Productivity Evaluation and Improvement of an Essential Balm Manufacturing Plant Using a Time Study Approach

[1]*O.A. Olalere, [2]P.A. Adedeji, [3]Adebimpe O.A., [4]B.Olayiwola

[1-4]*Department of Industrial and Production Engineering, University of Ibadan, Nigeria*

---**ABSTRACT**---

The higher demand for essential balm during cold season accounted for the need to increasing production and improving the product quality. This necessitated a change in the method of production from manual operation (which involves the use of mainly the manual labourer) to a semi-automated operation. It is therefore imperative to quantitatively justify the use of a semi- automated machine over the manual method of production.

This work therefore evaluated the semi-automated system and manual method using the time study approach which estimated the basic and standard time required for both methods. All the necessary cost inputs such as the bill of materials, cost of power and other fixed cost such as depreciation were incorporated to obtain the overall multi-factor productivity of each methods of production.

From the results obtained, the total standard time calculated from the semi-automated production system provided a sharp reduction by 39hours 24minutes in the use of machine operation, given us a percentage difference of 62.7% with the cost of production reduced by 30.20%. The productivity index when the machine was used for production was 0.003 as compared to 0.02 from manual method. Productivity of the machine operation is therefore greater by 33.3% as compared to that of manual operation. A critical assessment of the productivities in essential balm production, justified that using the automated machine is more productive in terms of ease, time, and economical point of view.

Keywords - *Essential Balm, Semi-automated, Time Study, Multi-factor Productivity*.

Date of Submission: 25 June 2014   Date of Publication: 20 July 2014

I.   INTRODUCTION

The improvement of productivity of a manual work compared to the use of an automated machine gives a desired expectation for a high quality and reliable goods. By this, the consumer has access to products of higher design, quality, and functionality at lower prices. What makes the concept of productivity dominant issues in the international market is that the consumers makes their buying decisions on product quality, and sometimes are ready to pay more for what they consider as high quality product.

Productivity improvement and evaluation is therefore an integral strategy towards excellence in manufacturing enterprise. It is an essential ingredient towards the attainment of a good financial and operational performance. It enhances the customer's satisfaction and reduces time and the cost to develop, produce and deliver product and services. It therefore has a close relationship to performance measurement for process utilization, process output, product cost, work-in-process inventory levels and on-time delivery. The improvement of production processes can be in the form of elimination, correction of ineffective processes, simplification of production processes, system optimization, throughput   maximization, and reduction of set-up time. This research work described the magnitude of change in the productivity when the company changed from using manual production processes to the use of an automated machine. The improvement in the productivity of the company per product is then quantified using the time study productivity approach to show the production set-up time when an automated machine method is adopted

II.   PRODUCTIVITY AND PRODUCTIVITY IMPROVEMENT

Productivity is the quantitative relationship between what we produce and what we have spent on a particular product and services. It is the ratio of output to input which ensures a reduction in the wastage of resources like men, material, machine, time, space, capital etc (Stephenson,1999). It can be expressed as human efforts to produce more and more with less and less inputs of resources so that there will be maximum distribution of benefits among maximum number of people. Improving productivity means increasing or raising productivity with the help of using same amount of materials, machine time, land, labour or technology. Productivity denotes relationship between output and one or all associated inputs. It is a continual effort to apply new techniques and methods to apply little input to obtain a higher output.

Patil (2007) defined productivity as a balance between all factors of production that will give the maximum output with the smallest effort. These definitions apply to an enterprise, industry or an economy as a whole. Therefore higher (improved) productivity means that more is produced with the same expenditure of resource i.e. at the same cost in terms of land, materials, machine, time or labour, alternatively, it means same amount is produced at less cost in terms of land, materials, machine time or labour that is utilized.

Productivity improvement techniques can be applied effectively to enterprises of any size, from one-person companies to corporations with thousands of staff. The majority of the techniques were first seen in mass-production operations but the benefits they can yield in SMEs are not to be underestimated. Indeed, the absence in SMEs of many of the rigidities commonly found in large companies make it easier for them to reap the benefits of productivity improvement techniques. Hence there is an increasing pressure on manufacturing companies to exploit such methods to become agile manufacturers of mass-customised products (Lisa,2001).

III.   WORK STUDY: A TOOL FOR PRODUCTIVITY IMPROVEMENT

Work study is an effective method used in evaluating the performance of a production plant. It breaks work into smaller element, studies the task, and re-arrange it to obtain the same or an improved efficiency at a reduced cost. According to the International Labour Organization ILO (1986),work study was defined as the technique of method and time study(work measurement) which ensures the best use of material and human resources to carry out a specific task. It is also a service/management-based method which examines the human work and investigate all the resources affecting the efficiency and cost of production (Glossary B.S. 1969).It minimizes cost either by designing a new method of performing the task for higher productivity or improving upon an existing method to effect a desired improvement. It is mostly used to increase production from a given quantity of input resources with little or no additional cost input (Chester,1980). Hence work study has a direct relation to productivity improvement.

The use of a bad operation or procedure to produce a particular product can hampered or delayed the overall production time. This singular factor reduces the company's productivity. To therefore reduce and improve the productivity, work measurement can be used, and this is concerned with investing, reducing, and eliminating ineffective time from the production effective time. According to Patil (2007),work measurement or time study establishes volume of work to be done by an operator or labourer in a given time of a specified task, under a specified condition and at a defined level of performance. It is therefore a scientific approach into fixing production standard in term of the standard time in executing a specific task.

IV.   RESEARCH METHOD

The time study was used for this study. It establish the time for an operator or labourer to execute the task of producing the essential balm to a specified set of condition and under a defined level of performance.Three time measures were used under this study, they include, the observed time, basic time ,and the standard time. The time study equipment used included a stop watch, a study- board, and a time study form. And following steps were followed to obtain the standard time of operation and subsequently calculated the overall multi-factor productivity index for the balm manufacturing plant under study.

1. **Select the task involved in producing an essential balm**. This task include material preparation, heating process, mixing process,cooling,pre-melting,filling,capping,labelling,arrangement,and packaging.
2. Selection of operator or labourer to be used for the study
3. Recording of details
4. Measurement of the duration of each work element
5. Estimating the time taken for each work element.
6. Converting the observed time to a normal time: The normal rating is measured in percentage.

Basic time $= \dfrac{Observed\ time\ x\ Performance\ rating}{100}$ …………………………….…………………**1**

7. Calculating the relaxation and other allowances: Relaxation allowance may be determined scientifically when observed time and performance rating are being recorded, depending on the nature of the work. Other factors which contribute to time allowance include posture at work, type of motion of the body, eye or visual strain and thermal conditions. There is also the contingency time allowance due to unanticipated official disturbance to one at work. The value can be determined as a matter of policy in an establishment.. It requires long periods of observations of task being performed. The total resting time the worker used during this period of work may be expressed as a proportion of the total observation period (Owaba, 2002).

Relaxation Allowance + Contingency time was assumed to be 9% of basic time
8. Estimating the Standard time of production: This is calculated using the formula below.

Standard time =Basic time + (Relaxation time allowance + Contingency time allowance)…………2

The multi-factor productivity index for both the manual and semi-automated production is respectively given below as:

$\dfrac{Total\ Unit\ of\ Balm\ Produced}{Total\ Cost\ Input\ (i.e\ Labour\ cost, Bill\ of\ material\ and\ Heating\ fuel\ cost)}$ ……………..……………..……..**3**

$\dfrac{Total\ Unit\ of\ Balm\ Produced}{Total\ Cost\ Input\ (i.e\ operator\ cost+Bill\ of\ material+\ power)}$ ……………………………….…………..**4**

V. RESULTS AND DISCUSSION

The available task in terms of time units, were obtained using the three types of time measurement. This includes the observed time, basic time and standard time. The normal time is the time a qualified worker spent producing a bottle of balm, while basic time is the product of normalized speed and the observed time. The standard time was the basic time the qualified worker takes to complete the producing the bottle of balm plus the associated relaxation time. For the purpose of this study, time study was carried out for a period of 11 days of manual operation and 5days of machine production to be able to determine the time taken in producing packet of balm. The production of 900 packets was observed during this period, and the time taken during the operation was recorded for both the manual and machine operation. This was done with the aid of a stop watch. The results were obtained using Matlab2012® and Microsoft Excel®, as shown in **Table 5.0 and 5.1**

5.1 ESTIMATING THE BILL OF MATERIALS

The bill of material was also obtained to obtain the quantity of raw material needed for production and their corresponding price. Bill of raw materials obtainable as at April 2014 in Nigeria market is given below:

Table 5.0: Bill of Material Cost for producing 750 Packet of Rub

Raw Material	Quantity	Cost	Total Costin Naira
Petroleum Jelly	98kg	N700 per kg	68,600
Methylsalicylate	24kg	N1200 per kg	28,800
Peppermint Oil	10kg	N500 per kg	5,000
Dyes	50g	N2500 per 50g	2,500
Paraffin oil	10Litres	N500 per Litre	5,000
Paraffin wax	5.9kg	N200 per kg	1,180
Labeling	30 Rolls	N350 per roll	10,500
Glass Bottles and cover	750 bottle…I bottle is N25	N300 per dozen	18,750

Sources: Cost of Chemicals & Materials Nigeria Market from Afram Chemicals
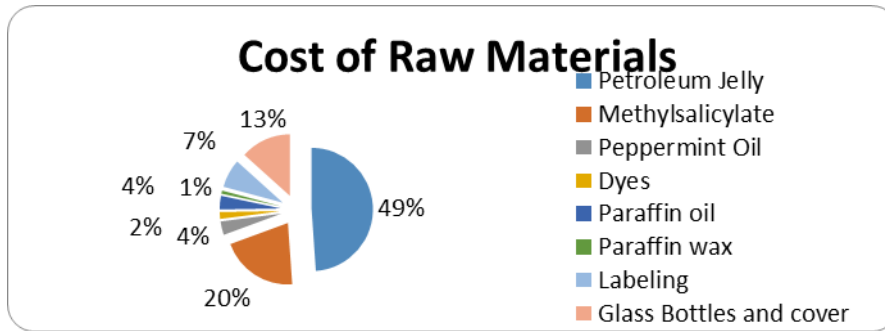
Total Cost of Material = **140,330 Naira**

Fig.5.0: Bill of Material

5.2 COST IMPLICATION OF THE INPUT PARAMETERS
There are two types of cost which are the
1. Fixed costs
2. Variable costs

The fixed cost of tooling the machine and depreciation cost depreciation cost and do not vary as the output varies

The variable costs are the costs which vary as the quantity of products made varies. E.g. direct labour cost, material cost, fuel, power etc. The total cost is given by:
Total cost of production = fixed cost + variable cost

5.3 ESTIMATION THE COST INCURRED OF MANUAL OPERATION
The cost incurred using the manual labour is given in table 4.1 and Table 4.2 below:

Table 5.1: Data for the Man-Hour for Manual Labour

Observed Days(d)	Number of Manual Labourer Hired	Total Packet Produced
Monday	11	82
Tuesday	10	79
Wednesday	7	67
Thursday	8	66
Friday	10	100
SECOND WEEK OF MANUAL PRODUCTION		
Monday	12	80
Tuesday	8	78
Wednesday	10	77
Thursday	8	84
Friday	8	104
Overtime	15	93
TOTAL PACKET PRODUCED FOR 1 BATCH = 900 PACKET		

Source: Tisco Industrial Limited (Research & Development)
Given that Cost per Standard Labour-hour =N500
The Cost of Hiring Manual Labourers (Naira) for each day is given below as:
Number of Manual Labourer Hired(n) x Standard-Man-Hour(S) x Amount collected per hour
Cost of Hiring Manual Labourer = Cost per Standard Labour-hour x Number of Manual Labourer Hired

Table 5.2: Results Generated for Man-Hour

Number of Manual Labourer Hired(n)	ProductionTime Per Day(Min)	BasicTime	Conting.	Standard_Time(minutes)	Standard Man-Hour(S)	Manual Labourers(Naira)
11	360	378.0000	34.0200	412.0200	6.8670	37,769
10	345	362.2500	32.6025	394.8525	6.5809	32,905
7	285	299.2500	26.9325	326.1825	5.4364	19,027
8	280	294.0000	26.4600	320.4600	5.3410	21,364
10	350	367.5000	33.0750	400.5750	6.6763	33,382
12	415	435.7500	39.2175	474.9675	7.9161	47,497
8	300	315.0000	28.3500	343.3500	5.7225	13,734
10	340	357.0000	32.1300	389.1300	6.4855	32,428
8	285	299.2500	26.9325	326.1825	5.4363	21,745
8	320	336.0000	30.2400	366.2400	6.1040	24,416
Total Standard Hour =62hours 57minutes *TOTAL COST INCURRED ON MANUAL LABOURERS =N284,266*						

5.4 ESTIMATING THE PRODUCTIVITY INDEX FOR MANUAL OPERATION

The total Cost incurred using the manual production technique = Fixed Cost + Variable Cost
The fixed cost are the costs that do not change with the change in the unit of balm produced within the relevant range whereas variable cost changes with change in the units of balm produced per day.

Total Cost incurred on manual labour =**N284, 266**
Bill of Material =**N140, 330**
Heating Fuel =**N 5,000**
Variable Cost =Cost incurred on manual labour +Bill of Material +Heating Fuel
Variable Cost incurred using the manual production technique = 284,266 + 140,330 + 5,000 =**N429, 596**
The fixed cost is assumed to be negligible ≈ 0
Therefore the total cost input = **N429, 596**
The Productivity index for manual production is given below as:

$$\frac{Total\ Unit\ of\ Balm\ Produced}{Total\ Cost\ Input(i.e\ Labour\ cost, Bill\ of\ material\ and\ Heating\ fuel\ cost)} = \frac{900}{429,596} = 0.002$$

Therefore the productivity index using the manual method of operation is given as 0.002.

5.5 ESTIMATING THE COST INCURRED FOR MACHINEOPERATION

Table 5.3: Data for the Machine Hour

Observed Days	Number of Workers on Duty	Total Packet Produced
Monday	3	150
Tuesday	3	165
Wednesday	3	172
Thursday	3	200
Friday	3	213

Source: Tisco Industrial Limited (Research & Development)
Note:Estimated average time spent in producing one packet of the balm by Machine= 3mins

Table 5.4: Results Generated for Machine-Hour

Number Trained Operation	Production Time Per Day	Basic Time	Conting+Relax	Standard Time(Min)	Standard Machine Hour	Cost of Trained Operator/day (Naira)
3	200	240.0000	21.6000	261.6000	4.3600	19,620
3	250	300.0000	27.0000	327.0000	5.4500	24,620
3	150	180.0000	16.2000	196.2000	3.2700	14,715
3	220	264.0000	23.7600	287.7600	4.7960	21,582
3	250	300.0000	27.0000	327.0000	5.4500	24,525
Total Standard machine Hour =23hours 33minutes *TOTAL COST INCURRED ON TRAINED OPERATOR =N129,492*						

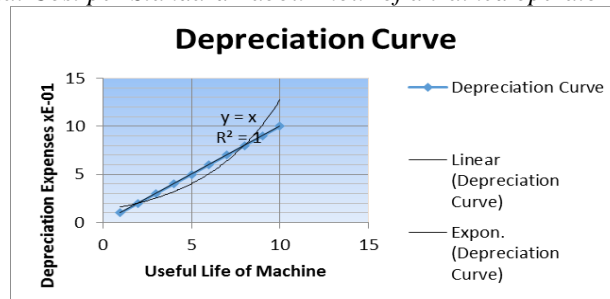*Given that Cost per Standard Labour-hour of a trained operator =N1, 500*

Fig.5.1: Depreciation Curve

The Cost of Hiring a trained operator(Naira) for each day is given below as:
Cost of Hiring trained operator= Number of trained operator Hired (n) x Standard Man-Hour(S) x Amount collected per hour.
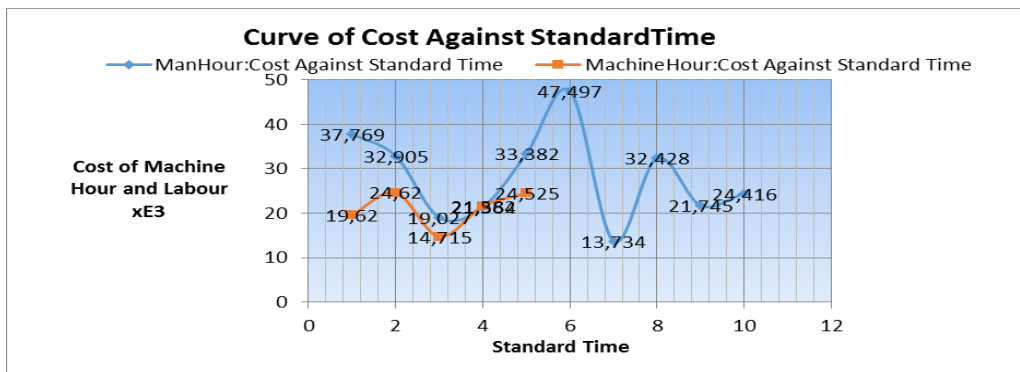

Fig.5.2: Interaction of Cost of Man-hour/Machine Hour on Standard Time

The above shows an interaction between the cost spent on both the manual labourer and that of a trained machine operator for a certain period of operation.

5.6 ESTIMATING THE PRODUCTIVITY INDEX FOR MACHINEOPERATION
Variable Cost =Total Cost incurred on trained Operator +Bill of Material +Power
Total Cost incurred on trained Operator =N129, 492
Bill of Material =N140, 330
Power = N30, 000
Variable cost = 129,492+ 140,330 + 30,000 =**299,822 Naira**
Fixed cost=Cost of Maintenance + Depreciation cost for the machine

Note: The maintenance cost is distributed over a period of 2 month. Hence it is not easy obtaining the accurate amount spent on maintenance since we are dealing with a single production.The depreciation cost for the machine.

Therefore Total cost of production of machine operation = 299,822 Naira

The Multi-factor Productivity index for machine operation is given below as:

$$\frac{Total\ Unit\ of\ Balm\ Produced}{Total\ Cost\ Input(i.e\ operator\ cost+Bill\ of\ material+power)} = \frac{900}{299,822} = 0.003$$

Therefore the productivity index using the manual method of operation is given as 0.003

5.7 ESTIMATING DEPRECIATION COST
The declining balance depreciation method uses the depreciable basis of the machine multiplied by a factor based on the life of the asset. The depreciable basis of the asset is the book value of the fixed asset -- cost less accumulated depreciation.
The machine was bought for **$20,000 ≈ 3.2Million Naira** (At N160 conversion rate to 1 US dollar).

The expected life of the automated filling machine is 10years.

Using double declining balance the depreciation would be calculated as follows: factor = 2 * (1/10) = 0.20

Table 5.5 Depreciation Expenses of the Automated Machine

Year	Depreciation Basis(10^6)	Depreciation Calculation(10^6)	Depreciation Expenses(10^6)	Accumulation Depreciation (10^6)
1	3.2000	3.2000 x 0.2	0.6400	0.6400
2	0.6400	0.6400 x 0.2	0.1280	0.7680
3	0.7680	0.7680 x 0.2	0.1536	0.9216
4	0.9216	0.9216 x 0.2	0.1843	1.1059
5	1.1059	1.1059 x 0.2	0.2212	1.3271
6	1.3271	1.3271 x 0.2	0.2654	1.5925
7	1.5925	1.5925 x 0.2	0.3185	1.9110
8	1.9110	1.9110 x 0.2	0.3822	2.2932
9	2.2932	2.2932 x 0.2	0.4586	2.7519
10	2.7519	2.7519 x 0.2	0.5504	3.3023

Note: The depreciation cost or depreciation expenses is a non-cash item i.e. no cash flows are involved as depreciation cost is mere estimate and not a real cash outflow and thus can never be a relevant cost, therefore the discussion whether a depreciation expenses is a fixed or variable cost in nature might be pointless.

5.7 ESTIMATING THE PERCENTAGE DIFFERENCE BETWEEN THE MANUAL AND MACHINE OPERATION
The percentage increase in productivity was calculated as:

$$\frac{Productivity\ by\ Machine - Productivity\ by\ Manual}{Productivity\ by\ Machine} \times 100$$

$$\frac{0.003 - 0.002}{0.003} \times 100 = \mathbf{33.33\%}$$

VI. DISCUSSION OF RESULTS
The summary of the above results is given below in Table 6.0

Table 6.0: Summary of Estimated Results

Estimated Parameter	Manual Operation	Machine Operation	Difference	Percentage Difference
Total Standard Hour	*62hours 57minutes*	*23hours 33minutes*	39hours24minutes	62.7%
Labour Cost	*N284,266*	*N129,492*	N154,774	54.4%
Cost of Production	N429, 596	N299,822	N129,774	30.20%
Multi-factor Productivity Index	0.002	0.003	0.001	33.3%

From table 6.0, From the results obtained, the total standard time calculated from the manual production system was gotten as 62hours 57minutes, whereas the value obtained for the machine operation is 23hours 33minutes.We can then deduced that there is a sharp difference of 39hours 24minutes in the use of machine operation as compared to the manual method of producing medicated balm, given us a percentage difference of 62.7%.

Similarly, the cost expended on the three operators using machine operation is less compared to that on the manual labour, giving us a difference of N154,774 (54.4% difference).The same applied to the cost of production which differs by N129,774.

From the two method of producing the essential balm, we can justify that we are able to save cost of production by 30.20%.

The productivity of the machine operation is therefore greater by 33.3% as compared to that of manual operation.

VII. CONCLUSION

A critical assessment of the production processes in essential balm production, inwe can justify that using the automated machine is more productive in terms of time saving, economical consideration, ease of production. It is therefore faster to adopt the automated machine than the manual production system. The time of production using the traditional manual method is much when compared to the use of automated machine. The productivity index when the machine is used for production was calculated as 0.003 as compared to 0.02 from manual method. This gives a 33.33% increment when compared to the manual production.

The automated method would incur more cost, but a trade-off between the cost of setting up and the quality with time saved is a gain for the company. Time saved is money saved.

REFERENCES

[1] Barker, A .M and Rollinus E.H,2009, "Motion and Time study: Design and Measurement," Journal of Industrial Engineering,45 (8), pp 24-28.
[2] Barnes, R. M., 1998, Motion and Time study: Design and Measurement, John Wiley, London.
[3] Beverly, E., 1994, "Evaluating Knowledge Workers Productivity," Thomas and John P. Baron.
[4] Black, S. & Lynch,1996, "Human-Capital Investments And Productivity, Technology, Human Capital and the Wage Structure," 86.(2),pp.263 – 267.
[5] Carnevale, D.G., 1992, "Physical Settings of Work. Public Productivity and Management Review," 15(4), 423-436.
[6] Charles-Owaba O.E.,2002, Organizational Design: A Quantitative Approach, Oputoru Books, Ibadan.
[7] Chester L.Brisley,1979,"Work Measurement in the 1980"s", 43rd Annual IMS Clinic Proceedings," Industrial Management Society, Des Plaines, IL.
[8] Chester L.B.,1978,"Comparison of Predetermined Time Systems (PTS)", Proceedings, AIIE spring Annual Conference, American Institute of Industrial Engineers, Norcross, GA.
[10] Craig C.L.,1972, "Balancing Cost and Accuracy in Setting Up Standards for Work Measurement, Industrial Engineering," 14,pp.82 – 92.
[11] Fritscher-Porter, K.,2003, "Ergonomic Advice," *Office Solutions*, 20(1).
[16] Gilbert F.B. and L.B.,1984, "Classifying the element of work management and administration," Journal of Industrial Engineering,45(8),24-28.
[17] Gilhooley, M.J.,1999, "Green Green Grass of Work," Facilities Design and Management, 21(9), pp.26-29.
[18] Glossary, B.S., 1969,"British Standards Institution: Glossary of terms used in Work Study," London.
[19] Hicks P. E.,1994, Industrial Engineering and Management, a New perspective, 2nd Ed.,McGrew Hill Int Eel.
[20] International Labour Organisation,1986 "Introduction to Work Study", Universal Publishing Corporation, India, PP.4.
[21] Jhamb L.C., 2006, Production (Operations) Management", Everest Publishing House, Pune, pp. 595-708.
[22] Kanaway G.,1992, Introduction to work study, International Labour Organisation, 4th Ed,Geneva.
[21] Keeling, B.L. and Kallaus, N.F.,1996, Administrative Office Management. 11th. Ed.
[22] Leaman, A, Bordass, B., "Building Design, Complexity and Manageability Facilities," vol. 11(9),pp. 16-27, 1993.
[23] Leaman, A.,1995 "Dissatisfaction and Office Productivity," Journal of Facilities Management, 13(2), ,pp. 3-19.
[24] Patil S. and Hukari N., 2007,"Industrial Engineering and Production and Operations Management", 4th Edition, Electro-Tech Publication, Satara, pp. 236.
[28] Smith, S. 2003,"Elements of Effective Ergonomics," Industrial Engineer, 35(1), 49-52.
[29] Stevenson W.J.,1999, Production and Operations Management, Boston, MA: Irwin McGraw-Hill.
[30] Taylor F. W.,1929, The Principles of Scientific Management Harper and Bros:,New York.
[31] The Gensler Design + Performance Index, 2006,The U.S. Workplace Survey , www.gensler.com.
[32] Uzee, J., 1999,"The Inclusive Approach: Creating a Place Where People Want to Work.," Facility Management Journal of the International Facility Management Association,pp.26-30.