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Real Bottleneck Analyses in Drug Industry

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Abstract:

In this research paper, we develop a complete production process analysis based on decision making measurers of performance to analyze and hopefully detect system bottlenecks for mainly serial production lines that consist of four machines with three buffers. Two types of bottlenecks are defined and their corresponding indicators are derived to improve system performance. Computational tools for modeling, analyzing, and improving manufacturing systems. We collect a real data from a well-known Jordanian drug Company Dar AlDawa.

Keywords: bottleneck analysis, bottleneck indicators.

Introduction:
Due to the large inflation in industry and increasing the competition between these industries there has been a constant need to keep pace with scientific developments to reach the best solutions to industrial problems that lead to waste of time and money.

Bottleneck occurs in many branches: - industrial field, education, health care services, economy, etc.
The companies need to improve a comprehensive framework to provide solutions to the industrial problems using a set of quantitative tools. The quality and operational performance continuously to survive and grow in this highly competitive business world. Bottleneck analysis has become one of the widely popular methodologies for production improvement in the industry. It is bottleneck is a point of congestion in a production system (such as an assembly line or a computer network) that occurs when workloads arrive too quickly for the production process to handle. In the simplest definition, a process bottleneck is a work stage that gets more work requests than it can process at its maximum throughput capacity.

1. Definition of bottlenecks. Several basic definitions are summarized by (Lawrence and Buss 1995)[5].
2. Congestion points occur in product flowing.
3. The resource whose capacity is less than the demands placed upon it.
4. A process that limits throughput.
5. Temporary blockades to increased output.
6. A facility, operator etc. that impedes production.
7. Any operation that limits output.
8.

This can be summarized in the following diagram:

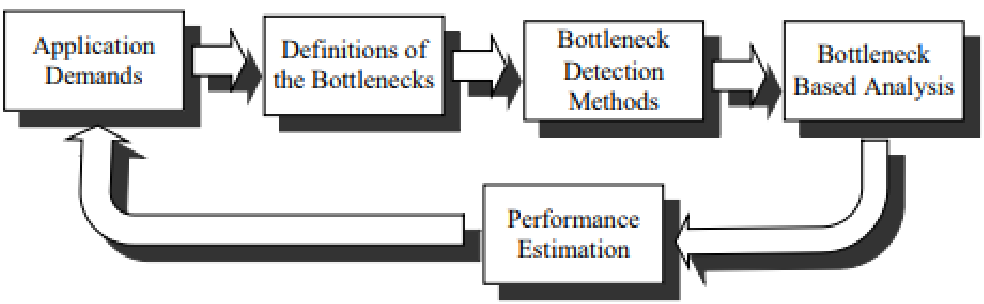

Diagram (1)[4]

Case study:

This study aims to investigate the machine that cause bottleneck during the manufacturing process of Ibuprofendrug in Dar AlDawa Company.

Problem formulation:
The total working hour in this company is 3 shifts for 24 hours with one hour break for each shift; in this case study data are collected for one operating month.
The structure of serial production line in this company is shown in figure 1.

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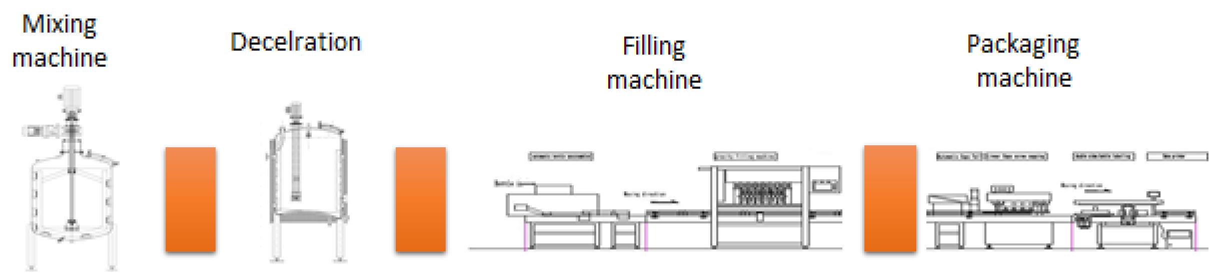


Figure (1) a serial production line.

Where:-
P1:- mixing machine
P2:- declaration
P3:- filling machine
P4:- packing machine

1) Performance evaluation

After measuring total time, operating time and repaired time for each machine and calculating the probability of occurrence, data was collected in the following table.

Table (1) probability table

Machine Nc	Total Tim	Operation Tim	Repair Time	P	R	N
Mixing	25200	4995	2735	0.198214	0.108532	
Deseleration	25200	1951	1345	0.077421	0.053373	4
Filling	25200	15510	6660	0.615476	0.264286	4
Backaging	25200	7800	3198	0.309524	0.126905	1

According to Yunyi Kang and FengJu(6) the following equations providesexact formulas for multiple system performance measurements.

$$\eta_1 = P_1 + P_2 - P_1P_2 - P_2R_1$$

$$\eta_2 = P_1 + P_2 - P_1P_2 - P_1R_2$$

$$\theta_1 = R_1 + R_2 - R_1R_2 - P_1R_2$$

$$\theta_2 = R_1 + R_2 - R_1R_2 - P_2R_1$$

$$\rho = \frac{\eta_2\theta_1}{\eta_1\theta_2}$$

$$D_1 = P_1R_2\eta_1\eta_2\theta_2(P_2 + \theta 2)$$

$$D_2 = P_1R_1R_2\eta_2[\theta_2^2 + P(\eta_1 + \theta_1)(\eta_2 + 2\theta_2)]$$

$$D_3 = \sum_{j=2}^{N-1} P_1P_2R_1R_2(\eta_2 + \theta_2)^3 \rho^{j-1}$$

$$D_4 = P_2R_1\eta_1\theta_2[R_2(\eta_1 + \theta_1) + \eta_2(P_1 + R_1)]\rho^{N-1}$$

$$\phi(P,R,P,R,N)=\begin{cases}\dfrac{P_1\theta_2}{(R_1+R_2-R_1R_2)(P_1+R_1)}, N=1\\[2ex] \dfrac{P_1\eta_1\eta_2\theta_2^2(P_2+R_2)}{D_1+D_2+D_3+D_4}, N>1\end{cases}$$

Then we calculate the blockage and starvation using the following equations:

$$\hat{BL}_i = P_i\phi(P_{i+1}, R_{i+1}, P_i, R_i)$$

$$\hat{ST}_i = P_i\phi(P_{i-1}, R_{i-1}, P_i, R_i)$$

Table (2) blockage value

Machine No.	N	p	R	η1	η2	θ1	θ2	ρ	D1	D2	D3	D4	ϕ	BL
Mixing	0	0.198214	0.108532	0.251886	0.30156	0.178277	0.1761	1.212005	3.59E-05	3E-05	0	0.003228	0.01854	0.0037
Deseleration	4	0.077421	0.053373	0.612396	0.761009	0.352226	0.364614	1.20045	0.003408	0.000203	0.000335	0.000327	0.98778	0.07647456
Filling	4	0.615476	0.264286	0.652693	1.193611	0.502836	0.506532	1.815406	0.025153	0.04499	0.016882	0.046353	0.402554	0.247762397
Backaging	1	0.309524	0.126905	0	0	0	0	0	0	0	0	0	0	0

Table (3) starvation value

Machine No	N	p	R	η1	η2	θ1	θ2	ρ	D1	D2	D3	D4	ϕ	ST
0														
Mixing		0.198214	0.108532	0.198214	0.198214	0.108532	0.108532	1	0	0	0	0	#DIV/0!	#DIV/0!
Deseleration	4	0.077421	0.053373	0.251886	0.24971	0.145533	0.147709	0.976749	2.21E-05	1.11E-05	1.08E-05	2.13E-06	7.72E-01	0.059748629
Filling	4	0.615476	0.264286	0.612396	0.624785	0.283092	0.270703	1.06692	0.001878	0.000489	0.001064	0.00032	5.09E-01	0.313345937
Backaging	1	0.309524	0.126905	0.652693	0.656389	0.279545	0.275849	1.019137	0.005403	0.005754	0	0.001914	6.70E-01	0.207355775

Bottleneck analysis:

Uptime bottleneck (U-BN):-It refers to the machine that improves the system production rate the most from the current level when the average operating time (uptime) of this machine is increased.

Average uptime: the average time that a machine keeps operating before failure.

Average down-time: repairing time a machine needs to recover once failed.

The average uptime, downtime, and machine efficiency for a geometric machine i is expressed respectively as follows:

$$T_{u_i} = \frac{1}{P_i}$$

$$T_{d_i} = \frac{1}{R_i}$$

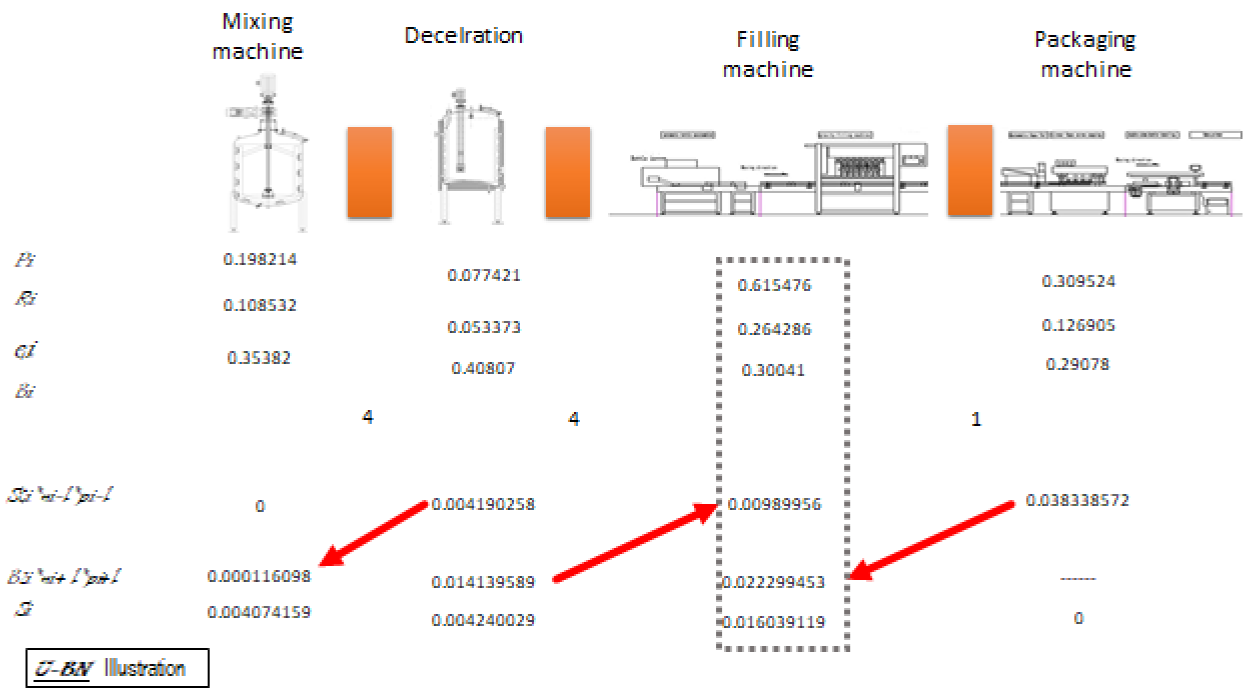
$$e_i = \frac{R_i}{P_i + R_i}, i = 1, 2, ..., M$$

With multiple machines, an arrow assignment rule for uptime bottleneck identifications in systems.

Arrow Assignment Rule for U-BN: If BLiei+1Pi+1 < STi+1eiPi, assign an arrow from mi+1 to mi; otherwise, assign an arrow from machine i to machine i +1 , i =1,...,M−1.

The U-BN can be easily found by tracing the upward and downward of the assigned arrows. More than one bottleneck may be detected by the rule.

If no arrow release from that machine, based on the arrow assignment rule a machine is the U-BN.



In this case study BL1P2e2 is 0.0001160098 where is ST2P1e1 is 0.004191258, so an arrow releases from machine 2 to machine 1. After completing arrows for each sequential machine pair, it is clearly appeared that machine3 the only machine with no arrow release from it so, they is a local bottleneck for machine uptime.

Downtime bottleneck (D-BN):- It refers to the machine that improves the system production rate the most from the current level when the average repairing time (downtime) of this machine is decreased.

For D-BN: If BLiei+1Ri+1 < STi+1eiRi, assign an arrow from mi+1 to mi; otherwise, assign an arrow from machine i to machinei +1 , i=1,...,M−1.

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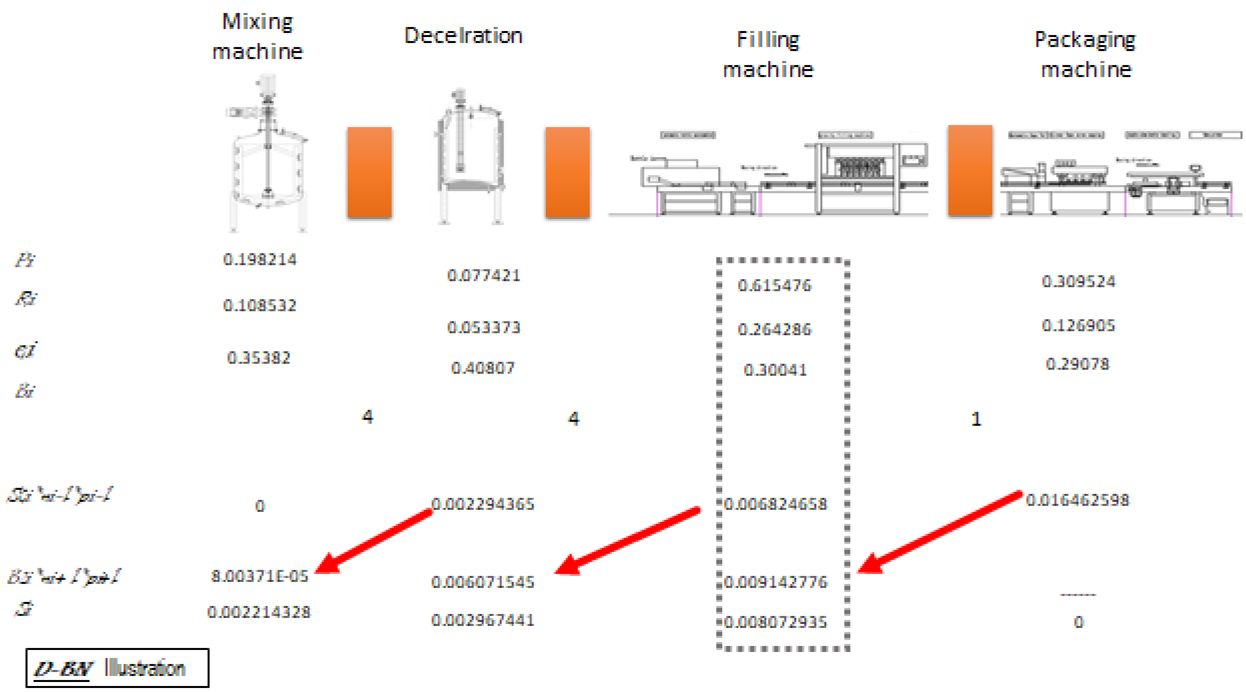

After assigning the arrows it is clearly appeared that machine 3 has downtime bottleneck.
Repaired include: - cleaning, maintenance, adjustment and setup. The next table shows the percent of these factors on repair for filling machine.
Table(4) (total repair time=6660 minute)

Repair type	%
Cleaning	75.73
Maintenance	18.24
Adjustment	4.73
Set up	1.3

The main factor that affects repair time is cleaning.

Conclusions:
Two types of bottlenecks are presented and their associated indicators and arrow assignment rules are developed to find the machines that have the most influence on overall system performance.
After identifying the bottleneck, the degree of the bottleneck is important for determining how to manage this bottleneck.
The main machine that cause delay in production is filling, at which cleaning occupies the greatest percent of occurrence, improvement should be concerned in, auto clean machine should be used ,more than one machine are options for in improvements.
In our case study we found that the same machine which has uptime bottleneck also hasdowntime bottleneck, but that not usually occurred.

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