CAPACITY PLANNING USING A SPREADSHEET

Jeremy Mant, MBPICS

INTRODUCTION

This article describes and illustrates a spreadsheet for planning capacity requirements in a multi-stage manufacturing operation in which quantities of product are required for despatch in specified period numbers.

OBJECTIVE

The objective of the model is to provide a means for planning the utilisation of departmental capacity in relation to a required pattern of despatches. The model shows the required capacity in each department, time-phased according to specified lead times.

The initial despatch plan may produce a result that overloads capacity in a department in certain weeks. The effect on capacity utilisation of re-scheduling the despatches of one or more products can immediately be seen in all four stages of the process. Thus the effect of splitting large despatch volumes across several weeks may be to use capacity much more effectively and yet meet customer service requirements. Whilst this may incur more set-up time, the overall throughput of the plant may be increased, with smaller batches passing through each process.

ASSUMPTIONS

The model assumes that the set-up and processing times for each product at each production stage can be defined to a reasonable degree of accuracy. It is assumed that there are no product losses at the various stages of manufacture. This aspect is further dealt with under 'Enhancements'.

In all cases lead time has been taken as one time period. This has been done because the objective is seen as processing orders through the plant as quickly as possible. Lead times for processes are often based on how long a product typically takes to pass through that stage. But this is itself a function of set-up time, processing speed and the relationship between capacity requirements and capacity availability. By matching the capacity requirement in, say, a week with the processing time available we arrive at a realistic plan of what can be accomplished in a time period. Standard lead times may be very inaccurate where capacity requirements and availability do not typically match well.

DATA REQUIREMENTS

The model is set out here to show the capacity requirements for three products passing through four manufacturing stages:

- Forming,
- Machining
- Inspection and
- Test
- Despatch.

For each product, in each stage of manufacture, a set-up time and processing rate can be specified. This data is stored in a Lookup table. The lead time and cumulative lead time are also stored in this table.

LAYOUT

The model is laid out in four blocks, with the final process of Despatch at the top and the initial process of Forming at the bottom. The time periods are shown across the top. The time period represented by each column could represent a shift, a day, a week, or a month – but a week is assumed here. The layout of the model is shown in Figure 1. As presented here, only a small number of periods is shown. This could be extended to cover many more periods.

FIGURE 1
CAPACITY PLANNING MODEL

			WEEK NUMBER						
CODE			1	2	3	4	5	6	7
DESPATCH	abc	QTY	REQUIRED DESPATCHES			300	400	2000	3000
		HRS				30	40	200	300
	def	QTY				2000		1000	
		HRS				400			200
	ghi	QTY				100	100	100	100
		HRS				30	30	30	30
TOTAL HOURS REQUIRED						460	70	430	330
TOTAL HOURS AVAILABLE			500	500	500	500	500	500	500
UTILISATION						92.0%	14.0%	86.0%	66.0%
INSP AND TEST	abc	QTY			300	400	2000	3000	
		HRS			32	42	202	302	
	def	QTY			2000		1000		
		HRS			403		203		
	ghi	QTY			100	100	100	100	
		HRS			34	34	34	34	
TOTAL HOURS REQUIRED					469	76	439	336	
TOTAL HOURS AVAILABLE			500	500	500	500	500	500	500
UTILISATION					93.8%	15.2%	87.8%	67.2%	
MACHINING	abc			QTY	300	400	2000	3000	
				HRS	152	202	1002	1502	
	def			QTY	2000		1000		
				HRS	2003		1003		
	ghi			QTY	100	100	100	100	
				HRS	36	36	36	36	
TOTAL HOURS REQUIRED				2191	238	2041	1538		
TOTAL HOURS AVAILABLE			2500	2500	2500	2500	2500	2500	2500
UTILISATION				87.6%	9.5%	81.6%	61.5%		
FORMING	abc	QTY	300	400	2000	3000			
		HRS	30.5	40.5	200.5	300.5			
	def	QTY	2000		1000				
		HRS	602		302				
	ghi	QTY	100	100	100	100			
		HRS	43	43	43	43			
TOTAL HOURS REQUIRED			675.5	83.5	545.5	343.5			
TOTAL HOURS AVAILABLE			700	700	700	700	700	700	700
UTILISATION			96.5%	11.9%	77.9%	49.1%			

It will be seen that for each of the four processes, the three products – abc, def and ghi – are set out in the same order, with two spreadsheet rows assigned to each product. The first of these rows carries the volume of product to be processed. The second row calculates the required plant capacity for set-up and processing time by reference to the standard data held in the Lookup table and the volume of material to be processed.

It is preferable to include all products in each process table, even though some products may omit some stages of production. The model must, and does, deal with this situation by specifying zero lead time, set-up time and processing time where a product does no use a particular process. This approach allows for easy modification of process routes and makes the model easier to follow.

The Lookup table should be placed below and to the right of the main model if a single-page spreadsheet is being used, or put on a different spreadsheet page if a multi-page spreadsheet is being used.

The calculated capacity requirement is set against the actual capacity hours available and a utilisation calculated.

TECHNIQUES

The first step is to lay out the model to represent the products passing through the four stages of manufacture. Once the general shape of the model is developed, the next stage is to set out the Lookup table which contains the operating data.

For each product code used in the model, a row of data is required in the Lookup table. Very simple code examples have been used here. Avoid the use of wholly numerical product codes if you can, because the Lookup table will be more robust if letter and number combinations are used.

All product codes should be entered into the Lookup table in uppercase. The product codes used in the four processing blocks should also be in uppercase. The @UPPER function converts labels from lower or mixed case to upper case. This allows lowercase to be used in the main part of the spreadsheet, if this is better for ease of presentation.

Extensive use is made of the @VLOOKUP function in calculating the capacity requirement at each stage of production. Functions also have to be combined in this model to test whether a capacity calculation is required.

The back-scheduling of product requirements from Despatch down to Forming makes use of the @CHOOSE function in conjunction with the @VLOOKUP function.

Whilst the formulae are relatively complicated, they can be built up gradually using the Edit key to make additions. The reasons for having two lines for each product at each stage of production are :

- The model is easier to follow.
- The calculation of capacity requirements is easier because it can be done within the process area being evaluated.

ENHANCING THE MODEL

There may be many ways in which readers can develop the ideas set out in this model to meet their own requirements more adequately. The most obvious is to allow for 52 periods, so that the model could be used as an annual planning template.

Another area that might be suggested is that the model could recognise that losses through defects can occur at various stages of manufacture. These loss rates would be product and process related. They would show the product that would be needed at each stage of manufacture in order to achieve the final despatch requirement. Where a product had a relatively high loss rate in some particular process, the manufacturing capacity required could be significantly understated if such losses were not recognised.

This model only deals with three products. In all probability users will require significantly more than this number. This simply requires that each block of the model is increased, with two rows for each addition – to allow for sufficient product groups. In addition, the Lookup table would need to be extended to accommodate the new product. If more processes are required, then more blocks must be added to the model and the Lookup table extended. It is possible to copy the formulae into new blocks, provided that use is made of Absolute Addressing.

The possibility that a product can be made using alternative process routes can be accommodated by the use of slightly modified product codes. Each code needs to be represented in the Lookup table. Where a process is not used, lead time, set-up time and processing rate will be set to zero and cumulative lead times will remain unchanged.

Effective use could be made of graphs to highlight shortfalls in capacity and in depicting the level of plant utilisation over the periods covered by the model.

CONCLUSION

This model will provide a good basis for capacity planning in a relatively simple plant where products can be grouped and the process routes are well-defined. It can also serve as a prototype where consideration is being given to the acquisition of a specialised planning system. It could prove extremely useful in planning capacity within a manufacturing cell where the main planning system does not do this in sufficient detail.

It may also serve as a useful training aid in POM courses. This type of model is one that is typically presented in the BPICS course entitled **"Use of Spreadsheets in Production and Inventory Control".**

About the Author

Jeremy Mant BSc(Econ), ACMA, AMIMC, MILog. Jeremy has varied industrial experience over more than 20 years in work study, accountancy, distribution planning and inventory management, which has involved substantial work in computer systems development. Since 1986 he has been a Training Consultant specialising in Computer Applications. A significant part of this work has required the training of managers in the use of personal computers, through intensive 'hands-on' training courses. He also undertakes training and consultancy work in inventory management and logistics. He is a Member of BPICS and a senior visiting Fellow at Loughborough University.