The Next Step – The Automation Options

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When you have decided on automation for a particular product line, there are a number of machine configurations, which may fit your needs. The next step is to define your requirements and decide which are the most important. While determining the type of automation to use, take a few minutes to document the following information in order to get a better understanding of what to consider:

- Annual Volume of Product (Current, Future, Maximum)
- Anticipated Product Life
- Number of Product Part Numbers
- Product Design (Fixed?, Revised?, New?)
- Number of Changeovers (Current, Desired)
- Estimated Changeover Time (Current, Desired)
- Typical Lot Size (Current, Desired)
- Total Number of Parts in Assembly (Lowest, Average, Maximum)
- Number of Common Parts per Assembly (Lowest, Average, Maximum)
- Number of Unique Parts per Assembly (Lowest, Average, Maximum)
- Total Number of Operations per Assembly (Lowest, Average, Maximum)
- Number of Common Operations per Assembly (Lowest, Average, Maximum)
- Number of Unique Operations per Assembly (Lowest, Average, Maximum)
- In Process Inspection Required?
- In Process Testing Required?
- Functional Test Required?
- Material Handling Requirements (Batch?, Conveyor?, Chutes?)
- Ergonomic Considerations (Carpal?, Vibration?, Fatigue?)
- Available Floor Space
- Number of Shifts per Day (Current, Desired)
- Net Hours per Shift
- Net Days per Year
- Anticipated Equipment Uptime
- Number of Machines Required
- Required Machine Production Rate*
- Priorities (Cost, Throughput, Flexibility)
- Other considerations:

* The required machine cycle time can be determined by using the following calculation:

Production Rate = Forecast Annual Volume on Machine / (Available Time per Year * Anticipated Uptime)

It is recommended to base this calculation on “straight time” in order to make overtime, extra shifts, and weekends available to cover your peak volume demands.

After you have answered these questions, and you have a good understanding of the equipment requirements, it is time to determine the machine configuration that best suites those requirements. In order to assist with this decision, let us review the five basic automation styles.

The basic automation styles are:

1. Single Station
2. Continuous
3. Synchronous
4. Non-synchronous
5. Hybrid

The following is a brief description of each along with their advantages and disadvantages:

1. Single Station

Single Station machines are exactly what the name implies. They are a mechanization of a single station, which can be semi-automatic, automatic, or robotic. They are primarily used for operations that are difficult to accomplish manually, or used for manufacturing a part that requires few operations.

Advantages:
- Simple
- Low cost
- Good utilization/uptime

Disadvantages:
- Low number of operations
- High manual labor
- Additional material handling required

2. Continuous

Continuous machines do their manufacturing operations without stopping. All work is performed by stations or operations that move with the work piece. These machines lend themselves to very high volume and low mix. Certain categories of continuous machines can be flexible within families of parts. Continuous machines can be single station, rotary, or linear design and most are dedicated to a particular part envelope.

Advantages:
- Very high volume
- Durable
- Smooth/Quiet

Disadvantages:
- Relatively complex
- Can be expensive

3. Synchronous

Synchronous machines utilize a mechanism where all work pieces are moved together to sequential workstations. Operations are performed on the work pieces while they are in dwell at their respective stations. There are a large number of synchronous configurations, which will be explained in more detail later. Synchronous machines are often preferred when automating relatively high volumes with little changeover, or with large lot sizes.

Advantages:
- Relative low cost
- High speed
- Can add operations by using multiple fixtures
- Can increase throughput by using multiple tooling

Disadvantages:
- Usually dedicated or uses manual changeover
- Production is limited to the slowest operation
- Uptime is inversely proportional to the number of operations

The following are common synchronous machine configurations:

Dial Index Machine:

Dial Index machines have a circular fixture plate with fixtures evenly spaced around its periphery. The dial sits on an indexing drive, which rotates the plate a fraction of a turn and progressively presents each fixture to each workstation. “Dial Machines” are the most common type of synchronous machine due to their simplicity and relative low cost.

Advantages:
- Low cost
- Minimum number of fixtures
- Easy to concept and design
- Uses minimal floor space

Disadvantages:
- Can handle a limited number of operations
- Machine can be crowded due to limited space
- There is limited access to the tooling
- There is limited access to the work piece

Linear Machine (Carousel / In-line):

Linear machines move the work pieces or fixtures in a straight line progressively presenting each part to each workstation. These machines will usually be configured in a carousel or in-line design. The carousel will move the fixtures in a rectangular or oval path, returning the fixtures to the starting point. The in-line machine will utilize a shuttle, walking beam, or indexing conveyor to move the work pieces in a straight line. These machines are selected when a synchronous design is desired, but additional workspace is required.

Advantages:

- Accommodates more operations
- Improved access to work piece
- Improved access to tooling
- Improved access for maintenance and repairs

Disadvantages:
- More expensive
- More fixtures
- Additional floor space

4. Non-synchronous

Non-synchronous machines utilize individual workstations, which operate independently without regard to the other stations on the machine. In some cases, the machine will transfer work pieces from station to station without fixtures. These machines are usually dedicated since they rely on the part features for guiding and locating. In more flexible machines, work pieces are transferred while fixtured on pallets. These machines are flexible since different work pieces and different processes can be handled on the same machine. The concept of flexibility will be addressed in more detail later.

The following are characteristics of non-synchronous machines:
- Stations operate independently
- Work pieces are capable of accumulating
- There is queue between stations which can be used for balancing and uptime optimization

Non-synchronous machines lend themselves to the higher mix, lower volume automation projects. Typically, the production rate is slower than the synchronous alternatives. Most run slower than (20) cycles per minute; however, the throughput can be increased by using multiple parts per pallet combined with multiple tooling. In addition, uptime is usually higher than the synchronous alternative due to the independent workstations, and these machines often incorporate programmable changeover in order to accommodate high mix.

Advantages:
- Flexible
- Improved utilization/uptime
- Not paced by slowest operation
- Access to all part surfaces
- Easy access to tooling

Disadvantages:
- Expensive
- Large "footprint"
- Many fixtures

As mentioned earlier, a key advantage of non-synchronous machines is flexibility. Flexibility can mean a number of things in the manufacturing environment. In brief terms we usually think of a non-synchronous machine as flexible in current production and for future production. Current production refers to programmable changeover, programmable workflows, and the potential for small lot sizes. Future production refers to the machines reconfigurability. This means that the equipment is modular so you can add, remove, or rearrange stations. In addition, you can phase in automation as volumes ramp up or you can redesign the modules to run new products.

5. Hybrid

Hybrid is a term for automated systems, which are a combination of synchronous and non-synchronous machines. With this arrangement, the high speed of a synchronous system can be combined with the flexibility of a non-synchronous system. Typical systems would have synchronous machines feeding pallets on a non-synchronous line or pallets that automatically index through synchronous cells that are built into the line.

Hybrid systems generally have the following characteristics:

- Combination of synchronous cells and non-synchronous systems
- queue between high speed cells for increased throughput and improved uptime
- Generally a palletized system for consistent part transfer and improved flexibility
- Modular design for flexibility

Advantages:

- Has the high throughput & accuracy of a synchronous system
- Has the flexibility and improved utilization/uptime of a non-synchronous system
- Automatic & manual cycle times can be balanced
- Maintains easy access to part surfaces & tooling

Disadvantages:

- Usually the highest overall system cost
- Building the system in phases requires detailed planning
- Has a large system "footprint"
- Utilizes many pallets and/or fixtures

Summary / Equipment Concepts

After you determine that it is time to automate the product line that was selected as the best choice, the next step is to match your requirements to the type of automation outlined above. A natural starting point is to narrow down the production rate requirement for each piece of equipment in the production line. After you determine your current and future annual volume, you then decide if you want to produce that volume on multiple lines or on a single production line. The equipment production rate can then be calculated using the formula in the beginning of this article.

Determining the production rate required is a good starting point for concepting the automation; however, there are many additional factors, which have to be considered. After the project requirements are fully understood, it is a good idea to determine the specific requirements that are most important to you. Using the general pros and cons in this article can give you a good idea of the direction that you want to take when concepting the automation, but in order to assure a successful automation project; a multi-phased approach is highly recommended.

With the multi-phase approach, the entire project team will start by defining the specific goal of the project. They will then agree on the project “musts,” prioritize the project “wants,” and document other information pertinent to the success of the project. This information is then used to develop concepts and decide on the best approach. The best approach is then refined into the final concept and risk areas are validated. The automated production line can then be designed and built with a certainty of success.

Belcan, Specialty Equipment Services Division, has used the multi-phased approach as a standard business practice throughout our history. Over the years, the approach has been refined to a formal process that we offer to our clients as the low risk approach. The process steps are defined as follows:

- Define Client Requirements
- Develop Preliminary Concepts
- Perform Trade-off Analysis
- Refine the Concept
- Perform Prototype Equipment / Processing Trials
- Production Design and Build

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