Chapter 13

Production/Process Design

The process design strategy sets the corporate strategy for the production of the products that were designed in the product design process. Part of the process design may include how vertically integrated a company wants to be. Vertical integration is defined as: "When a company expands its business into areas that are at different points of the same production path."[77] In the 1980s Anheuser Busch tried to become completely vertically integrated and own the entire supply chain and operations management chain. They moved into the bottle and glass making business, can and aluminum making business in addition to the beer making business as was discussed in Chapter 3; once they realized that their core competency was making beer, they divested themselves of the other aspects of the operations management chain.

The production or process design is critical to the future of the company and the profitability of the company. The product of this design phase may very well determine the future capital investments in equipment and facilities. How the product is to be produced may dictate the flexibility to produce other products.

Per our previous discussions on strategy and processes, the production process can take the form of mass production, continuous production, assemble to order, make to order, batch processing, or projects (one at a time production such as dams, planes, or bridges).

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[77] vertical integration. (n.d.). *Investopedia.com*. Retrieved August 03, 2010, from Dictionary.com website: http://dictionary.reference.com/browse/vertical integration

Timing of Product Release

Timing the release of a product is tied to process design. When should the product be released to the customer? This is a difficult decision and is about as easy as trying to time the stock market. If a company releases the product too soon, it may not be ready for prime time and may have to be recalled. Hewlett-Packard did this with their tablets when the iPad was introduced. They had to pull it back, rework it and then re-release it.

Companies have to decide if they want to be the market leader or the market follower. Timing the entrance to the market is like trying to time the jump off the big rock formation at Waimea Bay in Hawaii (see Figure 13.1). During the winter months when the waves are 15-20 feet timing of the jump is critical. If you jump in too soon, you get swallowed by the wave and think you are going to die for about 45 seconds. If you jump in too late, you will miss the wave all together and have to swim like crazy to the shore before the next one arrives. But, if you jump in just at the right moment, you get a great ride all the way to the beach. The same thing in business, if you jump in too late, you miss the market all together. But, if you jump in just at the right time, you can garner a significant market share without having to spend enormous amounts on marketing a brand new product.

Figure 13.1: The rock formation at Waimea Bay, Hawaii

Planning the Process and Design

One of the products of the product design process is the **Blueprints.** The product design should produce detailed drawings of the proposed products. These blueprints will allow the design team to properly design the process to produce the product and should provide the producer an idea of the skills needed to make the product.

From the blueprints the design team can determine all of the components of the product. This list of components is known as the **Bill of Material (BOM)**. The BOM is much like the ingredients listing on a recipe card for baking a cake. They both serve the same purpose. Bills of Material can be flat BOMs which only list the primary parts or assemblies. A multiple layer or indented Bill of Material shows the components of the assemblies and may be detailed down to the screws and washer level. According to the APICS/ASCM Body of Knowledge, a Bill of Material is defined as: "The BOM is the document that specifies the components needed to produce a good or service. It lists the parts, raw materials, subassemblies, and intermediates

required by a parent assembly. A BOM specifies the quantity required to make one item, specifies units of measure, and quantifies phase-in and phase-out dating."[78]

The next piece of planning data that comes from the product design process will be the **Assembly Chart** also known as a product structure diagram. The assembly chart is like the diagram in the box with the latest piece of gym equipment that I assembled. Inside the box was the Bill of Material (a listing of all the parts in the box), the assembly chart that provided a graphic of what the equipment should look like as it was assembled, an **Operations Process Chart** that listed each of the steps in the shelves assembly, and a **Routing Sheet**. The routing sheet showed the proper sequence of events to assemble the equipment from ingredients listed in the Bill of Materials.

Using the original analogy of baking a cake, a good recipe card not only lists the Bill of Materials to make the cake, the recipe card has a picture of the finished product, the assembly chart or steps in the baking of the cake, and the routing sheet that shows the proper sequence of what to do to assemble and then bake the cake. Just as these diagrams and listings are important in baking a cake, they are just as important in manufacturing or assembling a product.

Make or Buy Decisions

While concurrently conducting the product and process designs, a decision may become necessary as to whether or not a product should be made in house. Remember in the discussion of the product design one of the considerations was "do we have the technical expertise to make

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[78] *APICS Operations Management Body of Knowledge Framework*, 2nd edition, APICS The Association for Operations Management, 8430 West Bryn Mawr Avenue, Suite 1000, Chicago, IL, p. 51. For more on the Operations Management Body of Knowledge or APICS – The Association for Operations Management go to http://www.apics.org

this product?" Another consideration was "can we sell the product at a sufficient level to make a profit (breakeven analysis)?"

This analysis of the product design may lead the company to decide to not make the product themselves. Designing the product may be a core competency but making the product may not be a core competency. Before looking at why the company should not consider outsourcing, it is important to understand that in some situations it is not feasible to outsource. For example, if there is a barrier to making a make or buy decision such as "Buy American" or "Buy European." In some businesses, there may be "classified" or proprietary information such as the "Colonel's 11 herbs and spices" in Kentucky Fried Chicken that precludes outsourcing.

Let's take a look at some of the criteria that may lead a company to decide to outsource their manufacturing to a Third-Party Provider. None of these considerations are stand alone issues. Each of theses are related and should be considered in the make or buy decision.

Cost – Can someone else make the product cheaper with the same quality? It may be beneficial to outsource the manufacture of the product. One company that provided portable equipment batteries discovered that another company could not only make their batteries cheaper than the parent company could but could also make the batteries with the same quality. A little more research proved that the outsource company could also apply the company's labels to the batteries before shipping. The battery company was able to transform the manufacturing plant to a larger warehouse, create a workout room for employees, and establish a day care facility within the original plant location for the employees.

Keep in mind that cost is not a stand-alone factor. Almost any product can be made cheaper or less expensive. However, that does not mean that it will be of the same quality that our customers have come to expect from our brand name. For example, in the late 1990s and

early 2000s Sears outsourced the manufacturing of Craftsman Tools. This decision looked good on the surface until the number of returns for substandard tools started rising. If cost is the factor driving the make or buy decision, it is critical to ensure that quality is not overlooked.

Capacity – If a company does not have the capacity to make the projected demand of the product, it may be an effective strategy to outsource the manufacture of the product. We will look at capacity decisions in greater detail in a later chapter. This may be a temporary decision for short term spikes in demand or could very well be a long-term outsourcing decision based on forecasted increases in demand that exceed the capacity of the company.

Another factor related to capacity is: does the company we are looking at have the capacity to produce the product if the demand increases? For example, in 1990 a contract was awarded to a small, disadvantaged business to make a chemical packet that would allow Soldiers to heat their Meals Ready to Eat (MREs). At the time of the contract the numbers needed for annual training for the Army was not significant. However, within a few months of the contract award Operation Desert Storm (the first Gulf War) kicked off when Saddam Hussein invaded Kuwait. The result was an exponential growth in the need for these MRE heaters. The initial contract company did not have the capacity to expand operations, so another company ended up with the contract.

Quality – Can another company make the company's product better than the designing company? If another company can make the product and make it better, why not outsource? However, if the quality improvement creates a price that prohibits the value proposition then obviously it is not wise to outsource. As we mentioned earlier, this consideration is linked to cost.

Speed – Can someone else make the product faster? The second part of this question is – can they make it better or cheaper than the designing company? If the cost is not increased, if the quality is the same and the product can be produced faster and delivered to the customer faster, then it is logical to outsource the manufacture of the product.

Expertise – Does the company that can make the product faster or cheaper actually have the expertise to make the product? As a response to the escalation of the second Gulf War (Operation Iraqi Freedom), the US Government eased some of the research and development requirements and went to a streamlined procurement model. One company in Florida won several contracts to provide equipment to the deployed forces. It turns out that their expertise was not making anything, but they were experts in writing proposals to provide equipment. In fact, they were so good at writing and winning proposals that they were able to get start up monies up front for the contracts that they won. They never produced anything and when the General Accounting Office looked into their operations, they were found negligent and fraudulent in their operations. The investigation led to a conviction – these folks are now experts at making license plates in prison.

Equipment Selection/Process Selection

Part of the production and process design is the selection of equipment. This is another reason that the process and product designs need to run concurrently. If the product design identifies new or specialized equipment that must be ordered, it is imperative to get the equipment ordered as soon as possible. You never know when there will be a long lead time for the equipment.

When I was a young officer at Fort Gordon, Georgia, the installation decided to outsource the maintenance of all facilities as a test for outsourcing commercial operations. Seems the

mechanic who was responsible for maintaining the air conditioning systems for all of the buildings in the block that I was working on was not offered a job by the incoming contractor. It also seems that this individual knew that the air conditioning system for the block was not functional when he was let go in February. As he was not offered a job, he did not think it was his job to worry about something that would not be needed until long after he was gone. So, when the thermometer topped 95^{o} and 95% humidity (as is common in Georgia in the summertime), it was discovered that this block of buildings that were built with windows that did not open because the "modern" HVAC system had no air conditioning. The real kicker was the lead time for the part was over four months since it was only made in Sweden. Although a little different, that same principle is important when buying new equipment.

When considering the purchase of new equipment there is always some risk and uncertainty. The first consideration always seems to be the purchase cost of the equipment. Because of this some companies choose to piecemeal their purchases. This is like the old Johnny Cash song, "One piece at a time." In the Johnny Cash song, he worked at the Cadillac factory and took home one piece at a time. The problem came when they tried to put the car together after about twenty years. All of the pieces did not fit. The same thing happens when ordering equipment one piece at a time vice ordering all of the equipment at one time—by the time the last piece of equipment is purchased, it may not be compatible with the earlier purchased equipment.

Another consideration that may lead to an equipment decision may be the operating costs for the equipment. This may also play into a decision point if the operating cost in energy costs does not sync with the company's goals of being green.

If a decision is made to buy new equipment there may be some annual savings realized by using more modern equipment. There may also be some government revenue breaks or tax rebates for using more environmentally friendly and modern equipment.

Keep in mind that the process selected may impact fixed costs and variable costs. Therefore, if product design and process design are not conducted concurrently, this may mean having to relook the break-even point. This relook is necessary to make sure we have not moved the break-even point out of our favor resulting in making a product that we cannot make a profit from; or to see if the new process moves the break-even point in our favor resulting in a relook of the make or buy decision.

Process Analysis

The goal of process analysis is to analyze the processes to determine if there is waste or no value addition in the process. The usual tools for this are process maps, flow charts, and process charts. This is done with the understanding that every process adds cost but not every process adds value. And as we stated in Chapter 1 that the primary goal of Operations Management is to add or create value, it is important to know which processes are adding value and which ones are simply adding cost. If a process does not add value to (a) the customer experience; (b) the quality of the product; or (c) the bottom-line profits, why do it?

According to the APICS Operations Body of Knowledge process mapping is: “a visual form for documenting the details of a process. Depending on the map’s objective, the level of detail will vary. Process maps can take many forms, including flowcharts; relationship maps;

cross-functional maps; and supplier, input, process, output, customer (SIPOC) diagrams."[79] A process map serves several purposes, the first of which is applicable to this discussion—providing a visual picture of the process. The second important function of a process map is to use it as a teaching tool for new employees on the processes of the company. Figure 13.2 is a simple example of a process map for receiving operations.

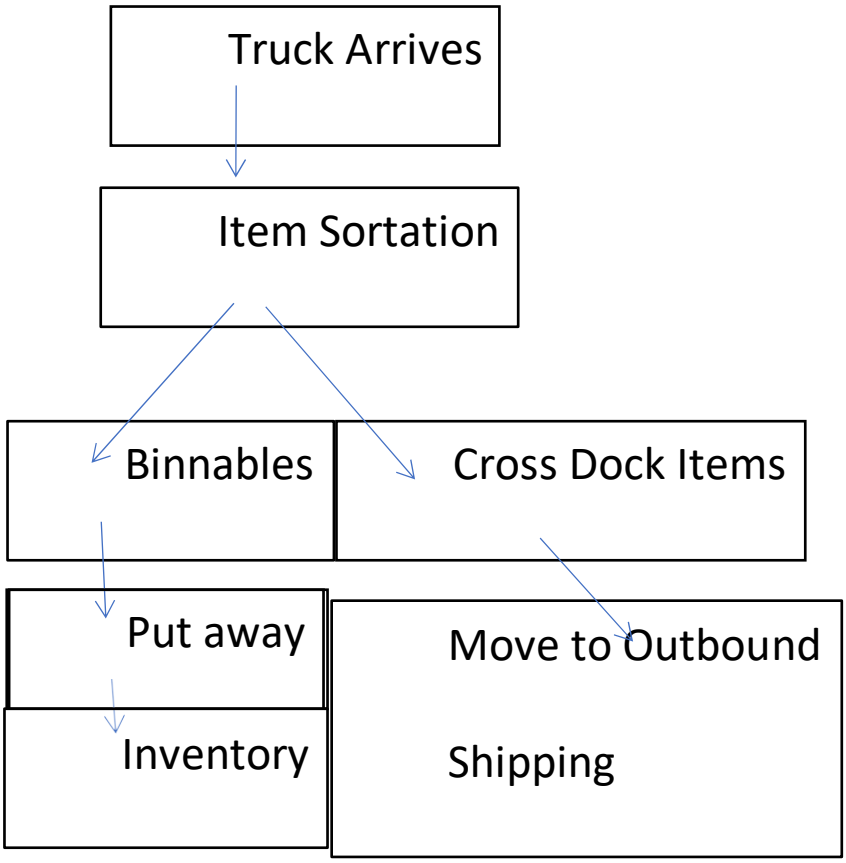

Figure 13.2: Sample Process Map

[79] *APICS Operations Management Body of Knowledge Framework*, 2nd edition, 2009, APICS The Association for Operations Management, 8430 West Bryn Mawr Avenue, Suite 1000, Chicago, IL, p. 33.

The goal of the process redesign operations is to get the waste out of the process. At the same time as the waste is identified and eliminated, thus streamlining the process, the process map links the processes to value creation. Once a process map is developed, the next step is to start capturing data and placing dates and time stamps on the process map. This will further enhance the ability to use the process map to improve efficiency and benchmark the processes against industry standards and company past performance to determine whether the changes are actually improvements. Remember every improvement is a change, but not every change is an improvement. The goal of the process mapping is to identify improvements you can believe in and not simply change.

Another, less costly method of improving the process is to personalize the process. Here is an example of personalizing the process. This is a process called "naming the aisle." Naming the Aisle is a simple process to talk about and relatively easy to implement. In a distribution center each aisle has a location placard at the end of the aisle. By placing the team names that are responsible for the maintenance of the aisle or the team leader's name on the aisle and then putting the metrics such as picking accuracy, inventory accuracy and orders picked per hour on the end of the aisle adds pride to the workers. This also adds a little internal competition to see which aisle is better. The combination of pride and competition improves the overall operations of the process.

Another method of improving the process is through the use of Six Sigma. The goal of Six Sigma is to reduce variability in the process. If the variability is reduced, the process should be improved. Motorola introduced the world to the Six Sigma concept in the early 1980s with the steps of:

Define
Measure
Analyze
Improve
Control

This methodology became known as the DMAIC method. Although Motorola introduced Six Sigma, General Electric received more attention with their use of Six Sigma. Even with the publicity that GE received for its use of Six Sigma, it was not until Jack Welch tied the implementation of Six Sigma to the bonuses of the executives that Six Sigma became successful in both the manufacturing and services sector of the company.

The US Army introduced a similar program to improve its supply chain processes in 1995. This program was called Velocity Management. The methodology for Velocity Management was Define, Measure, and Improve. The D-M-I methodology was basically "six sigma light." Like Six Sigma, this program sought to reduce the variability of the supply chain and as a result significantly improved the customer response by the supply chain systems. It was successful in that the D-M-I process resulted in saving the US Army over $300 million in annual expenditures for repair parts. The success of the D-M-I process led to similar programs in the US Navy, the Air Force and the Marines Corps.

Improving the process is also possible by simply varying the entry point of looking at the process. A different entry point provides a different perspective of the situation. The US Army conducted an After-Action Review of the initial supply chain operations for Operation Iraqi Freedom approximately one year after the invasion started. The first point here is that the After-Action Review should have been conducted closer to the event to get a good review of the processes to improve them.

Every senior leader that spoke at the After-Action Review had a different perspective and from each perspective they felt that what they did was good but everyone else came up short in their performance. Amazingly, there was overlap in the areas of responsibility, so the different perspectives were parochial in nature and not true perspectives. So, when changing perspective, it is important to get a true perspective of your own and not a jaded perspective or parochial point of view.

When Lieutenant General Gus Pagonis left the US Army and became the Vice President of Supply Chain Operations for Sears, he made each of his employees spend time in a store or distribution center on a regular basis. The point of doing this was to make sure the employees could see from other perspectives the actions based on their decisions and allow them to modify policies based on their work experiences. Sometimes things look like good ideas in the corporate headquarters but don't actually make sense in practice.

When I was in Kuwait, I regularly jumped on a forklift to unload trucks, move supplies, and load outbound trucks. By seeing things from the workers' perspective, I was able to understand the impacts of certain events on the operations such as rain impacts on a largely outdoor, unpaved facility and heat and dust related impacts to operations. I also put on coveralls and crawled under vehicles at the US Army National Training Center in the Mojave Desert to see the impacts of policies on maintenance to better understand how to support my customers. Some policies look good at the corporate office but do not translate well from the abstract to the concrete and result in vague or imprecise guidance at the worker level.

The hit television show, *Undercover Boss*, sought to do the same thing—provide CEOs a different perspective of their operations. The result of the bosses going undercover to do some of the work at different locations seems to have provided great insights to improve operations. One

of the ideas that may come out of changing perspectives and varying the point of entry into an operation may be a change in automated systems.

Before moving to a new automated system, it is imperative to evaluate the systems and the current operations. By evaluating and documenting all current activities it may become apparent that some of the current processes may not be needed in an automated environment and are thus non-value-added with the new systems. The analysis may point toward the use of an Enterprise Resource Planning program or ERP.

Enterprise Resource Planning Programs

The main goal of an ERP system is to take all of the old stovepipe data bases and information systems into one enterprise wide information system. Once all of these systems have been consolidated data mining is possible and the ability to hide information and data is eliminated within the company. This allows the company to have all employees working from the same data and forecasts. Figure 13.3 shows the feed of all other data bases to the ERP system.

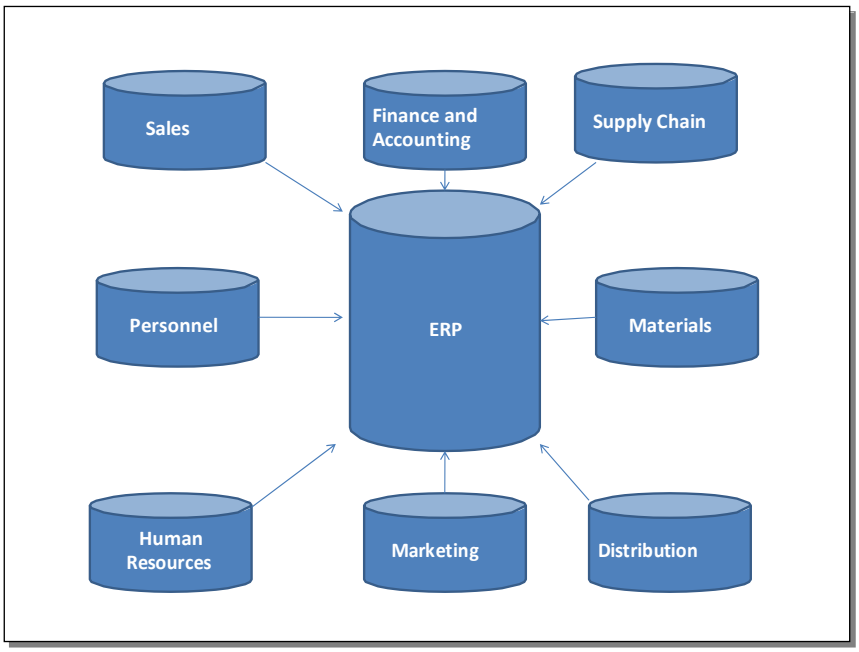

Figure 13.3: Example of an ERP Database

SAP (Systems, Applications, and Programs) is the largest provider of ERP software with over 22% of the market.[80] Oracle is also a strong player in providing ERP systems with approximately 15% of the market share. Oracle realized several years ago that they needed a good personnel and finance module for their ERP systems. Rather than develop a new set of software modules, Oracle purchased PeopleSoft and incorporated what was at the time the best available standalone module into their system.

ERP is not always the end all solution to systems and process improvements. Although it is getting better, for every good news story on the implementation of ERP systems there is always a horror story or a company such as Dell that spent millions of dollars only to pull the plug and go back to the old system. In 1999, Hershey's implemented an ERP system. The result was missing the majority of their Halloween candy shipments due to a glitch in the software.

[80] http://www.businessnsoftware.com/erp-market-share/

This incident placed Hershey's on the *Supply Chain Digest* list of the worst supply chain disasters of all time.

Radio Frequency Identification (RFID) Tags

RFID tags have been around for over 20 years. In the late 1980s the US Army looked at using what was then being called MITLA chips or Microprocessor Technology with Logistics Applications to track the shipment of supplies and equipment worldwide. In 1994, the US Army started tracking the shipments of materials and supplies using the SAVI tags as shown in Figure 13.4. The newer generation of tags are about the size of an iPhone 8.

Figure 13.4: SAVI RFID Tag on a Pallet in Kuwait

The research into the use of this particular tag started before the completion of Operation Desert Storm (the First Gulf War) but picked up steam immediately after the War. When this operation was complete there was over 27,000 twenty foot equivalent (TEU) containers on the

dock at Dhahran, Saudi Arabia with no clue what was in them or who they belonged to. The US Army wanted to reduce or eliminate this problem for future operations. With the RFID tag the Army was able to track every shipment from origin until final destination.

This particular tag is an active tag. An active tag is always on and can be read from up to 300 feet with an interrogator. With the proper software, this particular tag can be fed into the ERP system and tracked worldwide, thus giving the company using the tags supply chain visibility. The downside of this tag is that it is relatively expensive. This is relative when compared to the cost of losing a shipment or a customer due to a lost or misrouted shipment.

The tags getting the most attention over the past decade is the passive tag. Wal-Mart, with great fanfare, announced that as of January 1, 2005 every supplier would have to start using RFID tags down to the item level. The Department of Defense made a similar announcement about the same time. Wal-Mart quietly backed off their demand to only include the top 100 suppliers to two distribution centers and in 2009 announced that they would apply tags to shipments that suppliers did not tag and charge the companies for the tags. This worked out to the advantage of the companies. In 2013, Wal-Mart did not admit defeat with their initiative but did announce that they would charge suppliers per pallet that was not tagged. The cost of this charge was much smaller than the cost for smaller suppliers to buy the tags and the infrastructure to write the tags.

In July 2010 Wal-Mart announced a program to place RFID tags in jeans and other clothes to “improve inventory accuracy.” This same concept was attempted in 2006 by United Colors of Benetton with a great outcry of invasion of privacy by their customers in England. This outcry led to abandonment of the program.

The concerns about invasion of privacy is not a new concern with RFID tags although passive tags need to be activated by a reader and can only be read from about a foot away. California has considered several laws to let customers know if the product that they are buying has an RFID tag and if so, give the customer the option of having it disabled. The concern is: if I can read the tag, who else can read it? Figure 13.5 is a picture of a tag developed by Michelin to track and inventory tires. Another use of this tag was to let customers know if there was a recall or if they needed to rotate their tires. Again, the concern is that if they can read the tags who else can read it and can someone track my vehicle to see where I am going and where I have been. In 2018 several companies started working on an encrypted tag. This development will allow companies to keep others from reading their RFID tags and should alleviate some privacy concerns.

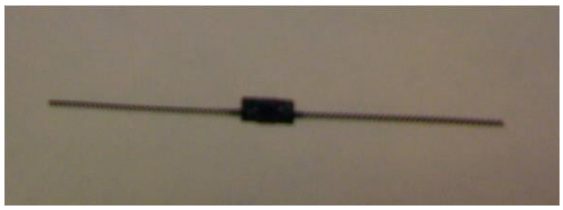

Figure 13.5: Michelin RFID Tag for Tires

Comparing Two Processes

What if there are options for the production processes? There is a rather simple calculation for choosing the best process based on cost analysis. This calculation compares the two processes to determine which process will provide the lowest total costs based on the forecasted production levels. Equation 13.1 shows the calculation for the Point of Indifference. The Point of Indifference is that production point where the total costs for either process are equal.

Point of Indifference = the point where:

$$\text{Fixed Costs}_A + \text{Variable Costs}_A (x) = \text{Fixed Costs}_B + \text{Variable Costs}_B (x)$$

Where x = demand quantity or forecasted production level

Equation 13.1: Point of Indifference

Example 13.1 Using Equation 13.1

Process A:	Process B:
Fixed Costs = $250,000	Fixed Costs = $350,000
Variable Costs = $50/item	Variable Costs = $35/item

Step 1: Set up the Equation 1 equations to set Process A and Process B equal to each other to solve for x (forecast production quantity and Point of Indifference)

$$\text{Fixed Costs}_A + \text{Variable Costs}_A(x) + \text{Fixed Costs}_B + \text{Variable Costs}_B (x)$$

$$\$250{,}000 + (\$50)(x) = \$350{,}000 + (\$35)(x)$$

$$(\$15)(x) = \$100{,}000$$

$$x = 6{,}666.6667 = 6{,}667$$

Items must be rounded up to a whole number as a partial product is not feasible or possible,

Therefore the Point of Indifference is at a production level of 4,000

Step 2: Insert the Point of Indifference into the Equations to determine the best process: If the forecasted production level is 6,000, the lowest total costs are calculated:

Process A:

= $250,000 + ($50)(x)

= $250,000 + ($50)(6,000)

= $550,000

Process B:

= $350,000 + ($35)(x)

= $350,000 + ($35)(6,000)
= $560,000

Step 3: Select the process with the lowest total costs. In this example, the company should select Process A. Based on this calculation, if the forecasted production had been 7,000, Process B would be chosen.

Process A:
= $250,000 + ($50)(x)
= $250,000 + ($50)(7,000)
= $600,000
Process B:
= $350,000 + ($35)(x)
= $350,000 + ($35)(7,000)
= $595,000

Summary

The selection of a process for production of the product designed in Chapter 7 may impact expansion decisions, may impact investment expenses, or may very well drive the make or buy decision process.

The selection of processes and equipment for the production of a product must be conducted concurrently with the design of the product if the goal of getting a quality product to the market as quickly as possible is to be met by the company.

Thinking Questions and Problems

1. Why is the process development process important to the Operations Management Chain?
2. What is the goal of process design?
3. What is the importance of the Point of Indifference?
4. If a company has the option of choosing between two processes for the production of their product, calculate the Point of Indifference with the following data:

   Product A: Fixed Costs = $500,000; Variable Costs = $125 per item produced

   Product B: Fixed Costs = $750,000; Variable Costs = $75 per item produced
5. If the forecasted production for the above data is 9,000 units, what process should the company select?
6. Research RFID tags and explain the size and capability differences between active and passive tags.
7. What aspects should a company consider if making a make or buy decision?
8. What is ERP and why is it important?
9. What documents comprise the recipe card for a product?
10. Create a process map of any process that you are familiar with.
11. What is the purpose of a process map?

12. Why is it important to relook the Break Even Point calculation as part of the process design steps?