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CAPACITY ANALYSIS IN MANUFACTURING USING ANALYSIS OF OVERALL EQUIPMENT EFFECTIVENESS

Beatrice Cristina PACEA (ANTON)
"Transilvania" University of Braşov, Department of Product Design and Robotics, beatrice.anton@yahoo.com

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Abstract: The objectives described below have as main aim: the identifying of the availability, the performance rate and the quality rate for obtaining an optimal overall equipment effectiveness. This overall equipment effectiveness is referring to types of manufacturing strategies: the job shop, the flow shop and the cellular shop.

1. Introduction

Manufacturing can be thought of as a series of operations that transforms a raw material of some sort into an end item that will be shipped to a customer. Within this series of operations, think of each individual operation as a transformation that changes an input into an output.

Each operation performs a different kind of transformation. The output of one process becomes the input of the next process, and so on down the line. Note that it is posible to have more than one machine perform the same operation. An example of this could be a group of injection molding machines that all mold the same part.

2. Types of Manufacturing Strategies

There are 3 basic types of manufacturing strategies (although hybrids of these forms do exist). These three basic types are job shops, flow shops, and cellular shops. The most common hybrids are mixes of these processes. These include: the project, the batch job shop and the batch flow shop. A brief description of each basic type follows:

The Job Shop – Job shops are designed to produce a wide variety of small volume products and services. They are characterized by labor intensity, general purpose equipment, proces oriented labor and layot, and intermittent workflow.

The Flow Shop – Flow shops are designed to produce a limited number of high volume products and services. They are characterized by streamlined workflow, capital intensity, dedicated equipment, product oriented labor and product oriented layout.

The Cellular Shop – Cellular shops are designed to produce intermediate volumes of products and services, each grouped into families (or cells), each with its own process technology. They are characterized by a mixture of capital and labor intensity, limited purpose equipment, cell oriented labor and layout, and workflow that is either batched or a mixture (of intermittent and streamlined workflow) [1, 2, 3].

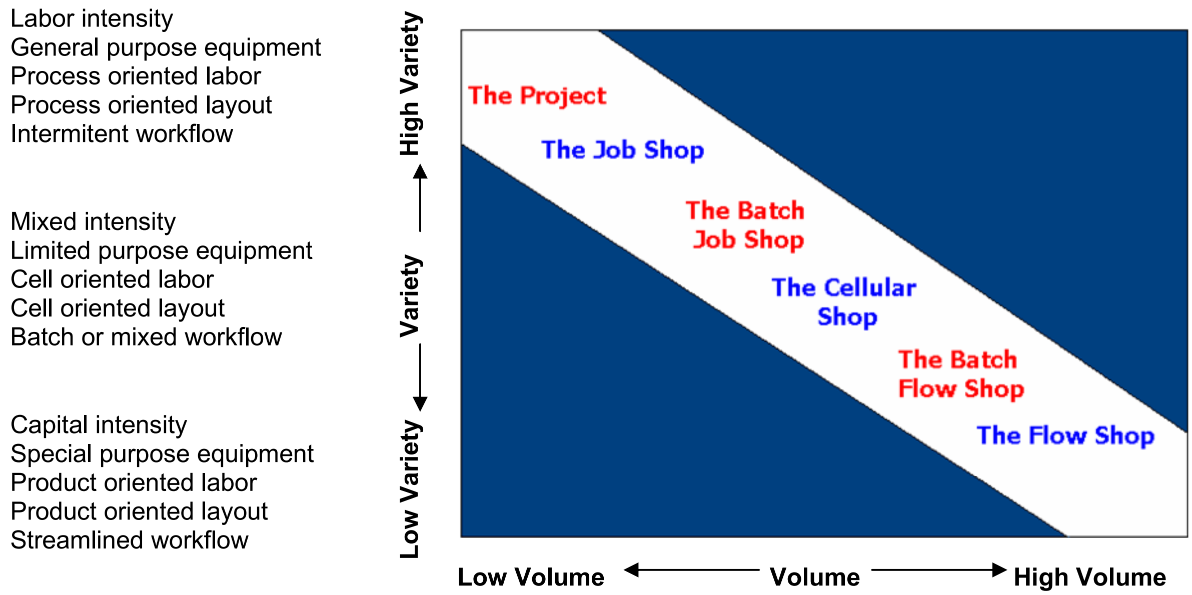


Figure 1: Basic types of manufacturing strategies

3. Total productive maintenance (TPM) – The Origin of OEE

Total productive maintenance (TPM) is defined: *Preventive maintenance plus continuing efforts to adapt, modify, and refine equipment to increase flexibility, reduce material handing, and promote continuous flows. It is operator oriented maintenance with the involvement of all qualified employees in all maintenance activities.*

The goal of TPM is to improve equipment effectiveness so that it can be operated to its full potential and maintained there. There are two main thrusts to achieving this goal:

1. Quantitative, which emphasizes improvement in total end item availability and in improved productivity per period.
2. Qualitative, which emphasizes reduction in the number of defective products and stabilization of quality.

Several losses interfere with the overall objective. They are described as:

1. *Breakdown losses*: These are losses of quantity via defective products and losses of time due to decreased productivity from equipment breakdowns.
2. *Setup and adjustment losses*: These losses stem from defective units and downtime that may be incurred when equipment is adjusted to shift from producing one kind of product to another.
3. *Idling and minor stoppage losses*: Typically, these kinds of small losses are relatively frequent. They result from brief periods of idleness when between units in a job or when easy to clear jams occur.
4. *Reduced speed losses*: These losses occur when equipment is run at less than its design speed. Design speed may not be known. Materials or tooling may be off-spec or require special treatment. There may be fear of ruining equipment if it is run too fast.
5. *Quality defects and rework*: These are product related defects and corrections by malfunctioning equipment.

6. *Startup losses*: These are yield losses incurred during early production, from machine startup to steady state [2, 4, ***6].

4. Overall Equipment Effectiveness (OEE)

Overall Equipment Effectiveness (OEE) was originated in Japan as a metric for quantifying the previously discussed six losses that interfere with the overall objective of TPM.

OEE is defined as:

OEE = Availability x Performance Rate x Quality Rate, (1)

Where:

Availability – is enhanced by eliminating equipment breakdowns, setup/adjustment losses and other stoppages;

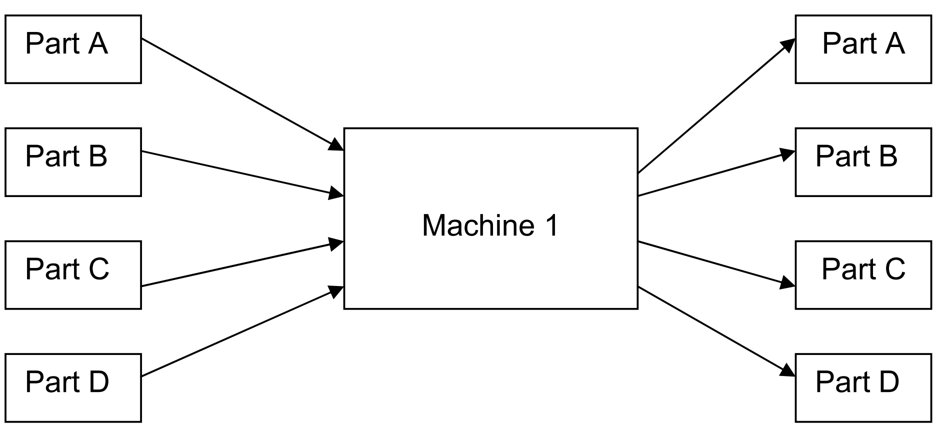
Performance Rate – is enhanced by eliminating equipment idling and minor stoppage losses, and reduced speed losses;

Quality Rate – is enhanced by eliminating quality defects and rework, and startup losses.

The other valuable property of OEE is that it can be used to make a true capacity assessment of a facility or piece of equipment. This is accomplished by multiplying the OEE by the theoretical production capacity (which is calculated by multiplying the ideal production rate by the projected available operating time) [2, 3].

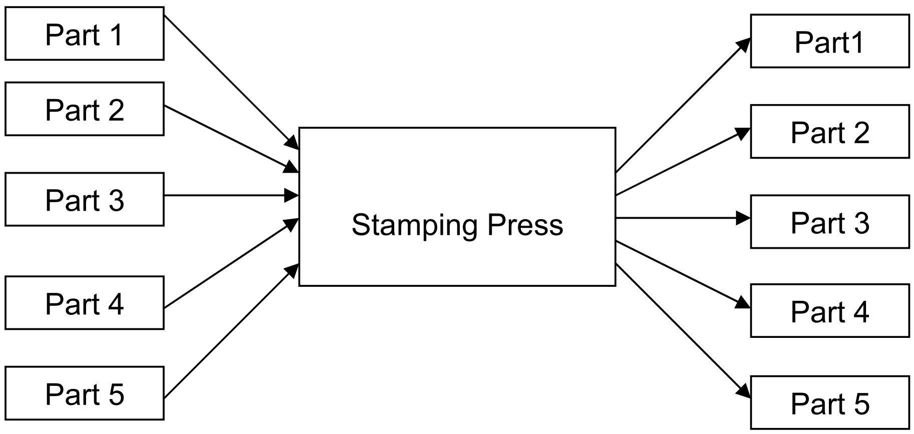
5. Type of OEE

Type: Many part types, one machine (when one machine can perform the same type operation on different types of parts).
Where it is usualy found: In a cellular shop, batch flow shop, batch job shop.
Examples: Automatic welders, some stamping presses, injection molding machines, painters/coaters [***5,***7].



Example of type: Many part types, one machine (when one machine can perform the same type of operation on different types of parts).

The Problem:
Scenario:
This example occurs at a post launch review. It takes place in a cellular shop designed to produce several types of stamped rail assemblies on a cross loaded press line. The constraint operation is a stamping press that stamps 5 different types of parts.



Available Data:
Relevant data collected from the last month of production:

Production time: 8 hours/shift, 2 shifts/day, 6 days/week (20 minutes for lunch, tag-relief used for breaks).
Days of production: 21.
Total breakdown time + time for minor setups and adjustments:1360 minutes
Total number of parts made (good + bad): 240, 000.
Total good parts: 235,689.
Planned cycle time the one used for capacity planning: 3.5 seconds/part.
Number of changeovers: 41.
Total time for changeovers: 1130 minutes.

Weekly Requirements:

Part	Weekly Requirements	Facilitized Volumes
Part 1	18,960	19,100
Part 2	14,750	12,800
Part 3	23,500	20,750
Part 4	2,995	3,500
Part 5	8,705	9,000
Totals	68,910	65,150

The Solution:
Strategy:
The best way to attack this problem is to add all part requirements into one aggregate requirement. The problem can then be solved like a one machine, one part problem.

Information you need to input:
Item A – Shifts/day: 2 shifts/day (given)
Item B – Hours/shift: 8 hours/shift (given)

Item D – Planned downtime: lunch, breaks (minutes/shift): 20 minutes/shift (given)
Item G – Days/week: 5 days/week (given)
Item I – Total minutes run: 19,320 minutes (8 hours x 60 minutes/hour – 20 minutes for lunch = 460 minutes/shift, 460 minutes/shift x 2 shifts/day x 21 days = 20,160 minutes of available run time)
Item J – Total breakdown time + changeover and setup time (minutes): 2,490 minutes (1,360 minutes + 1,130 minutes)
Item K – Total number of parts made (good + bad): 300,000 (given)
Item L – Total good parts: 298,344 (given)
Item O – Planned cycle time the one used for capacity planning: 3.5 seconds/part (given)
Item P – Average time per changeover (minutes): 17.66 minutes/changeover (1,130 minutes/64 changeovers)
Item Q – Projected changeovers per shift: 1.52 changeovers/shift (64 changeovers/42 shifts)
Item S – Projected downtime/shift: 32.38 minutes/shift (1,360 minutes/42shifts)
Item AD – Weekly demand: 68,910 (given)
Item AE – Weekly facilitized volume: 65,150 (given)

<u>The OEE and capacity analysis for example:</u>

Operating pattern and machine data:		**Proccess 1**
A. Shifts/day		2
B. Hours/shift		8
C. Minutes/shift	= B x 60	480
D. Planned downtime: lunch, breaks (minutes/shift). If tag relief is used, enter 0.		20
E. Total planned production time/shift (minutes)	= C - D	460
F. Total planned production time/day (minutes)	= A x E	920
G. Days/week		6
H. Total planned production time/week (minutes)	= F x G	5520

Actual production run data		**Process 1**
I. Total minutes run		19320
J. Total breakdown time + changeover and setup time (minutes)		2490
K. Total number of parts made (good + bad)		240000
L. Total good parts (first time through only - do not include parts that were re-processed or rewrked)		235689
M. Total bad parts	= K - L	4311
N. Actual cycle time (sec/part)	= ((I - J) x 60)/K	4.2075

Other data:		**Process 1**
O. Planned cycle time-the one used for capacity planning (sec/part)		3.5
P. Average time per changeover (minutes)		17.66
Q. Average changeovers per shift		1.52
R. Average downtime: changeover time/shift (minutes)	= P x Q	26.9
S. Average downtime: (breakdown time + time for minor setups and adjustments)/shift (minutes)		32.38
T. Total projected unplanned downtime/day (minutes)	= (R + S) x A	118.57

OEE calculation		Process1
U. Equipment Availability	= (F - T)/F	87.112%
V. Performance Efficienty	= O/N	83.185%
W. Quality Rate	= L/K	98.204%
X. OEE	= U x V x W	71.162%

Capacity analysis	Process 1
Y. Planned uptime (hours/day)	15.33333333
Z. Planned uptime (days/week)	6
AA. Planned rate of production (parts/minute)	17.14285714
AB. Theoretical production capacity per day	15771.42857
AC. Theoretical production capacity per week	94,628.57
AD. Weekly Demand	68,910.00
AE. Weekly Facilitized Volume	65,150.00
AF. Weekly Parts Available for Shipment	67,339.71
AG. Daily Demand (Actual-830)	11,485.00
AH. Daily Demand (Facilitized)	10,858.33
AI. Daily Parts Available for Shipment	11,223.29
AJ. Percent Above/below DPV	-2.28%
AK. Percent above/below Facilitized Volume	3.36%

AL. Percent above/below DPV for bottleneck operation (Minimum Value of AJ)	-2.28%
AM. Percent above/below facilitizedDPV for bottleneck operation (Minimum Value of AK)	3.36%

6. Conclusions

After the analysis of capacity and of OEE calculation it was reached the folowing conclusion: these methods determine correct results regarding the efficient optimization of the production process.

With the help of the job shop, the flow shop, the cellular shop and the analysis the following results were obtained: percent above/below DPV for bottlenek operation is -2.28%, percent above/below facilitized DPV for bottleneck operation is 3.36%.

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