ECONOMIC BATCH PRODUCTION AT THE ROLLING MILL OF THE CEYLON STEEL CORPORATION

J. S. Gunasekera and H. P. Fernando

1. Introduction

At the Ceylon Steel Corporation steel billets are hot rolled into different profiles. The total annual production is around 30,000 M T and there are about 54 different profiles consisting of rounds, angles and flats. These profiles are rolled in batches. The quantity of steel to be rolled per batch has been calculated in the past by taking into account such factors as the sales forecast, the production capacities and other technological requirements. The management has now taken steps to incorporate the economic aspects of batch production in determining the quantity of steel to be rolled per batch. A mathematical model for the calculation of Economic Batch Quantities has been developed and the EBQ's so calculated are used in drawing up the production plans.

2. Batch production

Production in batches as against job production or continuous production is common in the industries of developing countries like Sri Lanka. Batch production is the manufacture of a number of identical items either to meet a specific order or to satisfy continuous demand. When production of the batch is terminated, the plant and equipment are available for the production of similar or other products.

Two principal problems arise in batch production: the size of the batch and the scheduling of production. This paper deals with the first one of these problems, namely the evaluation of the optimum batch sizes. Once these have been worked out the second problem would be to obtain a satisfactory master production schedule for the entire production taking into account the plant capacity, the change over times and the effects of batch sizes on the cycle time.

3. Economic batch quantities

There are two main factors which govern the economics of batch production:

(a) The set-up cost;
(b) The storage cost.

Long production runs are more economical when the setting-up times and the set-up costs are high. Short production runs are more economical when the storage costs are high. In the Rolling Mill, the time for roll changing (i.e., setting-up time) associated with certain profiles is very high, thus justifying long production runs. However, long production runs result in large stocks of finished products, thereby increasing the storage costs, which include the capital tied with finished goods. This often leads to serious liquidity problems. To strike a balance therefore, between set-up cost and storage cost, an optimum production quantity must be calculated for each profile. Figure I gives a graphical representation of this principle.

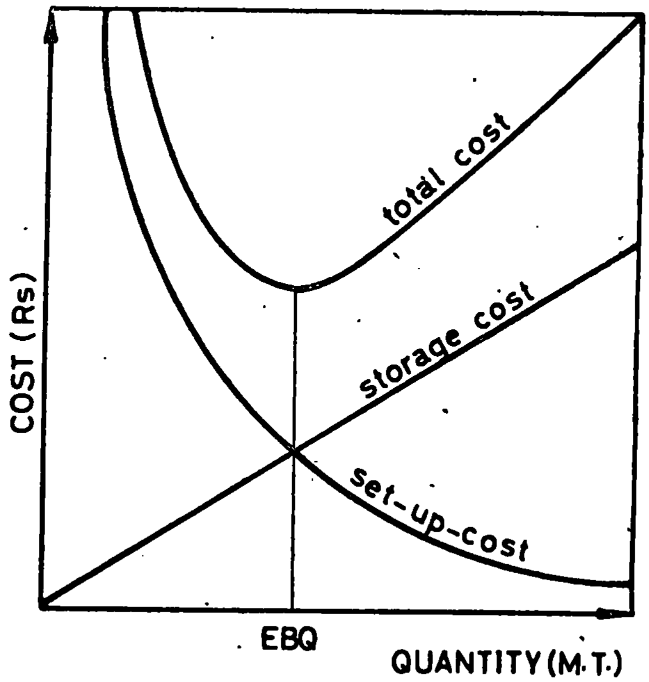

Fig I. Variation of cost with quantity produced

4. The EBQ model

A large number of models are available for the evaluation of economic batches. The particular model would depend on the ultimate objective of the organisation. Eilon[1] suggests the following criteria for the selection of a suitable model.

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1. Minimum costs per piece.
2. Maximum profit of the batch.
3. Maximum ratio of profit to cost of production. (i.e., Maximum return).
4. Maximum rate of return per unit time.

On the face of it all these seem to yield the same ultimate result. Eilon has proved that the batch quantities for each of these criteria are infact all different. Hence the model has to be chosen very carefully to fit the objectives of the organisation and its overall policy.

Burbidge[2] suggests the use of "Standard Batch Control" particularly for the Engineering Assembly Industry. This method has advantages in certain industries, for example in the automobile industry where a large number of parts are made to specific orders. In other industries, for example in steel rolling where the demand for the profiles vary widely EBQs become very valuable in keeping the total cost of production low.

5. The rolling mill EBQ model

The following model has been developed for the calculation of economic batch quantities. The main assumptions made are:

(a) that the rates of production and consumption are linear,

(b) that the rate of consumption is very much less than the rate of production.

The main object of the model is to minimize the total annual cost.

Notation

q_i	— EBQ for product i	...	(T/batch)
p_i	— Price of product i	...	(Rs/T)
A_i	— Annual requirement of product i	...	(T/yr)
q	— Quantity per batch	...	(T/batch)
a_p	— Rate of production	...	(T/yr)
a_c	— Rate of consumption	...	(T/yr)
T_p	— Production time	...	(Yrs)
B	— Buffer stock ...	...	(T)
t_i	— Set-up time for product i	...	(Hrs/batch)
C_s	— Setting-up cost ...	...	(Rs/batch)
C_{h1}	— holding cost—interest	...	(Rs/T/yr)
C_{h2}	— Holding cost—space	...	(Rs/T/yr)
q_m	— Maximum stock level	...	(T)

The total Annual Cost can be expressed as:

$$C_T = C_s \frac{A_i}{q} + (C_{h1} + C_{h2})\left(\frac{q_m}{2} + B\right)$$

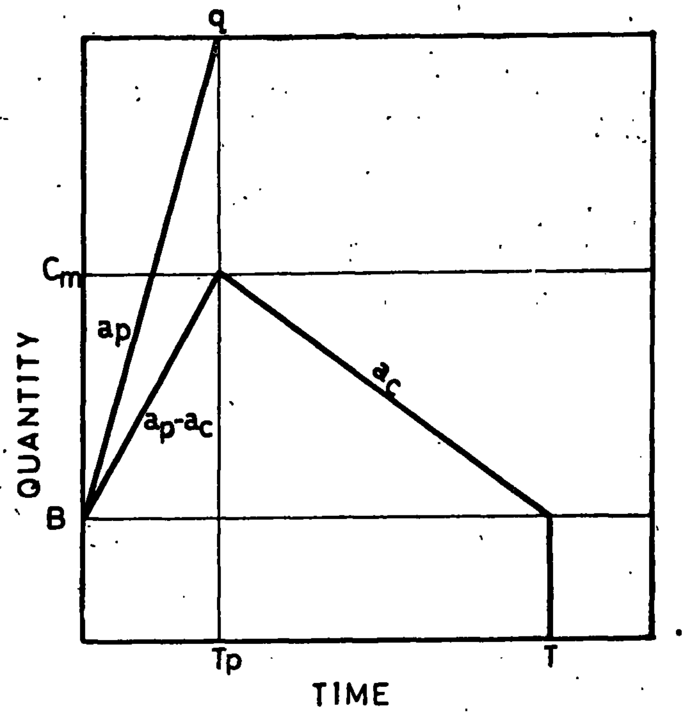

Fig. 2 Variation of stock level with time

Also we have, $a_p T_p = q$

$$T_p (a_p - a_c) = q_m$$

and hence,

$$q_m = q\left(\frac{a_p - a_c}{a_p}\right)$$

Therefore

$$C_T = C_s \frac{A_i}{q} + (C_{h1} + C_{h2}) \left(q\left(\frac{a_p - a_c}{2a_p}\right) + B\right)$$

Differentiation of the total annual cost with respect of q yields,

$$\frac{d\,C_T}{dq} = \frac{-C_s A_i}{q^2} + (C_{h1} + C_{h2})\left(1 - \frac{a_c}{a_p}\right)\frac{1}{2}$$

When C_T is a min. $\frac{d\,C_T}{d\,q} = 0$

and therefore the optimum batch quantity, q is given by

$$q_i = \sqrt{\frac{2\,C_s\,A_i}{(C_{h1} + C_{h2})\,(1 - \frac{a_c}{a_p})}}$$

if $a_c \ll a_p$ (Approximation)

$$q_i = \sqrt{2C_s\,A_i\,/\,(C_{h1} + C_{h2})}$$

The cost of not running the mill has been found, by estimating the labour cost, auxiliary material cost, depreciation, service cost and the opportunity cost due to loss in production, to be Rs. 5,864 per hour.

Therefore the setting-up cost $C_s = 5864\ t_i$

Assuming an annual interest rate of 20% of the capital tied up in stocks, $C_{h1} = p_i \times 20/100$

Storage cost due to space C_{h2} has been found to be Rs. 72 per ton per year by estimating the warehouse salaries, material costs, depreciation and overheads.

Using these figures

$$q_i = \sqrt{\frac{11720\ t_i\ A_i}{0.2\,p_i + 72}}$$

Therefore if A_i, the Annual Requirement t_i and p_i are known q_i which is the EBQ for product i can be calculated.

6. Conclusion

Production in batches as against jobbing or continuous production is common in the industries of countries like Sri Lanka. The case of the Hot Rolling Mill of the Ceylon Steel Corporation is just one example of this type of production in Sri Lanka. The model presented here can be used with modifications in any type of industry where batch productions are undertaken. The optimum production runs can be evaluated very simply using this model. The master production schedule is then drawn for the entire range of products taking into account the machine capacity, short term sales forecast, changing times, stock position etc.

A word of warning should be given here for the prospective users of EBQ models. The use of EBQs and Master Production schedules do not themselves end all the problems of production planning. These should be treated as useful tools of management which help the decision-making of the managers. The determination of the final master schedule and the production quantities will be based on the experience and the judgement of the production manager with the solutions from the model serving as scientific guidelines or indicators.

The use of Economic Batch Quantities for production by the Ceylon Steel Corporation is another attempt towards applying principles of scientific management at Oruwela. It is hoped that while reducing costs and improving the efficiency of the Rolling Mill, the use of EBQs will also help to ease off the liquidity position of the Corporation as well.

References

1. Eilon, S., *Elements of Production Planning and Control*, McMillan 1962.
2. Burbidge, J. L., *Standard Batch Control*, MacDonald & Evans 1957.
3. Eilon, S., *Scheduling for Batch Production*, J.I.Prod. E., Vol. 36, No. 9, 1957.

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රවුම් යකඩ, පටටම්, කෝණ ආදී වශයෙන් ලංකා වානේ සංස්ථාව වානේ බිලට් දඬු විවිධ පැතිකඩවලට රෝල් කරනු ලැබේ. අතීතයේදී විකුණුම් පුරෝකතන, නිෂ්පාදන ධාරිතාවත් හා වෙනත් කාර්මික අවශ්‍යතා ගුරුකොටගෙන කාණ්ඩ වශයෙන් රෝල් කළයුතු වානේ ප්‍රමාණය ගණනය කරන ලදී.

එක් කාණ්ඩයකදී රෝල් කළයුතු වානේ ප්‍රමාණය ගණනය කිරීමේ දී කාණ්ඩ නිෂ්පාදනයේ ආර්ථික ක්ෂේත්‍රයන් ඇතුලත් කිරීමට පාලනාධිකාරය දූත් පියවර ගෙන-ඇත. ආර්ථික කාණ්ඩ ප්‍රමාණයන් ගණනය කිරීම සඳහා සංඛ්‍යා සූචක ක්‍රමයක් වැඩි දියුණු වී ඇති අතර, එලෙස ගණනය කළ ආර්ථික කාණ්ඩ ප්‍රමාණයන් නිෂ්පාදන සැලසුම් සකස් කිරීමේ යොද ගනු ලැබේ. ආර්ථික කාණ්ඩ ප්‍රමාණ ක්‍රමයෙහි සාධනය මෙම පත්‍රයෙන් ඉදිරිපත් කෙරේ.

இலங்கை உருக்குக் கூட்டுத்தாபனத்தில் சிக்கனத் தொகுதி உற்பத்தி

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இலங்கை உருக்குக் கூட்டுத்தாபனத்தில் உருக்குக் கட்டைகள் பழுக்கக் காய்ச்சப்பட்டு உருண்டைகள், கோணங்கள், தட்டைகள் ஆகிய உருவமைப்புகளாக உருட்டப் படுகின்றன. இந்த உருவமைப்புகள் தொகுதி, தொகுதியாய் உருட்டப் படுகின்றன. கடந்த காலங்களில் விற்பனை முன்னுராய்வு, உற்பத்திக் கொள்ளளவு முதலாம் வேறு தொழிற் ஞானங்களை கவனத்திற் கொண்டே ஒரு தொகுதிக்குத் தேவையான உருக்கின் அளவு கணிக்கப் பெற்றது. தற்போது ஒரு தொகுதிக்கான உருக்கின் அளவை கணிப்பதற்கு சிக்கனத் தொகுதி உற்பத்தி முறையை கவனத்திற் கொள்ள முகாமையாளர் நடவடிக்கை எடுத்துள்ளனர். சிக்கனத் தொகுதியின் அளவை கணிப்பதற்கு ஒரு கணித சூத்திர அமைப்பு உருவாக்கப்பட்டுள்ளது. உற்பத்தித் திட்டங்களை வகுக்கும்போது இந்த சிக்கனத் தொகுதி அளவே பயன்படுத்தப் பெறுகின்றது. இந்த சூத்திர அமைப்பு கோர்க்கப்பட்ட முறையை இக்கட்டுரை விளக்குகின்றது.