Systematically Manufacturing Success

Stanley B. Gershwin

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Manufacturing Systems Engineering

- *Manufacturing Systems Engineering* (MSE) is a rigorous, vigorous, rapidly developing field.

- It has already saved HP, GM, Peugeot, VW, and others billions of dollars.

  ⋆ *Details on the HP case below.*

Manufacturing Systems Engineering

- MSE develops methods and tools for designing and operating manufacturing systems.
- It uses sophisticated mathematics and computational tools for performance analysis and control.
- It deals with material flow, inventory, real-time scheduling, etc.

Factories and Airplanes

How is a factory like an airplane?

- They are both complex systems involving people and technology.
- They are both require skill and attention to control.
- They are both subject to random disturbances.
- Specific airplanes and specific factories are designed for specific missions.
- The price of failure is high.

Factories and Airplanes

How is a factory not like an airplane?

- Poorly designed or controlled airplanes crash immediately.
  - ⋆ Airplanes are inherently unstable.
  - ⋆ Sophisticated control was necessary from the beginning.
  - ⋆ Designers and pilots struggle with aerodynamics and gravity.
- Poorly designed or managed factories fail more gradually.
  - ⋆ Factory designers and managers struggle with human competitors.

Human competitors were less dangerous enemies than aerodynamics and gravity.

Factories and Airplanes

Consequently, sophisticated control theoretical methods were developed for airplanes while simple methods were adequate for factories.

Trends

Globalization and competition

- Improvements in communication and transportation and reductions of trade barriers lead to world-wide competition.
- That is, *the human competitors are becoming more dangerous.* Consequently, more sophisticated tools for factory design and operation will be needed.

Trends

Acceleration

- Increasingly, there are ...
  - ⋆ frequent new product introductions,
  - ⋆ short product lifetimes, and
  - ⋆ short process lifetimes.
- Consequently, ...
  - ⋆ *factories are built and rebuilt frequently,* and
  - ⋆ there is not much time to tinker with a factory. It must run well immediately.

Trends

Outsourcing and contract manufacturing

- Many companies let others do their manufacturing, and they concentrate on product design and marketing.
- Many other companies manufacture, but hire specialists to design their new factories.

Trends

Outsourcing and contract manufacturing — possibly a dangerous trend

- The best products are designed with manufacturing nearby, with close interaction between designers and manufacturers.
- If manufacturing expertise is a commodity, it can be bought by anybody. If you don't have in-house manufacturing expertise, you lose an opportunity to gain an advantage that cannot be bought.
- You cannot have up-to-date manufacturing expertise without manufacturing. So how can you evaluate the job that your remote manufacturer is doing for you?

Trends

Environmental considerations Local manufacturing is superior to distant manufacturing for some products because

- it reduces fuel consumption, and
- it can be closer to the source of recycled materials.

This means that some products should be made locally.

Trends

Diversity and rapid response times

- Customers are impatient, and will not tolerate long lead times.
- The number of products and product variations on the market is growing rapidly.

This means that some products should be made locally.

Trends

Strategy

- Manufacture one portion of the product where costs are low, even though it is far away. This is the portion that can be predicted far in advance; or that is shared by many product varieties, etc.
- Manufacture the rest locally. The demand for this portion of the product will be highly volatile, and it will require rapid production responses.

Trends

Therefore,

- Local factories are like sports cars: fast, agile, and sometimes underutilized.
- Remote factories are like family cars: safe, inexpensive, used for routine tasks every day.

Trends

For this reason, it is crucial that local factories ...

- have short lead times (and therefore low inventories),
- be flexible, ie, have short and cheap setups within a product family
- be reconfigurable, ie, permit easy changes of product families.

Manufacturing Systems Engineering

- MSE develops methods and tools for factory design and control.
- These tools are quantitative and they are based on mathematical analysis.
- The modeling of random events (machine failures, demand spikes, supplier errors, etc.) plays a major role.

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- Factory designers and managers are encouraged to develop a *systems* intuition.
- The use of black-box software is discouraged.
- The use of black-box thinking is forbidden.
- The use of simulation is minimized.

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MSE provides computational tools

- to support the design of factories, including the choice of machines, locations and sizes of buffers, locations of inspection stations, etc.
- to support the design of material flow control systems including kanban, CONWIP, etc.
- to predict the performance (production rate, inventory, lead time, service level, etc.) of a given factory operated with a given material control policy.

Manufacturing Systems Engineering

MSE requires, for performance prediction, data including

- process flows
- operation times, MTTRs, MTTFs of each machine
- quality behavior of each machine

Manufacturing Systems Engineering

MSE requires, for system design, the above information and

- costs of each alternative machine for each operation
- inventory holding costs and floor space costs
- backlog costs

and possibly other items.

Manufacturing Systems Engineering

HP Case study

- Hewlett Packard manufactured ink jet printers manually until 1993, and then decided to automate.
- It was urgent to ramp up production quickly to capture market share in this new market.
- After installation of the automation was under way, it became apparent that it would not meet production goals because of a slight reduction in reliability in each of over 200 workstations.

Manufacturing Systems Engineering

HP Case study

- A simulation project was aborted when it became clear that it would not be successful.
- Mitchell Burman, an MIT graduate student at the time, developed a model based on our MSE methods in under a week. He proposed a remedy and convinced HP to implement it.
- The rememdy worked, and increased HP's printer revenues by about US$280,000,000.

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HP Case study

- Dr. Burman completed his PhD at MIT and founded Analytics Operations Engineering (`http://www.nltx.com/`).

Manufacturing Systems Engineering

HP Case study

How did he do it?

- HP's original design called for no buffers, and HP did not know how to calculate the production rate of such a system.
- Burman experimented with one of our MSE tools and saw that a small amount of buffer space, correctly located, would greatly increase the production rate of the system.

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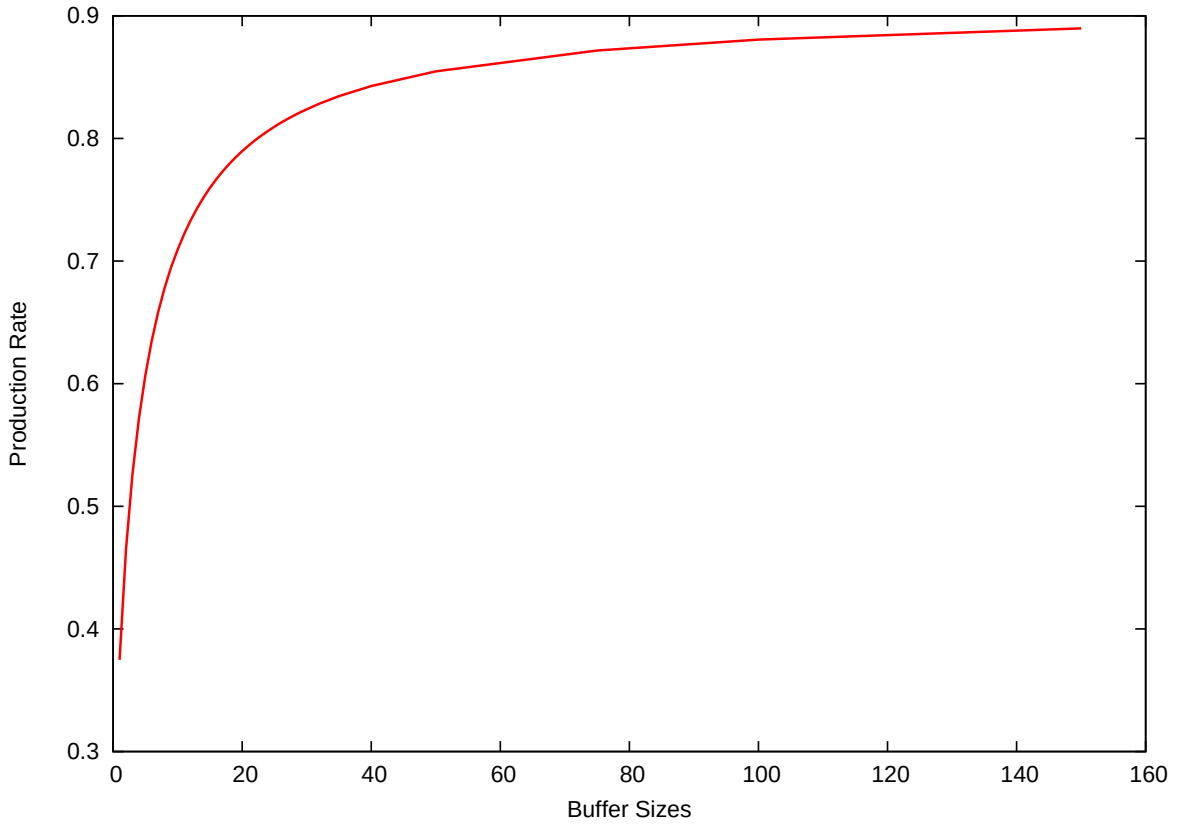
HP Case study



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The good news

- MSE has already been used and has generated value exceeding billions of dollars.
- MSE can be implemented in easy-to-use software.

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The bad news

- MSE is not widely known.
- The mathematics and science behind MSE are demanding.
- MSE is still under development, and is currently available for a limited range of issues.
- Extending MSE is a research activity.

Conclusions

- Local manufacturing will remain important, but it must respond rapidly to demand changes.
- MSE is needed to design and efficiently operate such factories.