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Decision Support System (DSS) for Capacity Planning: A Case Study

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Abstract: A Decision Support System (DSS) refers to a class of systems which support the process of making decisions. DSS is given the opportunity to overcome the cognitive limitations of human decision makers and offers effectiveness and efficiency in making decisions. Capacity planning is the process of determining the necessary people, machines, and physical resources to meet the production objectives of the firm. Without provision of adequate capacity or recognition of the existence of excess capacity, the benefits of an effective Manufacturing Planning and Control system cannot fully realize. The proposed DSS provides a correspondence between the capacity required to execute Master Production Schedule (MPS) and capacity available to implement MPS.

Keywords: Decision Support System; Cognitive Limitations; Capacity Planning; Manufacturing Planning and Control System; Master Production Schedule.

I. INTRODUCTION

Decision making is a process of selection from a set of alternative courses of action to fulfil the objectives of the decision problem more satisfactorily than others [8, 9]. Decisions may be categorized into structured, unstructured and semi-structured decisions [3, 7]. Structured decisions involve situations where the procedures to follow, when a decision is needed can be specified in advance. Such decisions are structured or programmed by the decision procedures or decision rules developed for them. Unstructured decisions involve decision situations where it is not possible or desirable to specify in advance most of the decision procedures to follow. In between the above categories there exist semi structured decisions, where some decision procedures can be pre specified, but not enough to lead to a definite recommended decision.

Although a Decision support system can be used for a wide variety of decisions, the decision support concept applies better to semi structured and unstructured problems.

Gorry and Scott [4] offer following definition of a DSS: Decision Support Systems couple the intellectual resources of individuals with capabilities of the computer to improve the quality of decisions. They comprise a computer based support system for management decision makers who deal with semi-structured problems. George M. Marakas [8] defines DSS as a system under the control of one or more decision makers that assists in the activity of decision making by providing an organized set of tools intended to impose structure on portions of the decision making situation and to improve the ultimate effectiveness of the decision outcome.

A Decision Support System (DSS) refers to a class of systems which support the process of making decisions. The emphasis is on ‘support’ rather than an automation of decisions [1]. DSS allow decision makers to retrieve data and test alternative solutions during the process of problem solving. Effective problem solving is interactive and is enhanced by dialogue between the user and the system [3]. A DSS consists of hardware, software, data, model, and people.

Hardware resources include management workstations, department minicomputers, and corporate mainframes. Software resources include software packages such as DSS generators and spreadsheet packages that perform database management, model base management and dialogue generation and management. Data and model resources include a database extracted from internal, external and personal databases, and a model base that is a collection of mathematical models and analytical techniques. People resources include managers and staff specialists who explore decision alternatives with the support of DSS.

A DSS offers the following types of support:

• Explores multiple perspectives of a decision context.

• Generates multiple and higher quality alternatives for consideration.

• Explores and tests multiple problem-solving strategies.

• Increases the decision maker's ability to tackle complex problems.

• Improves response time of decision maker.

• Discourages premature decision making and alternative selection.

II. CAPACITY PLANNING

Production capacity is defined as the maximum rate of output that a production facility (or production line, work center, or group of work centers) is able to produce under a given set of assumed operating conditions. The assumed operating conditions refer to the number of shifts per day, number of days in the week (or month) that the plant operates, employment levels, and so forth [5]. Capacity planning is the process of determining the necessary people, machines, and physical resources to meet the production objectives of the firm [10]. A master production schedule details usually on a monthly, weekly or even daily basis, the quantity of specific products or product groups to be produced. To assess the realistic nature of the MPS, its resources must be checked. Capacity planning compares the available capacity with required capacity. Capacity planning may be done in two stages [6].

- Rough Cut Capacity Planning (RCCP)
- Capacity Requirement Planning (CRP)

1) *A Rough Cut Capacity Planning:*

RCCP is used to examine the effects of proposed MPS on key work centers, departments and machines. During RCCP work centers whose capacity is insufficient are identified. The capacity required at each selected work center is then calculated using the proposed MPS. If the required capacity exceeds the available capacity at one or more centers, the MPS must be modified. Every time the MPS is amended its effects on key resources must be re-examined. Thus RCCP is an iterative process for which the computer is well suited. The process ends when the MPS appears to be feasible. RCCP may be accomplished using following three methods.

- Overall Factors Method.
- Capacity Bill Method.
- Resource Profiles.

The overall factor method uses past data to determine the percentage of total production hours that can be attributed to each work center. These percentages are used to estimate the expected workload at each work center for each MPS time period.

Following equation has been used to obtain the total number of production hours required for a particular week [6].

International Journal of Advance Research in Computer Science and Management Studies
Volume 1, Issue 4, September 2013 pg. 24-30

$$H_t = \sum_{P=1}^{n} q_{pt} h_p$$

$$l_{wt} = H_t r_w$$

Where H_t = Total number of production hours required for the period t.

q_{pt} = Number of units of product p to be produced during period t.

h_p = Total production hours required by product p.

n = Number of products to be produced.

l_{wt} = Expected work load at work center w during period t.

r_w = Percentage of total production hours assigned to work center w during previous period.

Assumption: in this method is, the product mix remain same. This method is easy to use and requires a minimal amount of data.

Capacity Bill Method: This method estimates the expected work load at each work center 'w'for each MPS time period't' using the following equation [6].

$$l_{w,t} = \sum_{p=1}^{n} (q_{p,t})(h_{p,w})$$

$l_{w,t}$ = Expected work load at work center w for the period t

$q_{p,t}$ = Number of units of product p to be produced during period t

$h_{p,w}$ = Number of production hours required by product p at work center w

n = Number of products to be produced.

In resource profile method lead-time to manufacture the various components, subassemblies will be taken into consideration to project the required capacities at various work centers. This method is not considered in the present work.

2) Capacity Requirement Planning:

In capacity requirement planning lot sizes of the components to be manufactured and the lead times required to manufacture the components will also be taken into consideration which will give the realistic projection of the capacities. In the present work CRP has not been incorporated.

III. NEED FOR DSS FOR CAPACITY PLANNING

Manufacturing firms have made considerable progress in the installation and use of Material Requirement planning (MRP) systems to plan and control fabrication and assembly operations. But to manage effectively the MRP systems two road blocks must be overcome. They are:

1) Preparation of Master Production Schedule (MPS) and

2) The development of capacity plans to support that schedule

Many firms fail to implement MPS because of poor planning of capacity at individual work centers. A critical activity that parallels the development of the material plans is the development of capacity plans. Without the provision of adequate capacity or recognition of the existence of excess capacity, the benefits of an effective Manufacturing Planning and Control (MPC) system cannot be fully realized, because insufficient capacity will quickly lead to deteriorating delivery performance, escalating work-in-process inventories. On the other hand, excess capacity may be a needless expense that can be reduced. Firms must be equipped with information system which provides appropriate work center capacities (11). With this objective a DSS for

International Journal of Advance Research in Computer Science and Management Studies
Volume 1, Issue 4, September 2013 pg. 24-30

Capacity Planning is proposed. The proposed DSS provides a correspondence between the capacity required to execute a given material plan and that made available to execute the plan. If this correspondence does not exist, the plan will either be impossible to execute or inefficiently executed. The proposed DSS has been implemented for a small-scale industry, which manufacture Transformers.

A. Development of DSS:

Although several models are available, for the development of DSS for capacity planning only two models, namely capacities planning using overall factors (CPOF) and bill of capacity method have been used. Data regarding Master Production Schedule, time required for manufacture of each model of transformer, historical data regarding usage of various centers, bill of capacity for each model have been collected from an industry which manufactures transformers.

B. Case Study (for CPOF):

An SSI unit, Manufacturers of transformers had the Master Production Schedule (MPS) as shown in Table-I. To determine the percentage of total time for each work center historical data of four periods has been obtained. Each period is one month. Table-3 shows the percentage of total time for different work centers. The time required at individual work centers based on the overall factor method is shown in the table-IV.

C. Case Study (for Bill of Capacity method)

To implement the bill of capacity method in addition to Master Production Schedule, Bill of materials and Routing and operation time data have been obtained. Bill of capacity for each product is the sum of the operation timings required at different workstations to produce that product. By using MPS and Bill of capacities the work load at individual work centers has been calculated. For the selected SSI unit Bill of capacity for different models of transformers are obtained and presented in Table-V. And required capacity for various work centers is presented in Table-VI.

TABLE-I Master Production Schedule for the year 2011-12.

End Product	1	2	3	4	5	6	7	8	9	10	11	12
M-1	400	440	400	300	600	400	450	400	360	250	400	400
M-2	150	120	150	150	-	250	200	240	160	170	180	170
M-3	-	150	120	170	150	-	-	120	120	200	-	140
M-4	44	45	30	45	30	35	60	-	45	50	55	20

TABLE-II Direct Labour Time for Each Model: M = Model

Sr.No	End product	Total direct labour time in standard hours/unit
1	M-1	5.58
2	M-2	6.92
3	M-3	9.33
4	M-4	17.00

TABLE-III: Historical Data to Determine the Percentage of Total Time Used by Work Centers.

S.no	Work center	Number 0f hours	Percentage of Total hours
1	Sheet metal cutting	190	1.12
2	Bending machine	166	0.98
3	Drilling machine	590	3.48
4	Gas cutting machine	870	5.13
5	Arc welding machine	2740	16.17
6	Core building station	2600	15.34
7	L.V.winding machine	1230	7.26
8	H.V.Winding machine	2740	16.17
9	Sub assembly workstation	3360	19.83
10	Final assembly workstation	1810	10.68
11	Spray painting work center	650	3.84

TABLE-IV: Capacity Planning Using Overall Factors

Wc	1	2	3	4	5	6	7	8	9	10	11	12
1	45	61	54.8	56.7	58.8	51	55	56.1	56	59.2	49.4	56.6
2	39.3	53.4	48	49.6	51.5	44.6	48.1	49.1	49	51.8	43.2	49.5
3	139.8	189.6	170.5	176.2	182.9	158.5	171	174.4	174	184	153.5	175.9
4	206.1	279.5	251.3	259.7	269.7	233.7	252.1	257.1	256.5	271.2	226.3	259.3
5	649.7	881.2	792.2	818.6	850.1	736.8	794.7	810.5	808.6	854.9	713.5	817.3
6	616.3	836	751.6	776.6	806.5	699	753.9	768.9	767	811	676.8	775.3
7	291.7	395.6	355.7	367.5	381.7	330.8	356.8	363.9	363	383.8	320.3	366.92
8	649.7	881.2	792.2	818.6	850.1	736.8	794.7	810.5	808.6	854.9	713.5	817.3
9	796.7	1080.7	971.6	1004	1042.5	903.6	974.6	993.9	991.6	1048.5	875	1002.3
10	429.1	582	523.2	540.7	561.5	846.6	524.9	535.3	534	564.6	471.2	539.8
11	154.2	209.2	188.1	194.4	201.8	174.9	188.7	192.4	192	203	169.4	194
Tpc	4018	5450	4899	5063	5257	4557	4915	5012	5000	5287	4412	5054

Wc=Work center Tpc=Total plant capacity(in hours)

TABLE -V: Bill of Capacity for Different Models of Transformers:

S.no	Work center	M-1	M-2	M-3	M-4
1	Sheet metal cutting	3.75	3.75	3.75	3.75
2	Bending machine	3.25	3.25	3.25	3.25
3	Drilling machine	11	17	20	33
4	Gas cutting machine	18.75	21.75	25.75	38.75
5	Arc welding machine	60	75	85	160
6	Core building station	55	68	75	129
7	L.V. Winding machine	21	30	48	96
8	H.V. Winding machine	48	60	90	243
9	Sub assembly workstation	66.5	80.5	110.5	176

10	Final assembly workstation	35.5	40.5	80.5	111
11	Spray painting work center	12.5	15.5	18.5	26

Total time per uni 335.25 415.25 560.25 1019.75 (In minutes)

TABLE-VI Capacity Planning using Capacity Bills (in hours)

Wc	1	2	3	4	5	6	7	8	9	10	11	12
1	37.1	47.1	43.7	41.5	48.7	42.7	44.3	47.5	42.8	41.8	39.6	45.62
2	32.1	40.9	37.9	36	42.2	37.1	38.4	41.7	37.1	36.3	34.4	39.5
3	140	189.4	172.3	178.9	176.5	163.4	172.1	181.3	176	188.1	154.8	179.1
4	207.8	274.4	250.2	250.1	271.2	238.2	251.8	263.5	251	257.8	225.7	259.6
5	704.8	922.5	837.5	848.3	892.5	805.8	860	870	850	879.1	771.6	864.1
6	631.2	823.5	751.1	754.2	802	725.2	768.1	788.6	758	779.3	688.9	777.3
7	285.4	406	359	388	378	321	353.5	356	374	412.5	318	369
8	648.2	879.2	771.5	827.2	826.5	711.7	803	740	810.2	872.5	722.7	781
9	773.6	1056.9	953.5	978.8	1029.2	881.4	943	986.3	966.6	1020.1	846.1	987.9
10	419.3	625.8	554.4	590	611.7	470.1	512.2	559.6	565.2	623.5	459.9	626.2
11	141.1	188.4	172	173	184.2	163	171.4	182.3	172.8	179.3	153.6	179
TPC	4020.9	5454.4	4903.5	5066.5	5263	4560	4918.2	5016.5	5004.1	5290.7	4415.5	5058.7

TABLE-VII: Available Capacities of Various Work centers

Work Center	1	2	3	4	5	6	7	8	9	10	11
Number of Machines	1	1	1	2	5	6	3	8	7	5	1
Capacity per month(hrs)	140	120	180	260	900	840	360	960	980	700	180

IV. Results and Discussions

Capacity planning by CPOF and capacity bills has been presented in the table-IV and table-VI respectively. In CPOF procedure, data requirements are minimal and calculations are straight forward. However the CPOF approximations of capacity requirements at individual work centers are only valid to the extent that product mixes or historical divisions of work between work centers remain constant. The capacity bill method provides a much more direct link between individual end products in the MPS and capacity required for individual work centers. It takes into account any shifts in product mix. Consequently it requires more data than the CPOF procedure. Results of CPOF and capacity bill method reveal the differences in work center estimates for each time period. These differences are far more important in firms which experience significant period-to-period product mix variations than in those that have a relatively constant pattern of work. Comparison of required capacities with the available capacities of individual work centers gives the managers to take an apt decision regarding the strategies to be followed whenever the required capacity exceeds the available capacity.

V. Conclusion

Making decisions regarding complex system's strains human's cognitive capabilities. There is a substantial amount of empirical evidence that human intuitive judgment and decision making can be far from optimal and it deteriorates further with complexity. Decision Support Systems can aid human cognitive deficiencies by integrating various sources of information, providing intelligent access to relevant knowledge, aiding the process of structuring decisions. The model based DSS for capacity planning gives the required capacities at various work centers. If there is a mismatch between available capacity and required capacity the manager has to take an appropriate decision to bridge the gap in order to realize the Master Production Schedule.

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References

1. Alter.S.L, 1980, "Decision Support Systems: Current Practices and Continuing Challenges, Addison-Wesley, Reading , M.A.
2. Berry. W.L, Thomas G. Schmitt, CPIM, Thomas E. Vollmann, 1982, "Capacity Planning Techniques for Manufacturing Control Systems: Information Requirements and Operational Features", Journal of operations Management, Vol. 3 (1), 13-25.
3. Davis, G.B, Margreth H.Olson, 2000, "Management Information Systems, Conceptual foundations, Structure and Development", Tata Mc Graw-Hill edition.
4. Gorry, G.A, and M.S. Scott Morton. 1989, "A Frame work for Management Information Systems", Sloan Management Review, 13 (1), 49-62.
5. Groover M.P, 2003, "Automation, Production Systems and Computer Integrated Manufacturing", second edition, Pearson Education.
6. Hamid Noori, Russel Radford, 1995, "Production and Operations Management: Total Quality responsiveness" Mc Graw-hill International edition.
7. James A O'Brien, 1998 "Management Information Systems. A Managerial End user perspective", Galgotia publications pvt Ltd.
8. Marakas, G.M, 2003, "Decision Support Systems in the 21st Century", Second Edition, Pearson Education.
9. Mallach, E.G, 2002, "Decision Support and Data ware house Systems" Tata Mc Graw-Hill publishing Company.
10. Seetha Ram L. Narasimhan, Dennis W. Mc Leavey, Peter J. Billington, 2003, "Production Planning and Inventory Control", Prentice Hall of India Pvt. Ltd.
11. Vollmann, T.E, William L. Berry and D. Clay Whybark, 2001, "Manufacturing Planning and Control Systems", Galgotia Publications Pvt Ltd.

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