Journal of Social and Management Sciences

University of Maiduguri

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J. Soc. & Mgt. Sc. Vol. 8 (1 & 2) 2001, pp10 - 19

MANPOWER PLANNING FOR PROCESS INDUSTRIES: A CASE STUDY OF DELTA STEEL COMPANY

A.O. Inegbenebor and J.D. Galadima
Department of Mechanical Engineering
University of Maiduguri
Maiduguri

ABSTRACT
This paper proposes a modified and interactive cost-effective model manpower planning for New Job shops to suit a process industry. This model employs historical and judgmental forecasting methods to determine the demand levels for the model. The results obtained by running the computer model shows that the steel making plant should engage a full time staff of 40 mechanical engineers against the 65, 320 mechanical technicians against 560 and 40 electrical technicians against 65 that are presently employed. In the steel rolling mill section, they should have engaged 24 mechanical engineers against 33, and 240 mechanical technicians against 256.

Keywords: Manpower planning . Processes industry . Modified model.

INTRODUCTION

Engineering production or manufacture is concerned with the manufacture of engineering products such as machines, machine components, engineering materials, etc, by the productive utilization of manufacturing resources such as facilities, materials, labour, space and technical skills (Ibhadode, 2001).

The steel production falls to the group of production methods of process manufacture. This process usually involves the production of bulk quantities of material through chemical rather than mechanical means. Examples include steel making plant, oil refineries and petrochemical plants, fertilizer plants, etc (Ibhadode 2001). In this method, production is continuous for 24 hours a day throughout the year barring breakdown and other problems.

Steel is a very important engineering material that has affected human civilization so markedly. In fact, the level of production is a measure of the military and industrial power of a nation. The superpowers and industrialized nations of the world owe their might to their high level of steel productions. There is a direct relationship between the quantity of steel produced in a nation and her military and economic strength (Ibhadode, 2001).

With this in mind, Nigeria as a nation has to do all it takes to reawaken her existing steel industries and complete without any waste of time other steel industrial projects. At present, Delta steel company is only producing steel liquid. Therefore, the manpower planning of this work will focus on it and use the company as a case study for other process industries in the country. As a pioneer steel making industry in the country, it cannot afford any loss associated with wrong manpower planning.

The most important resources of an organization are the people. Without the people there will be no possibility of executing planned projects. One of the key responsibilities of every senior manager is planning the optimum utilization of resources (both human and non-human). It is important, therefore, to ensure that efficient numbers of the appropriate caliber of people are available to the organization in pursuit of its objectives (Price, et al, 1980). Manpower planning is a strategy for the acquisition, utilization, improvement and retention of enterprise of human resources (Edwin, 1986). These must be backed up with factors that ensure effective and efficient manpower planning which include appropriate methods in recruitment, training and manpower development, and various motivational variables of employees.

Manpower planning involves making necessary decision that would enable an organization to meet its manpower requirement considering the factors that are prevailing. According to Pyme (1967), if manpower planning is to be economically viable, the supply and demand needs to be extended to include measurement and control of the variable affecting the supply and demand for skills. These variables include education, vocational training, utilization and innovation. In this content, manpower planning can be said to comprise of two basic aims (Garth, 1971).

(i) Ensuring optimum utilization of human resources
(ii) To provide the future manpower needs of the organization in terms of skill, numbers and age.

In carrying out a successful manpower planning there are four categories of staff that are important to be considered in this exercise. They are, existing staff, new recruits, and potential staff. Each of these categories requires different decisions to be made by the managers concerned. For example, the decision required about existing staff to fill vacancies in the organization may be done through performance appraisal, which will earn the staff promotion. This is the type of system of manpower planning that is operating at Delta Steel Company. In such case, the general problem will then be how to determine the optimum size of the labour force on a continual basis such that all order will be filled promptly. There must also be a need for a steady labour growth rate within the company.

These problems can be addressed by having well articulated manpower planning model which will propose an iterative cost-effective model take care of regular and overtime engagements in the company. Such a model had been proposed for New Job shop, which presumes no distribution pattern for labour demand. However, judgmental and statistical forecasting methods should be employed to determine the demand levels for the model (Aderoba, 2000).

There are a lot of manpower planning models. For example as cited in (Aderoba, 2000), as a tool for industrial decision making, (Pegels, 1981). (Nakamura and Shingu ,1984) have developed separate generalized models to optimize a company's recruiting and training levels. In Pegels, internal transfer was considered as a viable option for filling vacancies. As reported by (Aderoba, 2000) generally, manpower planning models for an industrial setting are geared towards production smoothing. This through workforce balancing as a result of hiring or laying off labour or by introducing overtime or idle time. The work of Kurosu (1986) is of a particular relevance to job shops. It prescribes the influence of demand uncertainties to wasting time and rate of losing customers. However , Kurosu prescribed timing procedures to take care of fluctuating demand. Recently, (Aderoba, 2000) used this approach to develop- a cost effective and iterative method of analysis for New Job shops for manpower planning decisions to prevent hiring and firing of staff in periods of fluctuations in demand.

The aim of this work is to modify Aderoba's manpower planning model for New Job shops to be used in process industries (A case study of Delta Steel Company). The model will provide a cost effective iterative and employs historical and judgmental forecasting methods to determine the demand levels for the model. This cost effective and iterative modify model is simple to understand and lends itself readily to manpower planning decision.

MODEL DEVELOPMENT

The model makes use of realistic demand forecast as well as relevant constraints for iterative dynamic analysis to determine levels of full time staff and overtime engagement required on a periodic basis for the steel industry.

To carry out this model it will require the answer to the following questions:

(i) What is the number of full time workers in each department in a particular period (t)?,

(ii) What is the forecast of labour requirement of each department in a period (t)?

(iii) What is the actual demand for labour in each department for that period?

(iv) What are the hours of full time engagement per given period?

The final analysis shall be made using the sum of the result from the various departments. It is necessary to note here that the cost of overtime engagement should be more than the cost of full time engagement per period. The realistic data of the nature of work schedule throughout one-year calendar in each department as well as the calibre of work force required were obtained from the management records of Delta Steel Company. Some times, labour cost is marked in per unit, per tons or per naira output basis. For the purpose of this work we make use of the staff salary per month to obtain the labour cost per hour for each category of staff.

MATHEMATICAL FORMULATION

Nomenclature:

M.E – Mechanical Engineers (include metallurgists and scientist material and others)
E.E. – Electrical Engineers (including electronics, and telecommunications and others)
M.T – Mechanical Technicians (include metallurgy and others)
E.T – Electrical Technicians (include electronics, telecommunications and other)
Min Z – Minimum number of staff required
N_{max} – Maximum man-hour requirement
N_{min}- Minimum man-hour requirement
Nopt – Optimum man-hour requirement
C.F – Conversion factor
A – Actual demand for labour
F – Forecast of labour requirement
H – Working hours per period (one day, month or year)
K(x)_ - cost of full time labour per hour
β - Exponential smoothening factor
S.D – Standard deviation (difference)

OBJECTIVE FUNCTION

The functional relationship developed by Aderoba (2000) for calculating manpower was used. The function is to minimize the total labour cost of meeting all orders. This is expressed mathematically as follows:

$$\text{Min } Z = \sum C_{it}.N_{it}H.\sum[X_{it}K_{it}(A_{it}-N_{it}H)] \quad \text{.........................Eqn. 1}$$

Where $X_{it} = 1$ if overtime staff is to be engaged in period t = 0 otherwise.
Here, C_{it} is cost of full time labour per hour in period it.
N_{it} is number of full time workers of type i engaged in period t.
K_{it} is cost of overtime labour per hour in period t ($k_{it}>C_{it}$)
A_{it} is actual demand for type 1 labour in period t (hours)
X_{it} is overtime labour per hour in period t.

CONDITIONS

The conditions were adopted according to Aderoba (2000); if the actual demand for (i) labour for a given period in a cycle is less than the actual full time labour available (i.e $A_{it}<N_{it}H$) then an extra cost is incurred as a result of the idle time involved. This cost is the product of the actual demand for labour and the cost of full time labour.

Mathematically;

$$\sum C_{it} (N_{it} H - A_{it}) \text{ ..... Eqn. 2}$$

However, this not actual cash layout but cost of utilized excess capacity.

(ii) If the actual demand for labour for a given period in a cycle is greater than the full time labour available (i.e $A_{it}<N_{it}H$) signifying shortage of labour, then there will be cost associated with engaging overtime staff which is calculated as:

$$K_{it} (A_{it} - N_{it} H) \text{ ....Eqn. 3}$$

This is actual cash layout. These two conditions are mutually exclusive events.

CONSTRAINTS AND RELAXATION

The constraints and relaxations that Aderoba (2000) reported in the modeling of the manpower planning for New Job shops were adopted.

(i) The full time labour should not be retrenched during the planning horizon to enhance the company's image. This constraint is expressed mathematically as:

$$N_{it} - 1 \geq N_{it} - 1_{it} \text{ for all i (t) ....Eqn. 4}$$

Where 1_{it} is the voluntary attrition by workers. That is, the growth of workers should be monotonically increasing during the planning period.

(ii) All orders must be executed during each period.

(iii) Overtime engagement cannot exceed a fixed proportion of regular time i.e

$$(A_{it} - N_{it} H) \# \propto N_{it} H \text{ ....Eqn. 5}$$

Where $\propto$ is the overtime/regular ratio.
From Eqn. 5. it can be seen that
$N_{it} > A_{it} /(1+\propto)H$ or $F_{it}/(1-\propto) H$ .... Eqn. 6

(iv) Fixed costs associated with hiring of regular and overtime staff is comparable and can be ignored in the model.

SOLUTION ALGORITHM

The model used here is based on Aderoba's (2000) model of manpower planning for new jobbing shop, however the following modifications have been made;

In Aderoba's model the command "increase t by 1" at step 70 resets the program to step 40 for the next computation, the next computation commence as soon as the value of A (the actual labour demand) is entered. This present model allows all the values to be entered before computation follows, thus line 50 and 60 allows the values to be entered while the command n = n-1:R=R+1 at line 100 and line 170 automatically sets the computer to the next data to be computed and ends the program when the data are complete (i.e when n = o, line 180).

(ii) The commands from line 200 to line 450 made the data to be presented in tabular form.

(iii) The standard deviation reveals how the workers are being utilized.

Program for manpower planning for process industry (Steel making Plant)

```
10 CLS
20 R = 10:C=1
30 Key off
40 Locate 1, 1:Input "Enter total number of entries", n
50 Locate 2, 1: Input "Enter the values of C:F",C:F
60 Locate 3, 1:Input "Enter the values of A", A
70 Locate 4, 1:Input "Enter the values of F", F
75 Nmax = F1/(216*C.F)
80 Nmax – Nmax/2
90 Nopt = ?
100 n = n-1:R=R+1
110 Go Sub 200
115 Read A2
120 F2 = F1+(0.3*(A1-F1)
140 Nmax = F2/216*C.F)
150 Nmin = Nmax/2
170 n = n-1:R=R+1
180 If n>o then go to 400 Else end
200 Locate R, C:Print "A"
210 Locate R, C+7: Print "F"
220 Locate R, C+14: Print "Nmax"
230 Locate R, C+20: Print "Nmin"
240 Locate R, C+26: Print "Nopt"
250 Locate R + 2, C: Print A1
260 Locate R + 2, C + 7: Print F1
270 Locate R + 2, C + 14: Print Nmax
280 Locate R + 2, C + 20: Print Nmin
290 Locate R + 2, C + 26: Print Nopt
300 Returns
400 Locate R + 2, C: Print A2
410 Locate R + 2, C + 7: Print F2
420 Locate R + 2, C + 14: Print Nmax
430 Locate R+2, C+20: Print Nmin
440 Locate R + 2, C+26: Print Nopt
450 Go to 115
```

ILLUSTRATIVE EXAMPLE

A one-category labour for steel making plant (mechanical engineers) i.e i = 1) is used to illustrate the model.

In making decision we have to analyse the results obtained from the computation carried out by the program, in this regard we have to select appropriate values of N_{opt} from each table such that when used will provide a suitable man hour of which when applied will minimize cost of over time engagement during times of high productivity and reduce cost associated with idling of staff when productivity reduces. The value of N_{opt} should be as much as possible $N_{max} \geq N_{opt} \geq N_{min}$ (Aderoba, 2000).

INPUT DATA

The input data are worked out from the Delta Steel Company record book, are given as follows:

A_{ME} + 6912 hrs/month
Cost of overtime engagement (Ko) = N150/hr.
Cost of regular full time engagement (Kr) = N120/hr.
Normal hours of full time engagement (H) = 216 hrs/month.
Planning horizon (T) = 12 months
Discount factor for exponential smoothing ($\propto$) = 0.3
Corrective factor (C.F) = 10
The values of F_{ME} for t = 1 …12 are 14040, 11902,
12025,11722,11316,9347,9588,10017,10252,8602,10233,10727 respectively.

RESULTS AND DISCUSSION

Table 1: Results for illustrative example for steel making plant (Mechanical Engineers)

Month	A_{ME}	F_{ME}	N_{max}	N_{min}	N_{opt}	S.D (5)	S.D (7)
1	6912	14040	7	3	5	2	0
2	12312	11902	6	3	5	1	-1
3	11016	12025	6	3	5	1	-1
4	10368	11722	5	3	5	0	-2
5	4752	11316	5	3	5	0	-2
6	10152	9347	4	2	5	-1	-3
7	11016	9588	4	2	5	-1	-3
8	10800	10017	5	2	5	0	-2
9	4752	10252	5	2	5	0	-2
10	14040	8602	4	2	5	-1	-3
11	11880	102333	5	2	5	0	-2
12	8856	10727	5	2	5	0	-2

The results of the calculations are summarized in Table 1, for steel making plant (mechanical Engineers). In this table, the standard deviation (S.D) reveals how the workers are being utilized.

When there are positive figures in the column of the standard deviation, these show that the workers are being overworked. However, when there are negative figures, these show that the workers are idle.

N_{opt} = 5 was chosen, with this choice there is a balance between idleness and overtime engagement.
N_{opt} = 7 represents the full time engagement of the staff available. The negative figures obtained by adopting 7 shows the level of idleness that results. This reveals over staffing of the plant.

Table 2: <u>Results for illustrative example for steel making plant (mechanical technicians)</u>

Month	A_{MT}	F_{MT}	N_{max}	N_{min}	N_{opt}	S.D (4)	S.D (6)
1	58680	119160	6	3	5	2	0
2	106200	101016	5	2	5	1	-1
3	99720	102571	5	2	5	1	-1
4	92700	101716	5	2	5	1	-1
5	32400	80921	4	2	4	0	-2
6	79920	66375	3	2	4	-1	-3
7	101700	70431	3	2	4	-1	-3
8	110160	79812	4	2	4	0	-2
9	38880	88916	4	2	4	0	-2
10	119160	73905	3	2	4	-1	-3
11	101880	87482	4	2	4	0	-2
12	86400	91801	4	2	4	0	-2

Table 2, shows the results for illustrative example for steel making plant (mechanical technicians).

N_{opt}. Shows the suitable values selected between N_{max} and N_{min}. Under N_{opt}, 4 has the highest mode, therefore 4 is selected as N_{opt}. From here, we can calculate our S.D. The S.D shows that workers will be overworked between January and April. At the month of May, there will be no overwork or idleness. This will also occur in August and September.

In June, July and October idleness will be experienced. But this balances the overworked earlier experienced. January shows that the extra work will be higher than February to

April, this is represented as 2. That is, extra 2 labours are required, but this can be handled by 5 adopted labours. When N_{opt} is equal to 6, it means that the full time engagement of staff available in the plant. This is adopted for S.D to see if it is suitable.

The result shows that a lot of idleness will be experienced in the plant. The S.D adopted 6 will only be suitable for the month of January.

Table 3: The present labour force in the various section of the Delta Steel Company and computer model generated labour force

(a)The steel making plant

S/No	Categories of Labour force	Present Number of the Categories of labour force	Computer model generated labour force for the categories
1	Mechanical engineers	65	40
2	Mechanical technicians	560	320
3	Electrical Engineers	16	16
4	Electrical technicians	65	40

(b) The steel rolling mill

S/No	Categories of labour force	Present Number of the categories of labour force	Computer model generated labour force for the categories
1	Mechanical engineers	33	24
2	Mechanical technicians	256	240
3	Electrical engineers	10	10
4	Electrical technicians	60	60

Table 3 (a and b) show the present labour force in the steel making plant and steel rolling mill and computer model generated labour force.

CONCLUSIONS

This study provides a method for evaluating manpower requirement in a process industry. It was based on the modification of manpower planning and interactive cost effective model for New Job shops. The model employs historical and judgmental forecasting methods to determine the demand levels for the model. The model when in use in the process industry will prevent over staffing and idleness of the workers. The model is both cost effective and iterative. It is simple to understand and lends itself readily to manpower planning decision making of the process industry.

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