Digital Manufacturing Approach of Facility and Plant Layout using Tecnomatrix Plant Simulation

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Abstract *The conventional method is an in-line process in which the product is designed, and the drawings are forwarded to shop floor for manufacturing the prototype. While digital technology is a cyclic process in which the product is designed conceptually and innovated in computer-aided design software. These designs and the processes are simulated for checking the feasibility of manufacturing the product. The product is inspected at every stage of the manufacturing process by the inspection techniques and tested by computer aided quality control methods. The supply chain management is also digitized for effective inventory and producing customized products.*

Key Words: Digital Manufacturing

1. INTRODUCTION

The manufacturing industry now faces the challenges of three major outstanding issues that are network, knowledgeable services, and the consequent complexity. Thus, it is difficult to control the nonlinearity, time variability, suddenness and imbalance of organizational structure and functions in manufacturing systems through traditional operation modes and control strategies. The depth and width of manufacturing activities are greatly expanded, and the manufacturing industry is developing in the direction of automation, intelligence, integration, network and globalization. Consequently, profound changes in the token, storage, processing, transmission and machining of manufacturing information takes place, so that the manufacturing industry gradually shifts from the traditional energy-driven state to being information-driven. Digitalization has become the indispensable drive factor in the product lifecycle of the manufacturing industry, thus digital manufacturing becomes a new manufacturing mode to adapt to the increasingly complex product structure, increasingly personalized, diversified consumptive demand and large manufacturing network, and naturally becomes an important feature in the future development of the manufacturing industry.

1.1 What is Digital Manufacturing?

Digital manufacturing is the use of an integrated, computer-based system comprised of simulation, three-dimensional (3D) visualization, analytics, and various collaboration tools to create product and manufacturing process definitions simultaneously.

Digital Manufacturing is a manufacturing process which, with the support of technologies such as virtual reality, computer networks, rapid prototyping and database, is based on customer demand so as to analyze, organize and recombine the product information, process information and resource information, implement the product design and function simulation as well as rapid prototyping, and then to perform rapid production to meet customer demand and quality standards [1].

1.2 Tecnomatrix Plant Simulation

VDI (Verein Deutscher Ingenieure, Association of German Engineers) Directive 3633 defines simulation as the emulation of a system, including its dynamic processes, in a model one can experiment with. It aims at achieving results that can be transferred to a real-world plant. In addition, simulation defines the preparation, execution, and evaluation of carefully directed experiments within a simulation model.

Plant Simulation is a discrete, event-controlled simulation program, i.e., it only inspects those points in time, at which events take place within the simulation model.

On the other hand, time elapses continually. When watching a part move along a conveyor system, you will detect no leaps in time. The curve for the distance covered, and the time it takes to cover it, is continuous, it is a straight line [16].

Benefits of Tecnomatix Plant Simulation:

- Enhance the productivity of existing production facilities.
- Reduce investment in planning new production facilities.
- Cut inventory and throughput time.
- Optimize system dimensions, including buffer size.
- Reduce investment risk by early proof of concept.

2. NISCO System case study

NISCO Systems is a small-scale industry engaged in manufacturing and assembly of Dry Bath Incubator(DBI). The company requires to setup new plant where, this product is being manufactured and assembled on separate assembly line. The industry assigned the task as project to design plant and facility layout.

2.1 Product Information

Fig -1: Dry bath Incubator

The digital dry block heaters are designed in basic and advanced model. Basic model is having excellent stability to regulate temperature at 370 Celsius temperature. The advance model is having accurate timer. Both models are available in dual size of the test tube in single block. The inbuilt processor in this dry bath regulates the wattages of the heat block to provide extremely accurate temperature and precession. The desired temperature is easily set using the easy to read display and the simple to use arrow keys, which are set on control panel at the front of equipment. Digital dry blocks include the built-in user recalibration feature, which allows the unit to reset factory setting and guarantees that temperature accuracy is maintained over the full life of the unit. The dry bath is designed to facilitate the easy placement and extraction of tubes.

Temperature control range : 37^{o} C

Stability : +/- 5^{o} C

Power consumption : 24 Watt

Increments : 0.1 ^{o} C

Table -1: Components of DBI

Sr. No	Component Name
1.	Top and bottom cabinet
2.	Aluminum block
3.	16X2 LCD display
4.	Bushing
5.	Control card
6.	RT 25W/2-ohm resistor
7.	Power switch and DC adapter
8.	Temperature sensor (LM 35)
9.	Connectors and cables

Table -2: List of assembly steps for DBI

Task	Process	Time (Sec)
A	Mount RT25W10OHM Register on Aluminum Block	60
B	Fit Aluminum Block to Cabinet Bottom	120
C	Fit LCD Display on Top Cabinet	120
D	Fit Control Card on Bottom Cabinet	120
E	Connect all connectors	90
F	Connect Power Switch to Cabinet	30
G	Connect DC Adapter to Cabinet	30
H	Connect Busing to Cabinet	30
I	Enclose Cabinet	45
J	Screwing Cabinet	45
K	Pasting Stickers	45
L	Final Inspection	600
M	Packaging	480
N	Store/ Dispatch	60

3. Methodology

3.1 Largest-Candidate Rule (LCR):

Step 1: -List all elements in descending order of Te value, largest Te at the top of the list.

Step 2: -To assign elements to the first workstation, start at the top of the list and work done, selecting the first feasible element for placement at the station. A feasible element is one that satisfies the precedence requirements and does not cause the sum of the Tej value at station to exceed the cycle time Tc.

Step 3: - Repeat step 2.

3.2 Kilbridge & Wester's Method (KWM):

It is a heuristic procedure which selects work elements for assignment to stations according to their position in the precedence diagram. *This overcomes one of the difficulties with the largest candidate rule (LCR), with which elements at the end of the precedence diagram might be the first candidates to be considered, simply because their values are large.

Procedure:

Step 1: **-** Construct the precedence diagram so those nodes representing work elements of identical precedence are arranged vertically in columns.

Step 2**:** -List the elements in order of their columns, column I at the top of the list. If an element can be located in more than one column, list all columns by the element to show the transferability of the element.

Step 3: **-**To assign elements to workstations, start with the column I elements. Continue the assignment procedure in order of column number until the cycle time is reached (Tc).

3.3 Ranked Positional Weights Method (RPW):

Introduced by Helgeson and Birnie in 1961. Combined the LCR and K-W methods. The RPW takes account of both the Te value of the element and its position in the precedence diagram. Then, the elements are assigned to workstations in the general order of their RPW values.

Procedure:

Step 1: -Calculate the RPW for each element by summing the elements Te together with the Te values for all the elements that follow it in the arrow chain of the precedence diagram.

Step 2: -List the elements in the order of their RPW, largest RPW at the top of the list. For convenience, include the Te value and immediate predecessors for each element. Step 3: -Assign elements to stations according to RPW, avoiding precedence constraint and time.

4. Analytical Solution

4.1 Precedence diagram

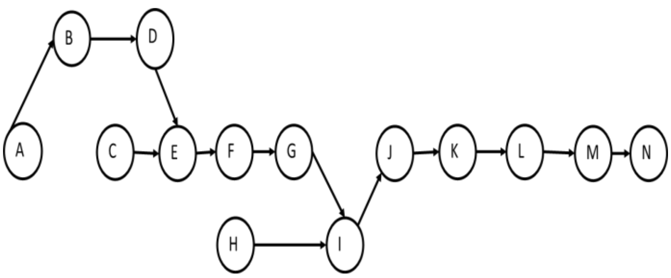

Fig -2: Precedence diagram for Dry bath Incubator

4.2 Solution by LCR

WS	ELIGIBLE TASKS	ASSIGNED TASKS	AVAILABLE TIME(Sec)	IDLE TIME
1	A C H	C	638	0
	A H	A	518	0
	B H	B	458	0
	D H	D	338	0
	E H	E	218	0
	F H	H	128	0
	F	F	98	0
	G	G	68	0
			38	**38**
2	I	I	638	
	J	J	593	
	K	K	548	**0**
3	L	L	638	
	M	M	158	
	N	N	98	**98**

4.3 Solution by RPM

WS	Eligible Task	Assigned Task	Remaining Time(sec)	Idle Time
1	A C H	A	638	0
	B C H	B	578	0
	C D H	C	458	0
	D H	D	338	0
	E H	H	218	0
	E	E	188	0
	F	F	98	0
	G	G	68	0
			38	**38**
2	I	I	638	0
	J	J	593	0
	K	K	548	0
			503	**503**
3	L	L	638	0

			88	**88**
4	M	M	638	0
	N	N	158	0
			98	**98**

4.4 Solution by K&W Method

Workstation	Eligible Task	Assigned Task	Remaining Time(sec)	Idle Time
1	A C H	A	638	0
	B C H	B	578	0
	C D H	C	458	0
	D H	D	338	0
	E H	H	218	0
	E	E	188	0
	F	F	98	0
	G	G	68	0
			38	**38**
2	I	I	638	0
	J	J	593	0
	K	K	548	0
			503	**503**
3	L	L	638	0
			88	**88**
4	M	M	638	0
	N	N	158	0
			98	**98**

4.5 Calculation

Total weeks	50
Shifts per week	6
Shift hrs	8
Total units	13500
Time (sec)	8'640'000
Total time	1825
Production rate	6
Cycle time	640
Assembly time	2.4
Station time	638
Worker required theoretical	3

4.6 Comparison

Comparing LCR, K-W, and RPW it can be seen that the LCR solution represents a more efficient assignment of work elements to station than either of the two preceding solutions. However, this result is accordingly by the acceptance of cycle time and make those methods different. If the problem were reworked with Tc = 0.92 minute, it might be possible to duplicate the efficiency.

Optimum no. of workstation- 03

5. Plant layout and Simulation using Tecomatrix Plant Simulation

5.1 2D Plant Layout Model

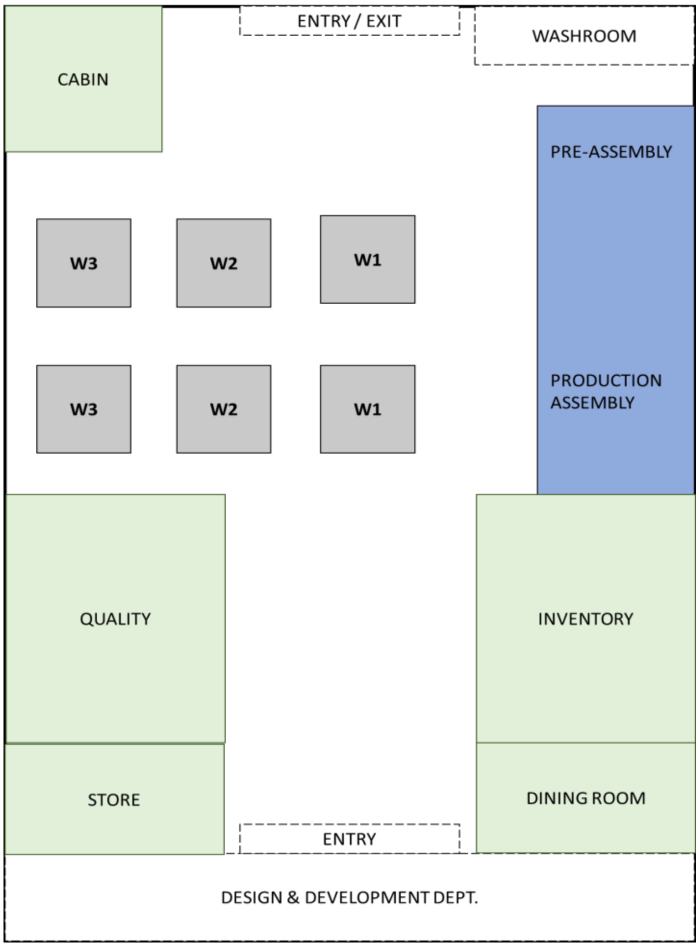

Fig -3 2D Plant Layout

5.2 3D Plant Layout Model in Plant Simulation

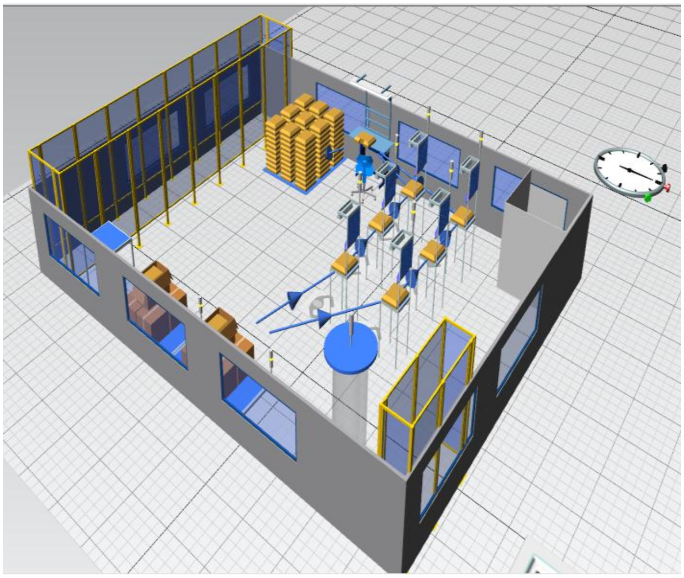

Fig -4 3D Plant Layout

5.3 Planning view Layout Model in Plant Simulation

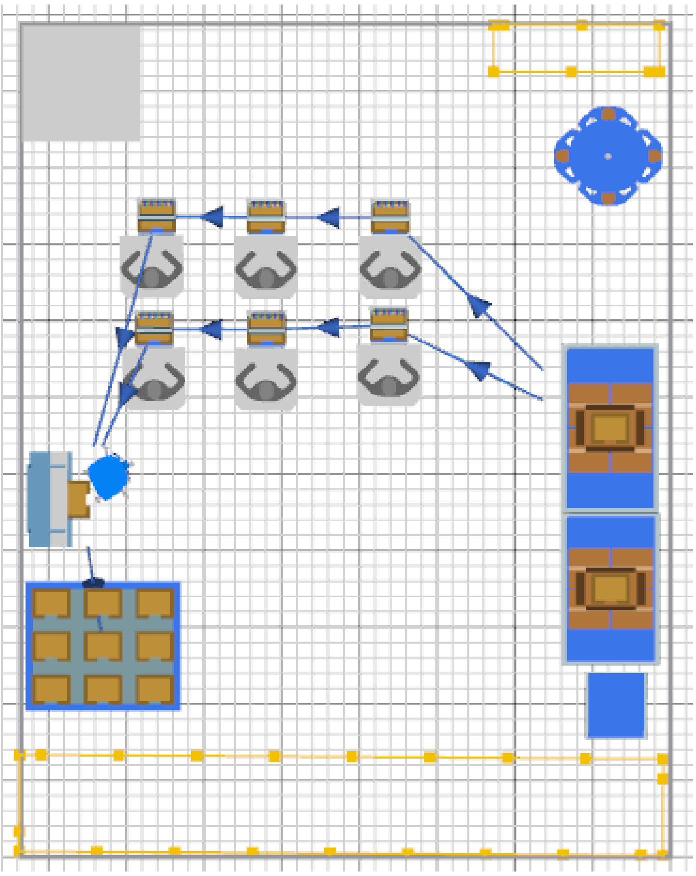

Fig -5 Layout in Planning View

5. Conclusion

It can be observed that Digital Manufacturing Approach helps to get prior solution to the industry and contribute to save the time being spent on planning. In this project LCR method gives optimum solution as by reducing no. of workstations and hence reducing cost associated with the production. Therefore two separate Assembly lines can be constructed in given plant layout as shown in fig.3.

Further it can be stated that, Tecnomatrix plant Simulation allows manufacturers to take decisions about plant layout, facility utilization and production activities by simply performing simulation by using software.

Overall Digital Manufacturing Approach by using Tecnomatrix Plant Simulation helps manufacturers to increase the productivity and maximize the utilization of resources.

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