Challenges in Setting up a Production Line during Pandemic

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Abstract. The pandemic caused by COVID-19 brought on many challenges. Sustaining manufacturing production is one of them. Some market segments may experience reductions in demands, while other market segments may experience explosions in demand. Companies have to manage these changing needs and supply uncertainties while keeping employees safe and remaining profitable. This paper characterizes the problems encountered in setting up new production lines in two different industries and describes solutions adopted and envisioned.

Keywords: New Factory, Production Line Set up, Pandemic, Production Management.

1 Introduction

During the pandemic, demands for certain products changed dramatically driven by medical and economic necessities as well as consumer behavior changes such as stock-up buying, more reliance on online and direct-ship. Some product category sales skyrocketed while others plummeted, and some products that plummeted may never rebound. For example, for a diverse agrifood business, demands of grocery items such as milk, butter, and cereal went up because consumers were eating more at home [1-3]. Demands for electronics continued to grow as stayed-at-home consumers needed more electronics to do their jobs and kept them entertained [4]. The demand for printed-circuit-board (PCB) for medical devices, in particular, increased [5]; and auto-part manufacturing plants had to be adapted to producing medical devices [6].

The pressure on the supply chain for raw materials to produce in-demand finished goods shifted common ingredients away from some commodities to meet the demand of others. Animal feed for backyard chickens increased dramatically and shifted ingredients away from other more traditional animals. The closure of some ethanol plants reduced the feedstuff ingredients of by-products such as dried distillers' grains, meaning some traditional animal feed could not be produced even though the demand was there. Dairy and other livestock farmers also 'stocked up' on feed supplemental blends and additives [1-3]. Increase in plant production capacities were needed to meet this shift in demand.

Similarly, the demand for batteries continued to grow, not only due to the growing demands of electronic devices, but also due to electric cars and alternative energy. New production lines need to be added to address shifts in demands and the continued growing demands. While some companies were able to squeeze out additional productivity to deal with the demand surge [5], some of them have to set up new production lines.

This paper documents the difficulties associated with setting up a new production line during the pandemic. The intention of documenting these is that it may spur developments of new production technologies and better the preparations for similar, emergency situations in the future.

The rest of the paper is organized as follows. Section 2 gives high-level activities associated with setting up a new factory and/or production line. Section 3 documents challenges associated with some of those activities and finally section 4 discusses ideas that could address those challenges.

2 Background

Setting up a production line or factory (from designing to commissioning) is a subset of a larger set of activities of the new product introduction [NPI] process. Jung et al. [7] outlined a set of activities involved in setting up or updating a factory using an IDEF0 activity model [8]. Table 1 lists these activities. While many activities can be done virtually with today's technologies, some of them require physical presence and face challenges, especially those related to the physical deployment of production equipment, network installation such as fiber optics and Wi-Fi access points, bar-code scanners and printers, conveyance equipment, and the various Test activities. Some of these activities are also challenged by supply shortages. The next section discusses more detail about these challenges.

Table 1:Activities involved in setting up a new factory as outlined in [6]

A1- Develop Factory Requirement	**A2 - Develop Basic Design**	**A3 - Develop and Deploy Detail Design**	**A4 - Test**
A1.1 - Analyze Market	A2.1- Set Production Target	A3.1 - Manage Capital Procurement (order/ receive)	A4.1 Verify Production & Inspection Equipment
A1.2 - Analyze Infrastructure	A2.2 - Determine Equipment & Manpower Capacity	A3.2 - Determine Manufacturing Method & Technology	Verify Process

A13 - Analyze Sales & Production Plan	A23 - Verify Process Throughput	A33 - Design and Deploy Production Equipment	A43 - Verify Material Handling System
A14 - Assemble Factory Requirement	A24 - Set Lot Size	A34 - Design and Deploy Inspection Equipment	A44 - Verify Factory Layout & Material Flow
	A25- Design Auxiliary Facility	A35 - Design and Setup Material Flow	A45 - Test Factory
	A26 - Design & Verify Manufacturing Line	A36 - Design and Deploy Material Handling System	A46 - Standardize Factory
	A27 - Assemble Basic Factory Layout	A37 - Design and Factory Layout	
	A28 - Develop Production Management System	A38 - Develop Material Management Plan	
	A29 - Assemble Basic Factory Specification	A39 - Assemble Detailed Factory Specification	

3 Challenges

One of the main decisions that is made when addressing increased demand (which even existed prior to COVID-19) is whether the existing plants can increase their production throughput, whether a new plant needs to be created, an existing plant can be expanded, or whether a co-manufacturing or contract-manufacturing partner can be used to handle the increased demand (expensed). For the agrifood business, a decision matrix was created to determine whether to 1) build a new plant, 2) retrofit existing, but unused, manufacturing plant the business owned through prior merger/ acquisition, or 3) whether re-purpose and expand existing plant. Prior to COVID, to address the need for increased demand for feed additives and pre-mixed ingredients operated under a subsidiary, the original plan was to bring back to life an idle plant that was part of a merger and acquisition of a competitor. After COVID hit, it was determined that it was better to repurpose and expand an existing plant and convert that plant from the parent operation company to the subsidiary while STILL producing the parent

company's feed supplements for livestock (dairy, beef, pig, turkey) as if it was a co-manufacturer. This decision reduced the amount of technical resources required to be on-site, as bringing back to life the old plant only needed resources to ensure the equipment was still operational, determine whether they required upgrade, etc. - less than resources that would be required for breaking a new ground for an expansion. The business decision did not take into account all the system integrations, and that required additional scoping.

Once the decision above was made, the company still faced challenges from the pandemic on three fronts. First, there was a supply chain disruption of devices and equipment needed to set up the factory. The shortages extended also to control equipment such as Programmable Logic Control (PLC) and computer systems.

The second issue was the supply chain disruption of personnel. Even if the social distance and other preventative measures such as mask wearing and air scrubbing can be employed to allow physical presence of local workers, getting experts and engineers particularly from abroad to the set-up site was next to impossible because of the travel restriction.

The third challenge stems from the first two challenges causing difficulties related to factory design and overall commissioning.

4 Discussion

This section discussed ideas that may be developed to address the challenges that have been described in Section 3. For the agrifood business, from a business applications perspective, it was determined that the subsidiary's Enterprise Resource Planning (ERP), Manufacturing Execution System (MES)/Inventory Management System would be used. This indicated a significant process change for existing personnel who used to use the parent companies ERP and no MES system. This meant re-training of personnel on new systems and processes that added significant lot traceability - a step in the positive direction. To support the new co-manufacturing processes, additional integration between the respective ERPs to communicate purchase orders, ship notices and invoices would need to be created. The formula bill of materials would come out of the parent company's formulation system and sent to the subsidiary's MES. The MES would now have an additional integration to the process control system that the parent company was already using at that parent location. It was decided to leverage the Open Application Group Inc. (OAGi) SME Express Pack the API definitions for all these integrations [9].

The use of web conference solutions facilitated all the workshops between the parent company, the subsidiary headquarter's personnel and the plant operations personnel. BPMN models were created as visual approaches to describe the business and manufacturing processes as it was understood. It was necessary for manufacturing engineers to travel to existing subsidiary plants to capture videos of the existing processes leveraging these systems, such as material gathering and flow, and record keeping. It was too hard to elicit this from the system documentation, emails, and screen sharing over web conferences. This put both engineering and plant personnel at risk.

To alleviate that, and as vaccines became more readily available, the agrifood company worked with the various government agencies and local health care providers in the region of the plant to conduct a one-day vaccination clinic where all personnel of the plant would be vaccinated as they were on the production line. This assisted future travel concerns to that plant by engineering and IT resources needing to do that work.

4.1 Shortage of industrial parts

Specific industrial equipment and devices were particularly vulnerable to instability stemming from restrained labor conditions in countries like Japan and Germany. Essential components for automated production such as PLCs were not easy to replace with alternative vendors in a short amount of time.

Short term resolutions to industrial part shortages includes subcontracting of credit. It's particularly more effective to apply subcontracting for standard parts such as PLCs. For example, each equipment vendor has a little buying power on PLC providers, but the manufacturer can exercise much bigger buying power with all demands combined. To put this into action, it is required to negotiate a separate term with a PLC vendor directly about discounted unit price and sourcing mechanisms to each equipment vendor.

Mid-to-long term resolution involves a more technical approach. Control systems in factories are slowly moving towards more PC-based controls. This opens up a new paradigm where more general programming skills become applicable in industrial applications. Therefore, manufacturers need to start considering more aggressive adoption of PC-based controls.

4.2 Immobility of setup engineers (potential delays in commissioning)

Immobility of setup engineers to be dispatched, oftentimes to foreign soils, greatly delay debugging of equipment thus not being able to meet target dates for production ramp-ups. With travel restrictions across countries and quarantine regulations ranging 2-4 weeks, scheduling became more difficult than before. Expenses (travel cost) are also higher for commissioning jobs.

Digital technologies can be leveraged to deal with this problem. Augmented reality (AR) can enable users to interact with both virtual and real worlds simultaneously by overlaying information on real world objects. Recently, AR solutions including hardware devices, software, and contents became much more accessible. There are remote assistance tools powered by such augmented reality technologies. This allows an expert on one node and a novice on the other node. Thus, companies can leverage less skilled workers on one end to be guided by experts located elsewhere to execute the commissioning jobs. For example, PTC Vuforia provides a comprehensive AR solution that is tailored to needs of industrial applications.

4.3 Factory design and commissioning difficulties

Pandemic puts more stress particularly on actual sourcing (FOB/acceptance test) and commissioning stages. Any changes in the factory design would cause significant

disruptions downstream because of the challenges in the supply chain and logistics. Adhering to the concurrent engineering strategy is ever more important to minimize design changes. Then, in the downstream sourcing activity, applying the divide-and-conquer (category management) approach to supply chain management is very important. In this approach, procurement strategies for standard parts vs. customized parts need to be clearly distinguished. For standard parts, procurement strategy is driven by the procurement organization to lower the cost while keeping the supply stable. For customized parts, a collaborative approach among engineering, quality and procurement organizations is required to freeze equipment specification as early as possible. Thus, procurement practice itself needs to be engineered and highly aligned with development activities (also known as procurement engineering).

5 Conclusion

Pandemic causes hardship on virtually everyone on the planet. Manufacturing enterprises have to continue to operate while subject to contraction, expansion, or adaptation to respond to changing industry demands. This paper discussed challenges and resolves manufacturers faced and used for the case of manufacturing expansion. It also offered visions about technological development that could help faced other challenges and disruptions better in the future. While the discussions were specifically in the context of a pandemic, some resolutions and technological vision discussed could be applied during the normal time that could provide positive impact on the process flexibility and cost reductions, e.g., related to travels and supply costs. In the future, more in-depth research could be performed on the expansion case and extended to contraction and adaptation cases (e.g., adapting an auto-part plant to make ventilators by Ford Motor).

Disclaimer

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