Cities

...Grew up near waterways.

In 1840, Cincinnati was the 6th largest U.S. city...10 x Chicago
P&G biggest Seller in 1862 ...STAR Candles...

P&G actually sold

Thomas Edison
- age 15 was a telegraph runner to the P&G Candle Factory

Light
Why did P&G Soap sales surpass Candles in 1876?

- The discovery of oil in 1859 in Pennsylvania made kerosene readily available.
By 1898...What was their Next BIG Thing?

VERNE SURPASSED—"When Jules Verne wrote his fascinating book, 'Around the World in Eighty Days' [1873], he aimed to show the utmost that could be accomplished by the means of transportation of his day. A quarter of a century later we are near the day when the ordinary tourist can make the trip in less than half of eighty days. The Russian minister of communication has stated that when the great Trans-Siberian railroad is opened, early in the twentieth century, the tour of the world can be completed in thirty-three days."
Travel Around the world...33 days!

“The Russian minister of communication has stated that when the great Trans-Siberian railroad is opened, early in the twentieth century, the tour of the world can be completed in thirty-three days.”

Scientific American ... December 1898
Railroad Network... 1830 to 1890
At the speed of the Wind, Water, or Animal...

- Prior to Rail...
  Communication was only as fast as walking, water or animals...

Wooden Oar & Sailing Ships

~5-10 MPH...

~ TONS OF CARGO
WHAT ICONIC RETAILER LEVERAGED THAT INNOVATION?
By 1890... Chicago was the 2nd largest city in the U.S. with over $1M People.

Richard Warren Sears was a railroad station agent in North Redwood, MN... Circa 1880’s
It was not just because of SEARS catalogue sales reaching ‘everywhere’ ... but manufacturing everything that SEARS sold!... From steel to door knobs
U.S. ‘Industrial Belt’ grows

Movement of goods and information...from WATER, and then to RAIL, was the explosive enabler of prosperity...

1954-2002

Change in total number of manufacturing jobs in metropolitan areas, 1954–2002. (Figures for New England are from 1958.)

- >6% loss
- 43–56% loss
- 31–43.2% loss
- 8.7–29.1% loss [United States average: 8.65% loss]
- 7.5% loss – 54.4% gain
- >62% gain

Three metropolitan areas lost more than four fifths of their manufacturing jobs: Staubenville, OH; Johnstown, PA, and Augusta, ME.
But that industrial ‘belt’ ... Rusted

Why?
Even for P&G manufacturing became unneeded

Procter & Gamble To Shut City Plant 275
Jobs To Be Cut On North Ave

`After a thorough economic analysis of the company`s
business, a decision has been made to consolidate at other
locations the manufacture of bar soaps and glycerine now
made in our Chicago plant, ` said Karl Schaulin.

Procter & Gamble Manufacturing Co.
said Wednesday it is closing its 59-
year-old Chicago plant and eliminating
275 jobs

Side
July 20, 1989|By Pamela Sherrod.
What Company is this?

• Began as a small chain of specialty retail stores in a major city
• ~20 years later migrated from specialty to become mainstream & grocery products retailer
• First to Introduce ‘economy store concept’ and grew to 1600 stores.
• ~30 year later became the world’s largest retailer... with 16,000 stores.
History of A&P

• Founded in 1859
• After WW1 Added Meat & Produce to ‘Dry Groceries’
• Reached $1B in sales in 1930...worlds largest retailer
• 1936 Adopted ‘Self-Serve’ Concept
• Decline began by 1950
• Filed Chapter 11 in 2010
• Became Private 2012
What Disruptive Innovations shaped A&P’s history...both growth and demise.
Unintended Consequences of a Military Decision

Interstate Highways
“To make his model work, he emphasized logistics, particularly locating stores within a day’s drive proximity to Wal-Mart’s regional warehouses, and distributed through its own trucking services”
• Store Openings

July 1, 1962

• Distribution Centers

March 1, 1962
- Store Openings
- Distribution Centers

1965 - 1970

Technology Optimization & Management, LLC
• Store Openings

• Distribution Centers

1970 - 1975

Technology Optimization & Management, LLC
- Store Openings
- Distribution Centers

1975 - 1980

Map showing the distribution of Walmart's store openings and distribution centers from 1975 to 1980.
• Store Openings

1980 - 1985

• Distribution Centers

1980 - 1985
• Store Openings

• Distribution Centers

1985 - 1990

Technology Optimization & Management, LLC
• Store Openings
• Distribution Centers
• Store Openings
• Distribution Centers
• Store Openings

• Distribution Centers
• Store Openings

• Distribution Centers

2005 - 2010
- Store Openings
- Distribution Centers
Distribution Centers... are on Interstate near Junctions

2005 - 2010
WHAT IMPACT DID ‘WALMART’ STYLE RETAIL HAVE ON MFG’S?
LIMA — Procter & Gamble is investing $6 million in its Lima fabric care facility and plans to hire more employees.

The company, headquartered in Cincinnati, recently started an expansion on Building 11 on its property and plans to complete it this fall.
Where is Lima, OH?

Walmart Distribution Centers
Sears was the largest retailer in the United States until October 1989, when it was surpassed by Walmart. [3]
What’s next?

Another Unintended Consequence Of a Military Decision...

The Internet & On-line retail

Jeff Bezos

Bezos at the ENCORE awards in 2011
WHAT WILL BE THE IMPACT ON MANUFACTURING?

Who REALLY KNOWS?... But ‘time to fulfill’ will be more important than shipping costs.
TIME ... WILL MEAN ‘LOCAL’ MANUFACTURING
‘LOCAL’ MANUFACTURING WILL BE ‘DOWNSCALED’...BUT NOT MORE EXPENSIVE
Can Manufacturers survive these disruptions? Yes and No

• No... If you make the wrong product
  – if you are selling ‘candles for light’, better learn to make soap if someone else finds Oil in the ground...or uses electricity.
  – If you cut winter ice out of the river to ‘make cold’...refrigeration will obsolete you
  – If you use a wet film to capture images... digital capture will obsolete you.

• Yes... if HOW you make it can be improved at a faster pace than anyone else.
U.S. Manufacturers must Innovate or Diminish

• It is NOT just about regulations
• It is NOT just about cheap labor (e.g. offshore)
• It is about INNOVATING **HOW** we make things... NOT just WHAT we make.
• INNOVATING MANUFACTURING at SCALE is too expensive to GUESS AND TEST.
And that Innovation extended to everything ... not just what we made... but how we made it.

P&G’S MANTRA...‘INNOVATION IS OUR LIFEBLOOD’
How long does it Take to make a Billion Pringles?
Assembled in Code

Digital simulations have become so powerful that companies send their products through the wringer—sometimes literally—before ever building a prototype.

By: James D. Myers

When Thomas Edison invented a practical electric lightbulb more than 120 years ago, he performed thousands of experiments on prototypes, and we still marvel at his methodical patience today. A modern inventor proposing a similar approach, however, would most likely be laughed at for good reason. Product research and development more and more lives in the realm of bits and bytes, with engineers designing testing, modeling and even simulating new ideas via computer before any physical version exists.

Powerful computer servers perform these simulations.

Computer power models and complex digital simulations increasingly dictate what new items look like, how they are made, what they are made of and how they will perform together. Driven by Moore’s Law, which holds that computer processing power doubles roughly every six years, users can now take advantage of massive computing power to push the envelope and stay on the cutting edge.
“Digital simulation have become so powerful that companies send their products through the wringer—sometimes literally --- before ever building a prototype”

James D. Meyers
May 2013 Scientific American
Making Tide PODs

Filling & making the POD
To never leak...
Something as simple as putting pods into a tub ... needed simulation

DOES NOT WORK

WORKS
Fluids: Making Absorbent Diapers

Multi-Phase Turbulence…

w/ Material Accumulation

At the Boundaries

CFDlib w/ FLIP Markers
(Bucky Kashiwa)
@ Los Alamos National Labs
WHY DOESN’T EVERYONE INNOVATE?

Including some parts of P&G!
MOST TIMES, YOU JUST CAN’T TEST

This is especially true for manufacturing at scale
2017 ‘T.O.M. Client’ Case Study: Cyclone Separator for Sticky Dust

• 1) Confirm Pressure Drop
• 2) Assess “Build-up” Risk
  – Inlet Chutes
  – Discharge Throat
• 3) Confirm Separation Efficiency

• Use Literature & Historic Empirical Equations for Existing Evaluation & New Design
• Use CFD to ‘test’ existing and proposed designs.
Cyclones at P&G
P&G Understanding of Cyclones

Images of muschelknautz designing cyclone separators

See more images of muschelknautz designing cyclone separators

Application of Muschelknautz models in design of cyclone
https://www.researchgate.net/publication/287632383_Application_of...
Application of Muschelknautz models in design of cyclone on ... The three-dimensional strongly swirling turbulent flow in a cyclone separator with a volute inlet ...
P&G Design Approach
1979 Understanding of Vortex & Wall Interference

![Diagram of inner and outer vortex profiles showing contact with cyclone wall.](image-url)
Geometry Comparison...Old vs New

- Bigger Inlet:
- Bigger Diameter

- Longer Cyclone:

- Smaller Tubular Guard:

- Lower Pressure Drop?

- Higher Separation Efficiency?

~15 Feet

Ideal Design from Procedure
Cyclone separation
Preliminary CFD Analysis

Presented to Technology Optimization & Management
February 27, 2017

NOTE: PRELIMINARY RESULTS – PLEASE DO NOT CIRCULATE
More ‘Apps’ from AWESIM Catalog
Overview

- CFD analyses have been initiated for the baseline, ideal design, and 3Crown (modified baseline) design
- Methods used here consist of primarily steady-state analysis using one of the two turbulence models:
  - Rayleigh Stress Model – calculates the full stress tensor and potentially provides the highest vortex structure resolution but is very difficult to get a converged solution
  - SST k-o with curvature correction – an alternative approach to RSM that is more stable and easier to converge but is more highly dissipative due to the way it models turbulent viscosity
- NONE of the solutions are typically what would be classified fully converged but exhibit enough stability in error residuals that some qualitative information might be gained from the PRELIMINARY results presented here
Baseline Geometry

Exhaust Duct
Common Plenum
Cyclones (in tandem)
Exhaust from Roaster
Return Duct
Tubular Guide
Baseline Velocity Profiles

Viewed from the exhaust side with the inlet and return ducts on the opposite side. Several transverse planes pass through the domain of the coupled system where plots of velocity magnitude are presented.
Existing Velocity Profiles

Viewed from the other side with the inlet duct (lower middle) and return duct (upper right) shown in front
Axial velocity viewed directly from the back (exhaust duct shown in upper right corner)
Baseline Pressure Profiles

Pressure distribution viewed from the same perspective as axial velocity
Pressure distribution viewed from inlet / return side; Total pressure through cyclone ~ 3.1 inches w.g. (compared to engineering estimate of 4.65 inches w.g)
Existing Flow Streamlines

Sample path lines entering through inlet and discharged through exhaust duct (opposite side) and return duct.
Vortex Inverts at ‘Throat’ Wall Contact
Baseline Streamlines (inlet/return side)
Baseline Streamlines (exhaust side)
Comparison of Simulation and Design Intent for Natural Length

Ideal Design

Velocity: Magnitude (m/s)

29.352
23.482
17.611
11.741
5.8705
0.0000
Inner Vortex Inverts
BEFORE
It touches the wall
Overview of Simulation Approach

- Pressure drop compares reasonably well with estimates but there are some deficiencies in the steady state solutions.
- Lack of convergence in RSM model may be mitigated by removing complexity of plenum/exhaust/return flow paths and just concentrate on a single cyclone.
- Questions remain whether a purely hexahedral, structured, conformal mesh or an unstructured poly mesh are better choices for modeling a cyclone.
- Flow fields travelling in opposite directions with just a thin shear layer between implies this is an inherently unsteady flow.
- A transient-state solution averaged over an appropriate time interval yields a pseudo-steady-state solution that incorporates some effects of random turbulent perturbations in the flow stream.
- This flow field can be “frozen” in time and used as the background continuum for the solution to the equations of motion in the Lagrangian particle calculations for collection efficiency simulations.
This Innovation was/is TOO EXPENSIVE to test... so for 50 years... everything they owned and everything they bought new HAS THE SAME PROBLEM!

UNTIL NOW
Rocket Science is necessary?

To improve how we make things for everyday life.
OK... SIMULATION WORKS, WHY DO NOT MORE MANUFACTURES USE IT?
Barriers to M&S using HPC

1) Many Mfg’s not embracing ‘their survival dilemma’ in HOW they make...because they see no useful alternatives.

2) Validation: The ‘Virtual World’ still viewed as as NOT REALITY.

3) HPC availability ..NOT THE BARRIER. (The roads, rivers, wires and bandwidth are there). Barriers are pilots, guides and tickets to ride are too expensive (software).

4) Expertise is scarce and culturally ‘strange’ to plant floors.

5) Software is too expensive at ‘wine by the glass’... Large companies build vineyards to use effectively.
SOME THINGS HAVE BEEN TRIED
Solved the Software and Hardware Problem... Not Enough.
The big problem with supercomputing is that the organizations that could benefit most from the technology aren’t using it.
AWESIM...

Solved the Expertise Problem With ESP's
WHERE ARE WE TODAY?
What has Worked in Pilots.

• Affordable Software ‘by the drink’ ... App form even better.
• Engineering Service Providers (ESP’s) that can ‘face’ Manufacturers culturally...but sales cycle is expensive.
• Public – Private engagements that helped reduce the initial engagement barrier for both Mfg’s and ESP’s
Future... What is needed.

- Computing, Software and Expertise Ecosystem with local ESP’s capable of true realism for processes.
- More compelling Leadership Engagement, Story Telling, Outreach ... to get at these first two barriers...

1) Many Mfg’s not embracing ‘their survival dilemma’ in HOW they mfg...because they see no alternatives.
2) Validation: The ‘Virtual World’ still viewed as as NOT REALITY.
Expertise: What ESP’s need

• Software that models reality... not some non-realistic, stylized view.
  – This is MUCH BETTER SCALING on FEA and CFD
  – This is MUCH BETTER SCALED COUPLING: DEM and CFD, FEA & CFD
  – Better ‘Story Telling’ Visualization Rendering... especially on Multi-physics simulations.
  – ‘BY THE DRINK’ software pricing they can include in affordable project proposals.
QUESTIONS