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The Time and Motion Study in Chemical Industry

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Abstract : *The aim of this paper to check necessary and unnecessary movement along with time in chemical industry. This paper gives a structure of systematic approach of time and motion in complete production process. This study is observing behavior of man, material, & machinery with comparing and defining of new standards with scientific management. With the help of this study developed various easy ways to improved humans effort in actual chain or line of production. It will help in supply chain, quality management, and material management & inventory management. The proposed methodology study is designated to systematic observation, analysis, redefining, scope of optimization & measurement of performance of each step in production for establishing new standard form of work and method.*

Keywords: *supply chain, quality, inventory, material management*

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I. Introduction

A time and motion study is associated with Scientific Management of late 19th and early 20th centuries in United States, primarily with the work of industrial engineers Frederick Winslow Taylor (1856-1915), Frank B. Gilbreth (1868– 1924), and Lillian Gilbreth (1878 –1972). It is applied today to industrial as well as service organizations, including banks, schools and hospitals. Demand & supply is extremely important factor to be considered in manufacturing industry and directly affect economy of production. So, management of manufacturing mainly concern satisfaction of people with their product and services with best-selling price which is Affordable to people. It will help in defining market position of product and help in development and growth of industry. This study is provide proper structure of utilisation of man, material, machinery, space, utilities etc. A time and motion study help in Scheduling, planning, defining ration for Queue(waiting line) in mass production and continuous process and also help in defining labor cost, cost of product, operation cost(it will provide specific data of all element of production). This time and motion study is conducted in EXCEL INDUSTRIES, lote. They have various efficiently running chemical plant within branch of EXCEL at lote MIDC. This study is conducted in their plant i.e., BIOCEL plant.

II. Objectives

1. Eliminate unnecessary motion, fatigue, and seek to improve human effort in doing job.
2. Improvement of method, procedure, technique, and processes related to a job.
3. Make effective utilization of materials, machines, human resources.
4. Improve layout and design of plant and equipment and working environment.

III. Application

1. Determining Schedules and planning of work.
2. Determined standard cost of particular work.
3. Estimating the cost of product before and after manufacturing it.
4. Determining machine effectiveness.

IV. Explanation

During this study observe that sequence and scheduling of complete production process. It is very important for productivity and for that purpose systematic observation, analysis of each single activity in process. As per critical path method (CPM) we have to know starting point and end point of every activity. Then we can calculate completion time for each activity and completion time of whole project. This study is identified minimum time or best possible completion Time of activity but in chemical plant of excel industry we also considered motion which is respect to time of activity. As we know as per supply chain management and quality management is absolutely rely on time and motion of particular. This study is started with our initial stage that is to know complete process and its individual activity with understanding standard operating procedure of each.

That is for comparison and to get new standards. In other word, before going to developed new technique, theory, procedure must be knows its existing standard and procedure. Our study is also give importance to optimization of resources. If we successfully utilized our own space, equipment for increasing capacity and strength then it has positive effect on our productivity and it is essential for any operation and also make significant data on labor proactivity. Chemical industrial work based on both certainty and uncertainty because it has lot of variation in temperature, pressure, fluid flow, viscosity, handling of hazardous chemical and storage, reaction of chemical and its side reaction and effects, rate of reaction, handling or treatment of end product(before and after packaging), safety considerations, maintenance of all equipment or its replacement etc. Excel industries have efficiently managed all departments with their management for accidental free activity because safety should be is main criteria in any industry. Our study suggests them for more utilization of resource, safety consideration (safety of environment, employees, machinery) and some modification too. So, now we will see step by step operation in Biocel plant of excel industries (Also shown in flow chart of Biocel plant). Biocel plant produced Sodium Penta-Chlorophenate product in tons. For that purpose used no. of reactor, Drum Dryer (Flaker), ribbon blender, Bin Discharge Activator (Vibrator), feeder, Screw conveyer, Extruder (Granulator or roller), Rotary dryer, heat exchanger, ventury scrubber, sparkler filter, and no. of valves etc. They have been used raw material like phenol, caustic, chlorine, catalyst, hydrose powder (sodium hydro sulphite). Study of time and motion is begin with preparation and uploading of charge. Charge is known as quantity of raw material in batch tank. Skill operator is dependent for transfer of fluid and process material through equipment's. Mostly process completion time and reach to defined quantity and quality of product depend on operator is operate valves automatically (PLC system). It mean that operator or corresponding worker is knows time and motion of process material from charge - finish product – packaging. While observing such process judgment to perform every operation is also important as well as scientific knowledge.

That is why Excel Industries product Sodium Penta-Chlorophenate is having good quality and they have produced huge ton of production of product. As per Process flow Chart of Biocel plant, R1, R2, R3 & R4 are reactors have perform step by step reaction namely chlorination and neutralization. Reactor R2 & R3 has chlorination reaction and Reactor R4 has neutralization reaction. Reactor R1 is received vapor line from R2 and produced mono-chlorophenate with HCL. HCl is passed for further treatment. Now R2 reactor received dip. Vapor line from R3 and also adding Cl2 line on top of reactor. R2 produced tetra chlorophenate. Every time operator and worker has to check, control, transfer, collect of material and product. In such case involve time variation and corresponding displacement of individual activity. Use of chlorine vapor is important for reaction in such reactor by providing chlorine tonner. Tonner is kind of storage of hazardous raw material like chlorine which is in high pressure. So handling of tonner is major event has to performed. Weight of single empty tonner is 600 kg and weight of full chlorine of tonner is 2500 kg. Loading and unloading of tonner is done by hydraulic system. For that purpose 3 people are designated including hydraulic system operator. One tonner is use for complete reaction and that is within 3 shift i.e. a day. Handling tonner pressure and its careful operations is important factor of plant. As per study, loading of empty tonner in truck is takes 1.25 minute and unloading of unloading of full tonner required 2 minutes. Time required for loading 11 empty tonners is 14.15 minute and unloading of 11 full tonners is 22 minutes. Motion of tonner (empty or full) is related with storage or spacing of tonner in specific area.

Now, R3 reactor is produced Penta-Chlorophenate transfer chlorine vapor to R2 at top and drain (transfer) bottom (main) product to R4 while checking quality of drain product at the same time. For draining it needed few 60 minutes and again it is depend upon operator skill. While performing neutralization reaction in R4 important to adjust pH, specific gravity, alkylity and adding measured materials like caustic, water, codex, sodium hydrosulphate etc. time and motion is make valid impact on maintaining pH, alkylity, specific gravity because it defines our product quality. Time of completion of neutralization reaction is 4 hours. After completion of reaction again quality checking operation is performed. It takes nearly 30 to 46 minutes. At each stage of study as per Program Evaluation & Review Technique (PERT) here calculated 3 time estimation namely Optimistic Time (OT), Pessimistic Time (PT) &Most likely Time (MT). It means maximum time required for completion of activity (OT), minimum time required for completion of activity (PT) and time required for activity (MT) repeated under same operating condition. Time and motion study is also important in PERT (shown in table of 3 time estimation). Time study is essential in PERT for its primary stage drawing network diagram (shown in Network Diagram). Network Diagram is shows time for single activity, time of completion of complete operation and best possible way to eliminate time of activity. It is very essential for making or establishment of new time limit of each activity and then analyzed completion time of process (also show in symbolic flow chart, Network Diagram &Activity Sequence and their work). After R4 product is transfer to many unit operations stages. Namely Sparker Filter (SF), Drum Dryer (DD), Ribbon Blender (RB), Bin Discharge Activator, Conveyor, Feeder, Extruder or Granulator, Rotary Dryer, temporary storage and packaging and permanent storage (Flow of process shown in Process Flow Chart). 5 to 8 people are assigned for SF to packaging. Storage of product is main challenge because continuous operation, improper use of storage area & time requirement for quality checking. After obtaining product from rotary dryer has calculated time and motion of workers, bags and drums. With the help of time and motion study we have calculated time required for filling, weighting, shifting of drums and bags. Then we have overall time required for complete operation of packaging of drum and bag (table of packaging of drum, table of packaging of bag).

Biocel plant has total production capacity of Sodium Penta-Chlorophenate is 180 ton. They have produced 7 ton product inform of granule and powder a day (3 shifts). Packaging of 1 ton of product required 40 drum (25 each drum). 180 ton needed 7200 drums and 7 to 8 worker are designated to this packaging operation per shift. During this process, inspection of quality operation is done and if failed then re-drying operation have performed for more purity and quality. Again one additional (shift of worker) batch is designated to do re-drying process. So this is we called unnecessary motion and time required for such process. If they have used another method of continuous process of re-drying then this excess time and motion is save. But excel industries never compromise with quality. Because of this re-drying process, it affect completion time of whole cycle and it is too costly. Re-drying operation is taking more time and displacement of worker and product. Our study successful suggest them about actual time and motion of each activity, modified or simplest way of time and motion of packaging, optimization of resources, and modification in storage space to maintained maximum capacity of storage of product (bags and drum). Packaging of drum operation is performed by 4 workers and they needed 5 hr. 57 minute for 1600 kg product weight. 5 workers designated for 2100 kg packaging of product and they needed 7 hr. 35 minutes. Thus calculation is involved with time to fill drum, time required to shift drum for weight, time for weight, shifting of drum to storage for single drum, 32 drum, 42 drum (also shown in table of packaging of drum). While packaging of bags 4 worker are designated to fill 32 bags. It included time to fill bag, time for weight of bags, time to shift of bags. One additional worker is there to fill polythene plastic in each bag and he required 1.20 minutes for 1 bag. Total time required for packaging of bags needed 96 minutes for 32 bags (for 800 kg) and additional time is 40 minutes for 32 bags. Biocel plant is produced 144 ton product in drum and 72 ton product in bags within 30 days. Capacity of production of Biocel plant is 7 ton in 3 shifts. Total production of drum and bags in month is 216 ton with 8 to 9 worker designated per shift.

Now let see existing and simplified motion for complete packing process in Biocel plant. Figure of existing and simplified motion shows that both packing of powder (bags) and packing of granules (drum). Motion of Packaging of powder is required 6 steps (motion). 1 step is filling of polythene plastic in bag and prepared all bag with plastic near control system. 2^{nd} motions go to product outlet machine and engage bag to outlet product machine. 3^{rd} motion is handling automatic weighting machine for on/off operation. 4^{th} motions is to remove filled bag from machine. 5^{th} motion is again weight of bag. 6 go to storage.

Now understand simplification of motion of bag by modification like adding fully automatic weighting machine which automatically filled polythene plastic in bags, engage and dis engage of bag from product outlet section (rotary dryer), arranging short range conveyer for traveling of bags upto storage space (Also shown in figure simplification of motion for bag packing operation). With our modification suggest few motion of worker and product. There is operator for automatically handling this all activity. So as per modified diagram eliminate unnecessary time and motion. With this we can efficiently handle packing of huge production. Also eliminate unnecessary workers because this operation needed 4 to 5 workers. It is not only about modification but also improvement of machines, utilization of working environment and layout or design of production plant. Now consider motion of packing of drum. 1-2 worker providing empty drum to dryer outlet. 2-3 because of dusting and some time required to fill that drum Worker move back to position one. 3-4 move for transfer filled drum with product to weight. And provide new drum. 4-5 pick-up drum and move for weight. 5-6 drum is shift to temporary storage. 6-7 Movement of temporary storage of drum to permanent storage. When re-drying operation is performed, they have to move from step 1 – 7 and that why Addition or unnecessary time and motion is need and need to be simplified as follow. (Show in motion of packaging of drum both existing and simplified). As per simplified motion diagram only few movements is needed for operation of packaging and storage with elimination of unnecessary motion and time. 1-2 filled drum with product is transfer to temporary storage from filling section. 2-3 Moving drum to permanent storage. Here we eliminate motion like 1-2, 2-3, 3-4,4-5,5-6. Because arranging automatic weighting machine to fill and check accurate weight and rearranging new drum instead of filled drum with product, screw conveyer for systematic movement of drums and at 1 step providing vaccum dust cleaner for safe working environment for worker. When re-drying operation is performed more than 8 hours is needed to do re-drying and inspection of quality, and again packaging (always additional shift is needed for re-drying).

Our study report suggests that, modification of rack for extra-large storage capacity within existing area of plant. As per elimination of un-nessecery motion if using time and motion sensor detector stimulation then management can grow up business with increasing productivity because we can obtained proper report of time and motion of individual worker and processes. This will help in determining labor cost, overall budget, control cost. Reducing time and motion with providing advanced instrumentation on filtration, Powder or granules packing section (with automatic screw conveyer, belt conveyer or spiral conveyer), more safety precautions (vaccum-dust cleaner, double air respirator). With 3 time estimation we can figure out existing time and overall time for completion of operation. So we can design new standard time for each and overall operation.

Figures and Tables

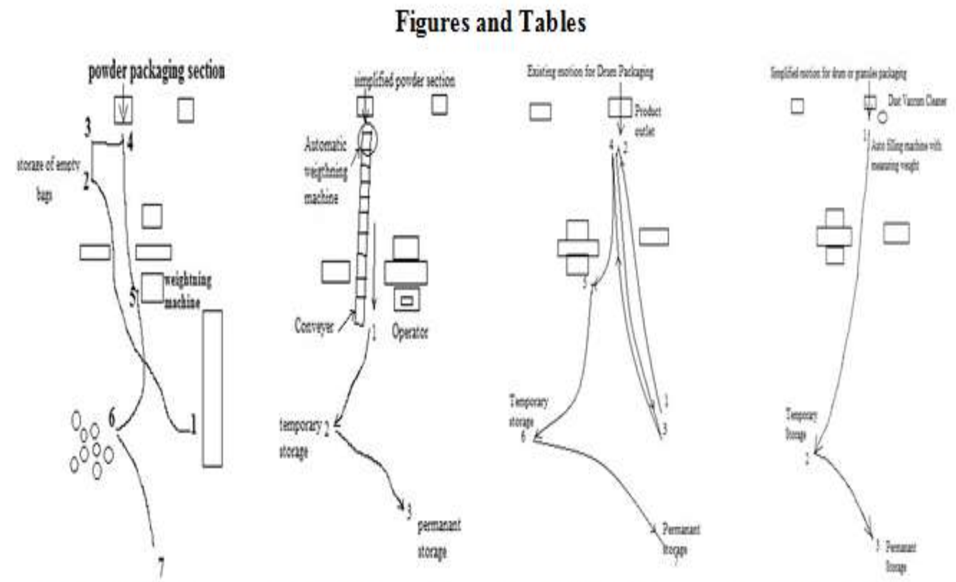


Fig. Existing motion Of bag packing | Fig. Simplified Moition Of bag packing | Fig. Existing motion Of drum packing | Fig. Simplified Moition Of drum packing

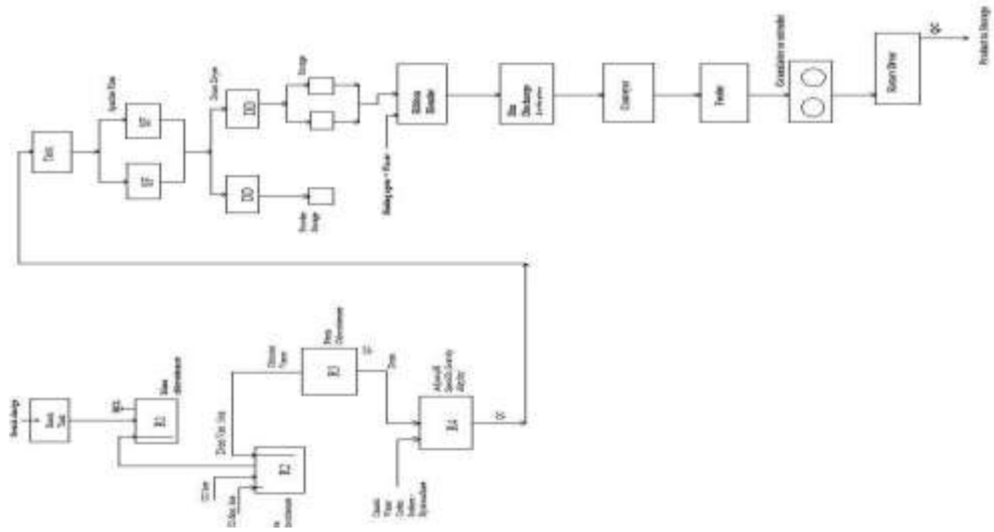


Fig. Process Flow Chart

Table of Drum:For continues process, considering drum (50 kg)

Weight (kg)	Drum No.	Time to fill drum	Time for weight	Shifting of Drum to Storage
50	1	10 to 11(min.)	6 Sec.	40 to 45 Sec.
1600	32	5hr.30min	192 Sec.	768 to 1280 Sec.
2100	42	7hr.05min.	252 Sec.	1680 Sec.

For 1600 kg weight (Drum) 4 workers are designated.For 2100 kg weight (Drum) 5 workers are designated.
50kg Drum = 32 Drum. & 25kg Drum = 64 Drum.
Result - total time required for filling + shifting + weighting for 4 workers 5 hr.57min. (32 Drum)
Result - total time required for filling + shifting + weighting for 5 workers 7 hr.35min. (42 Drum)

Table of Bag

Weight of Bag(kg)	Bag (Quantity)	Time to fill	Weight of bag	Time to shift
25	1	2-3 minutes	1 minute	3-4.5 minute
1800	32	96 minutes	32 minutes	96 minutes

Total time required to fill 32 bags by 4 workers is 4 hr.10 min.Additionally one worker is to fill polythene plastic in bag and Needed 38.8 minutes.Overall 4 hr. 50 minutes required for bag packaging operation by 1st shift & needed 3 shifts for complete operation.

Modification

Suggestion for increasing storage capacity: We can arrange 4th beam (level) in existing 15 racks. It overcome present storage problem and it is needed in future updated ton of production.

Existing 3 beams or level rack contains following No. Drum-

Beam or level	Drum
1	18
3	54

Existing rack of 4 beam or level contains following No. Drum-

Beam or level	Drum
1	18
4	72

Rack with updated storage capacity

Rack with level	3	4	5	6	7
No. of Drum	54	72	90	108	126

Time required for loading and un-loading of tonner

No. of tonner	Empty Tonner	Full Tonner	Time for Loading of tonner(minutes)	Time for un-loading of tonner(minutes)
1	1	1	1.25	2
11	11	11	14.15	22

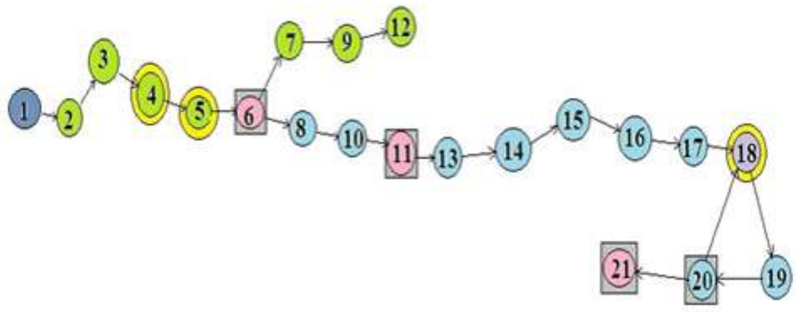
3 Time Estimation

No.	Optimistic	Most likely	Pessimistic
1 to 2	21 min	30 min	38 min
3 to 2	6 hr	7hr	9 hr
4 to 3	6.30 hr	7.15 hr	8 hr
4 to 5	20 min	26 min	35min
5 to 6	8 hr	8.30 hr	9 hr
6 to 7	10 min	12 min	15 min
6 to 8	9 min	12min	14 min
7 to 9	7 min	10 min	13 min
9 to 12	3 hr	3.50 hr	5 hr
8 to 10	3 hr	3.5 hr	4.30 hr
10 to 11	14 hr	16 hr	19 hr
11 to 13	14 min	17 min	18 min
13 to 14	25 min	28 min	32 min
14 to 15	14 min	18 min	26 min
15 to 16	9 min	14 min	18 min
16 to 17	8 min	11 min	13 min
17 to 18	18 min	22 min	35 min
18 to 19	5.30 hr	6.30 hr	7 hr
19 to 20	2 min	3.30 min	5 min
20 to 18	6 hr	6.40 hr	8 hr
20 to 21	5 min	6.30 min	8 min

Storage space according to ton capacity

Level	1 rack	15 rack	30 rack
3	1.35	20.25	40.5
4	1.80	27	54
5	2.25	33.75	67.5
6	2.70	40.5	81

Network Diagram



V. Conclusion

This report is implemented to identify easy and economical way of successive production. This methodology is defined applicability and importance of time and motion study in supply chain, material management and critical path. This will help in simplification and modification of production process with improving elimination of error of plant design and layout. It will gives an proper result to handling uncertainty in operation of production and quality management. It gives motivation, knowledge of utilization of man, material & machinery. It is also systematic approach developing new standards, policies from its initial stage of safety to final production and Setting of labor cost, Labor budget, overall budget, Labor requirement & Effective cost control. Controlling human behavior towards important of time and increasing growth of business.

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