Capacity-Based Lot Sizing

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INTRODUCTION

As US companies have evolved into lean manufacturers, many have become disillusioned with the "economies" of large batches. Most have abandoned economic lot sizing; but without a quantitative replacement, lot sizing in lean manufacturing is often empirical. Changeovers are reduced to justify smaller batches, but customers still refuse to order EOQ's.

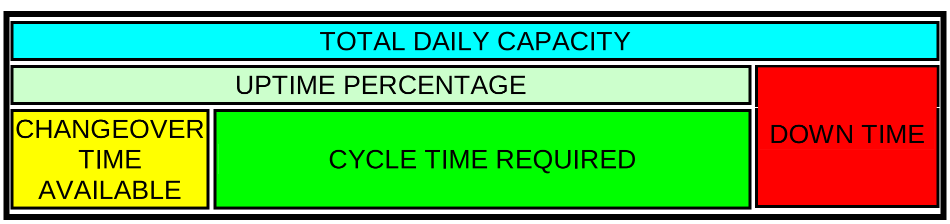
Those who have begun the lean journey now have a way to size batch-supplied supermarkets. Understanding replenishment intervals helps you to determine, for a changeover-intensive resource, the smallest interval over which the resource can produce some of every product. Capacity-based lot-sizing is not a cost-reduction technique - rather it is a tool to help you make more money - to increase your sales, to reduce your investment in inventory and to reduce total operating costs. So, capacity-based lot-sizing provides you with the minimum producible batch size, given the demonstrated capabilities of your manufacturing resources.

ECONOMIC ORDER QUANTITY (EOQ)

The basic assumption of EOQ is that as the lot size increases, the setup cost per unit decreases, since setup costs can be amortized over a larger quantity of parts. Conversely, as the lot size increases, the inventory carrying cost per unit increases, because parts are carried in inventory for a longer period of time. The EOQ is determined by the point at which the total of inventory and setup costs is at a minimum. Thus EOQ drives to minimize unit cost, but not total operating cost.

EVERY PART EVERY INTERVAL (EPEI)

Capacity-based lot-sizing is based on the assumption that the path to making more money in the manufacturing business is by simultaneously increasing THROUGHPUT (rate of sales), reducing INVENTORY (lead times), and reducing OPERATING EXPENSE (total spending). In addition to reducing inventory, capacity-based lot-sizing increases throughput by the labor content of the inventory reduction, and reduces operating expense by the carrying cost of the inventory reduction. Because it uses only existing capacity, capacity-based lot-sizing does not increase the operating expense associated with machine and labor capacity. Unlike EOQ, capacity-based lot-sizing is resource-specific, based on the total capacity of the resource, and how that capacity is consumed.



CAPACITY COMPONENTS

EPEI CALCULATION

The replenishment interval is determined by a multi-step process (see **CAPACITY COMPONENTS**):

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1. First, calculate the total daily capacity for the resource. If, for example, a machine is manned for two eight-hour shifts, its daily capacity will be 960 minutes.
2. Next, factor the available capacity for up-time. If the uptime on this example is 90%, the total daily capacity available to change over the machine and to cycle parts would be 864 minutes (960 times 90%).
3. Next, calculate the total amount of daily capacity required to cycle parts. Each part's daily requirement is multiplied by its cycle time per piece, and the results are totalled for all parts on the machine. If, in our example, 12 parts are run on the machine, and the daily demand is 10 each, and the cycle time is 6 minutes, the total daily cycle time required would be 720 minutes (12 parts times 10 each per day times 6 minutes cycle time).
4. By subtracting the 720 minutes of cycle capacity required from the 864 minutes of available capacity, we find that the amount of daily capacity available for changeovers is 144 minutes (864 minus 720).
5. Finally, the amount of time required to accomplish one changeover on each part is calculated. For our example, let's assume that it takes 10 minutes to change over the machine for each part number, or 120 minutes total for all parts (12 parts times 10 minutes each). So, the resource would spend 120 minutes of each replenishment interval in changeovers.
6. When we divide the available changeover capacity of 144 minutes by 120 minutes per interval, we find that each part could be set up and run 1.2 times per day (144 divided by 120). So, the batch size for each part would be the inverse, or .83 times its daily demand.

The days per interval (replenishment interval (RI) in days) can be reduced to the following formula:

$$RI_{DAYS} = \frac{\Sigma CO}{(A \times U - \Sigma(D \times CT)}$$

Where:
A = Daily resource time available
U = Uptime percentage
D = Daily demand for each part
CT = Cycle time for each part
CO = Changeover time on each part number

For our example, the result would be:

$$RI_{DAYS} = \frac{120}{960 \times 90\% - 720} = .83 \text{ Days}$$

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Of course, this is a simplified example. The real world is fraught with complications. For example:

- To take advantage of common tooling, it is often advisable to run parts in families; when this is the case, capacity-based lot-sizing still applies by using the reduced changeovers per interval, but your pull system must be designed to schedule the parts in families.
- Some parts may have long changeovers relative to the cycle times, which might establish a floor on the lot size, regardless of the capacity-based lot-sizing calculation.
- Any startup scrap should be considered as a cost tradeoff to reduced inventories.
- Where dedicated changeover operators are employed, the available changeover capacity should be adjusted to reflect labor capacity, not just machine capacity.
- Capacity-based lot-sizing may use forecasted requirements, and we all know how inaccurate forecasts can be. However, we also know that a forecast of total mix is more accurate than for individual items. Since capacity-based lot-sizing is based on the total mix and total capacity, the results are still valid.
- When demand rates are unstable for any reason, the capacity-based lot-sizing calculation may have to be recalculated frequently.
- When a part passes through more than one changeover-intensive resource, you will have to calculate the capacity-based lot-sizing on each resource. The one which gives you the largest replenishment interval is the constraint.

CONCLUSION

The intent of this discussion has been to provide the reader with a step-by-step quantitative approach to determining your minimum lot sizes, given your manufacturing constraints. Capacity-based lot-sizing invariably results in smaller batches than EOQ - without reducing changeover times, implementing manufacturing cells, or improving efficiencies. It does so simply by abandoning EOQ theory, and by recognizing the existing capabilities of your manufacturing resources. As a consequence, lot size inventories can be dramatically reduced, with a corresponding carrying cost reduction- as close as you will get to a free lunch!

Of course, your results will differ from those shown above. In using your data, capacity-based lot-sizing provides you with a model for determining the impact on your supermarkets and inventory investment of changes in your constraints. In any event, it is important that your replenishment intervals be modeled based on realistic expectations of your production capabilities, and that any results are tempered with common sense. If so, major reductions in inventory and lead times can result, helping you to position your manufacturing function as a true strategic weapon for your company.

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