

Productivity Assessment to Improve Performance: An Empirical Study from a Corrugated Box Manufacturing Unit

Mahima Gupta*, Dr Charu Shri

School of Management, The NorthCap University, Gurugram,
Haryana, India

Abstract-

In recent years, an impressive growth is recorded for SMEs (as they dominate the international business) and to strengthen their position further, it is required to evaluate every undertaking from holistic aspect. The isolated evaluation of either quantitative or qualitative factors can never reveal real picture. This research work has been carried out as a case study in corrugated box manufacturing unit which is a sub segment of paper packaging, with the objective of identifying areas with low productivity level. A Study of corrugated industry revealed that the productivity of the industry is not increasing in accordance with market potential and global demand. Therefore, PO-P model is used to measure productivity of organization as a system for accomplishing objectives as compared to its potential. To include performance objectives of qualitative nature questionnaire is used. Finally, for productivity measurement, sub-systems have been identified where improvement is needed. This helped in identifying optimal attainable output.

Keywords- Corrugated, Key Performance Areas, Performance Objectives, PO-P, Productivity Index, Packaging.

I. INTRODUCTION

Productivity is directly allied with 5 M's namely man, machine, material, money and management [1]. In a manufacturing industry, the ultimate goal is to speed up the process there by increasing productivity through proper utilization of 5M's. Productivity has direct relationship with profit but in current scenario the percentage of profits is getting thinner due to competitive environment and efficient supply chain management. Productivity improvement is one of the core strategies towards manufacturing excellence to achieve sound financial and operational performance. The rapid environmental changes that companies experience today affect not only the limited areas (sub system) of organization but triggers organizational performance and management philosophies. Changes have been considerable whereas management practices have lost their pace.

Globalization, competitive pressures, consumerism, information technology, deregulation, changing work attitudes, and the emergence of a knowledge-based economy, are all reasons of dramatic fluctuations in the business environment [2]. Global business trends indicate that small and medium enterprises play significant role for the growth of country's economy [3].

They are the core engines for productivity and fiscal growth in terms of GDP and employment [4]. In India, 37% of GDP, employment to 805 Lakhs and 44.7% of exports are contributed by MSMEs [5]. In general management process, performance measurement is a critical and reliable component which cannot be derived through financial measures only as the current business environment demand more accurate evaluation [6]. Productivity is a measure of performance and refers to the amount of output produced per unit of input. Productivity measurement serves as a communication means to allocate current performances relative to the standards those organizations have established. This enables the managers to find out the bottlenecks and potential factors of improvement and to evaluate the success of all qualitative and quantitative factors involved [7]. Since small enterprises are not equipped with resources and tools for productivity measurement, therefore, from past few years Systems approach has gained attention to evaluate the whole organization in totality where subsystems are interacting with each other. The approach, termed as the PO-P provides a methodology to determine the productivity index of the plant considering it as a system and it is useful for monitoring and control of performance. This approach considers enterprise as a system made-up of different small sub systems which are working independently and interacting with each other. This mutual interaction has given proper weightage to identify areas of low productivity.

Corrugated packaging is one of the prominent segments among manufacturing SMEs and India is currently ranked 15th in the world for its paper and paperboard consumption [8]. Performance measurement is necessary to improve current level of productivity of this manufacturing segment as it has so much of untapped scope to go ahead in global competition. The Indian packaging industry has been experiencing a competitive environment and determined hard to find different strategies and methods to reduce unnecessary manufacturing cost, waste and improve quality and overall performance of manufacturing unit. In current scenario, this industry is not capable to address challenges which is resulting in increased costs and shrinking profits that already invested high capital and operating costs. Here PO-P approach is used through medium of case study to reveal or to identify the areas of low productivity.

The objectives of the study are:

- A. To understand a holistic picture of corrugated organization as a complete system including all sub systems with both tangible and intangible variables.
- B. To identify the weak areas of performance those are responsible for low productivity.

II. METHODOLOGY

Productivity measurement using PO-P (Performance Objectives-Productivity) approach is the system productivity. It consists of following steps:

- 1) Identifications of sub systems
- 2) Identification of KPA's in each of the sub systems
- 3) Setting of performance objectives
- 4) Ranking and weighting of sub systems, KPA's and Performance Objectives
- 5) Determination of Objectivated Output
- 6) Calculation of Productivity Index

This approach emphasizes on achievement of goals objectivated within the constraint of resources available. The process is shown in Fig. I.

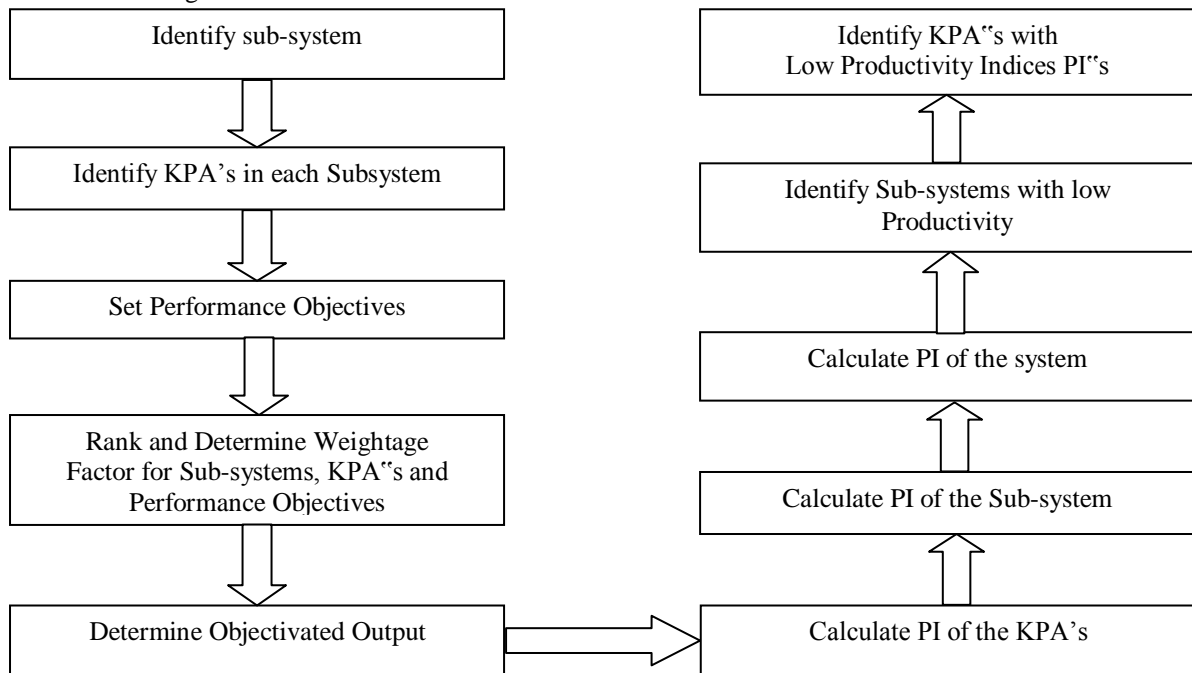


Fig. I Flow chart for PO-P Approach

III. PO-P: THE MODEL

PO-P model helps in calculating productivity index of the system in stages.

Let,

u= the sub-system

v= the KPA

y= the performance objective (PO)

w= the Weightage factor

O_{yvu} = the performance value of PO-y in KPA-v in sub-system u

O_{yvu}^* = the objectivated output of PO-y in KPA-v in sub-system u

Productivity Index PI of a system S, is arrived at as,

$$PI = \sum_{u=1} W_u (PI)_u \quad (1)$$

where,

$$\sum_{u=1} W_u = 1$$

$(PI)_u$, the Productivity Index of sub system u is determined as,

$$(PI)_u = \sum_{v=1} W_{vu} (PI)_{vu} \quad (2)$$

where,

$$\sum_{v=1} W_{vu} = 1 \text{ for all } u's$$

$(PI)_{vu}$, Productivity Index of Key Performance Area, v of subsystem u is given as,

$$(PI)_{vu} = \sum_{y=1} W_{yvu} \frac{O_{yvu}}{O^*_{yvu}} \quad (3)$$

where,

$$\sum_{y=1} W_{yvu} = 1, \text{ for all } u \text{ and } v$$

Substituting values of $(PI)_{vu}$, from equation (3) in equation (2), Productivity Index $(PI)_u$, of a sub-system u , can be rewritten as,

$$(PI)_u = \sum_{y=1} W_{yvu} \sum_{v=1} W_{vu} \frac{O_{yvu}}{O^*_{yvu}} \tag{4}$$

Value of $(PI)_u$, from equation (4) can be substituted in equation 1 to provide PI, Productivity Index of a system S , as

$$PI = \sum_{u=1} W_u \sum_{v=1} W_{vu} \sum_{y=1} W_{yvu} \frac{O_{yvu}}{O^*_{yvu}} \tag{5}$$

IV. A CASE STUDY

Corrugated boxes are required by all types of industries no matter whether it is a large/small/medium-scale industry. The booming Indian economy and a flourishing organized retail have raised the expectations that consumption of corrugated packaging will begin to expand again as the number and volume of goods packaged in corrugated increases. The industry is converting about 2 million tons of Kraft paper into corrugated boxes. Factories are spread-out in all parts of India, even in the remote industrially backward areas. The over 4,000 corrugated boards and sheet plants are highly labour-intensive, employing over half a million people – both directly and indirectly.

This study is undertaken to discover productivity analysis of corrugated box manufacturing unit situated in Gurugram (District), Haryana. This manufacturing unit is a semi-automatic plant offering wide range of boxes in numerous sizes, colors and designs, as per the specifications of customer. The whole process consists of eight steps on eight different machines operated by skilled labour. The productivity is very low in the semi-automatic production method. It approximately gives 7200 square metre production in one shift whereas automatic corrugators roughly give 33000 square metre production in one shift. The manual process for manufacturing corrugated boxes is shown in Fig. II.

Machines	Resources		
	Process specifications	Labour	Time
CORRUGATION ↓	2 reels of paper (1- 1.5 tones)	2 Men	4-5 Hrs.
SHEETER ↓	22-25 rolls of corrugated sheets (Avg. weight 35 kg/roll)	1 Man	2-3 Hrs.
PASTING ↓	2500 sheets	3 Men	8 Hr.
PRINTING ↓	2500 sheets	2 Men	5 Hr.
DIE CUTTING ↓	2500 sheets	3 Men	4 Hr.
ROTARY ↓	2500 sheets	2 Men	6 Hr.
SLOT ↓	2500 sheets	1 Man	5 Hr.
STITCHING	2500 sheets	1 Man	6 Hr.

Fig. II Process Flowchart (manual corrugated manufacturing firm)

Performance Objectives – Productivity (PO-P) technique is used to measure the existing level of productivity which is not consistent enough to improve profitability and performance. This approach will help in identifying low productive areas to bring improvements [9].

The corrugated manufacturing unit works with following subsystems:

- I. Marketing (A)
- II. Production (B)
- III. Human Resource (C)
- IV. Technology (D)

- V. Procurement (E)
- VI. Material (F)
- VII. Safety and Environment (G)
- VIII. Finance (H)
- IX. Transportation (I)

The Key Performance Area's in each sub system are listed in Table I.

Table I KPA's under considered sub-system

<i>Sub System</i>	<i>Key Performance Areas</i>
A. Marketing	Sales
	Market Penetration
	Market Research
	Customer Experience
B. Production	Manpower Utilization
	Asset Utilization
	Quality
	Maintenance
C. HR	Employee Satisfaction
	Employee Training
	Skills Enhancement
	Grievance
D. Technology	R&D Effectiveness
	Design and Development
E. Procurement	Purchase Management
	Pricing
F. Material	Inventory Control
	Storage Management
G. Safety and Environment	Tax Laws and Regulations
	Societal Goals
	Health and Safety Incidents
H. Finance	Costing
	Accounts Receivables
	Accounts Payable
	Profitability
I. Transportation	Transport Management

The weights are assigned to all sub systems through method of paired comparison in Table II. In this methodology, each objective is compared to every other objective and weightage (Of relative importance) is allocated on scale of 1- 3. The element of subjectivity and biasness is reduced by undertaking normal group technique, involving and discussing with all the top executives in corrugated manufacturing unit.

- 3- Allocated when there is a Major difference of relative importance
- 2- Allocated when there is a Medium difference of relative importance
- 1- Allocated when there is a Minor difference of relative importance

Table II Allocation of Relative Importance of Objectives

Codes	A	B	C	D	E	F	G	H	I
A		A-1	A-3	A-2	E-3	F-3	A-3	H-2	A-2
B			B-3	B-1	B-1	B-2	G-1	B-2	B-3
C				D-3	E-3	F-3	C-2	H-2	I-2
D					E-3	D-2	G-1	D-2	I-2
E						E-2	E-2	H-2	I-2
F							F-2	H-2	F-2
G								H-2	G-2
H									H-3
I									

In Table III, weights against each of the objective are then expressed as a fraction of total weights. To find potential sub-systems Pareto analysis has been used on the basis of relative marks derived from Table III. Relative marks are also illustrated in Fig. III. Pareto Analysis is a statistical technique in decision-making used for the selection of a limited number of tasks with significant effect. It also known as the 80/20 rule, by doing 20% of the work you can generate 80% of the benefit of doing the entire job. The analysis is done in Table IV.

Table III Allocation of weights to objectives

Code	Sub systems	Relative Marks	Weightage	Sub systems	Relative Marks	Weightage
A	Marketing	11	0.141	Marketing	11	0.153
B	Production	12	0.154	Production	12	0.166
C	HR	2	0.026			
D	Technology	7	0.089	Technology	7	0.097
E	Procurement	13	0.167	Procurement	13	0.181
F	Material	10	0.128	Material	10	0.139
G	S&E	4	0.051			
H	Finance	13	0.167	Finance	13	0.181
I	Transportation	6	0.077	Transportation	6	0.083
	TOTAL	78	1		72	1

Table IV Pareto Analysis

Code	Sub system	Relative marks	Cumulative	%	Weightage
E	Procurement	13	13	17	0.181
H	Finance	13	26	33	0.181
B	Production	12	38	49	0.166
A	Marketing	11	49	63	0.153
F	Material	10	59	76	0.139
D	Technology	7	66	85	0.097
I	Transportation	6	72	92	0.083
G	S&E	4	76	97	1
C	HR	2	78	100	
E	Procurement				
H	Finance				
B	Production				
A	Marketing				
F	Material				
D	Technology				
I	Transportation				

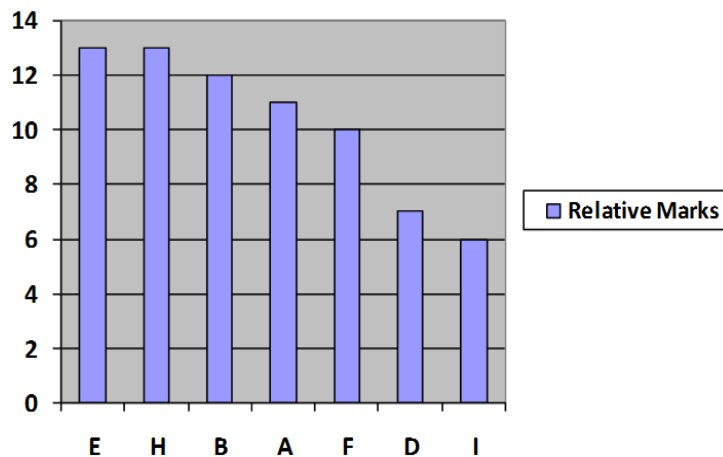


Fig. III Relative marks of sub system

The Weightage of all Key Performance Areas is done by using method of Direct Scaling. The evaluators are asked to decide upon the relative weight of each of the subordinate elements representing relative importance for the utility of the associated element on the next of hierarchy. The sum of the total weights of all elements is identified as hundred (Table V).

Table V Allocation of Weight to KPA's

Sub System	KPA's	Relative Weight	Weightage Factor
Procurement	Purchase Management	50	0.5
	Pricing	50	0.5
	Total = 100		
Finance	Cost Control	30	0.3
	Accounts Receivables	20	0.2
	Accounts Payable	20	0.2
	Profitability	30	0.3
Total = 100			
Production	Manpower Utilization	40	0.4
	Asset Utilization	30	0.3
	Quality	20	0.2
	Maintenance	10	0.1
Total = 100			
Marketing	Sales	20	0.2
	Market Penetration	30	0.3
	Market Research	30	0.3
	Customer Experience	20	0.2
Total = 100			
Material	Inventory Control	60	0.6
	Storage Management	40	0.4
Total = 100			
Technology	R&D Effectiveness	40	0.4
	Design and Development	60	0.6
Total = 100			
Transportation	Transport Management	100	0.1
Total = 100			

The Performance Index of all KPA's and sub systems has been determined in Table VI, VII and VIII. The performance results are evaluated in both quantitative and qualitative terms. The data required for evaluating quantitative PO's been collected from concerned employees in the corrugated box manufacturing unit through their records and maintained calculations.

Table VI Analysis to determine PI of KPA's and Sub-systems

Sub-system	Key Performance Areas	Performance Objective	WF	OV	AV	PI
Procurement	1. Purchase Management	1. Vendor Index (Approved vendors/Total Vendors)	0.4	0.733	0.167	0.0911
		2. Is the material procurement matches the specifications ordered. (intangible 0-1)	0.2	0.95	0.85	0.1789
		3. Timeliness Index (Purchases in time/Total Purchases)	0.4	0.9714	0.869 6	0.3581
	2. Pricing	1. Does the material procured come at best price. (intangible 0-1)	1	0.98	0.90	0.9184
Finance	1. Cost Control	1. Expense Control (Value of Production/Operational Expenses)	0.8	11.11	8.5	0.6120
		2. Costing of Job Orders (Job	0.2	1.43	1.40	0.1958

		Orders costed/Total Job Orders)					
	2. Accounts Receivables	1. Maintenance of books of accounts (Intangible 0-1)	0.4	1	1	0.4	
		2. Expense Control (Sales/Operational Expenses)	0.6	11.11	8.5	0.4590	
	3. Accounts Payable	1. Upkeeping of books of accounts(Intangible 0-1)	0.4	1	1	0.4	
		2. Expense Control (Total Purchases/Operational Expenses)	0.6	5.83	5.75	0.5918	
	4. Profitability	1. Return on Investment (Profits/Capital Employed)	0.3	0.2	0.213	0.3195	
		2. Accuracy of recording transactions (Intangible 0-1)	0.4	0.99	0.97	0.392	
		3. Audit Index (Intangible 0-1)	0.3	1	0.95	0.285	
	Production	1. Manpower Utilization	1. Direct labour utilization (standard hours recovery/direct labour attendance)	0.5	0.6	0.556	0.4633
			2. Cost effectiveness (standard hrs. recovery/personnel expenses)	0.3	0.164	0.132	0.3219
			3. Is the corrugated manufacturing firm uses locally available manpower for its operations. (Intangible 0-1)	0.2	0.9	0.6	0.133
2. Asset Utilization		1. Capacity utilization (standard hours recovery/capacity)	0.6	0.556	0.6	0.6475	
		2. Operating cost control (Standard hours recovery/Operating cost)	0.2	0.36	0.3	0.167	
		3. Are the employees trained enough to work with every machine. (Intangible 0-1)	0.2	0.90	0.65	0.144	
3. Quality		1. Index of defect free production (value of defect free production/value of total production)	1	0.975	0.941	0.9651	
4. Maintenance		1. Maintenance cost control (standard hours recovery/maintenance cost)	1	0.225	0.10	0.444	
Marketing		1. Sales	1. In absolute monetary terms	0.4	2 Cr.	1.7 Cr.	0.214
			2. Profitability (Profit/Sales)	0.6	0.1	0.1	0.6
	2. Market Penetration	1. (value of orders booked/total market available)	0.4	0.08	0.062	0.31	
		2. Are corrugated boxes exported?	0.6	0.8	0.2	0.15	
	3. Market Research	1. Market demand determination (Intangible 0-1)	0.6	1	0.6	0.36	
		2. Customer Preference (Intangible 0-1)	0.4	1	0.8	0.16	
	4. Customer	1. Repeat Order Index (Repeat	1	1.11	0.882	0.7946	

	Experience	Orders/Total Orders)				
Material	1. Storage Management	1. Cost Index (value of total stock/operating cost)	0.8	56	48	0.6857
		2. Stock keeping and releasing index (Intangible 0-1)	0.2	1	0.9	0.18
	2. Inventory control	1. Turnover ratio (value of material consumed/total stock)	1	0.714	0.583	0.8165
Technology	1. R&D Effectiveness	1. R&D Expenses (R&D Expenses/Sales)	0.5	0.025	0.008	0.16
		2. New product development (Intangible 0-1)	0.5	1	0.7	0.35
	2. Design and development	1. Product design simplicity (Intangible 0-1)	0.5	1	0.9	0.45
		2. Product design maintainability (Intangible 0-1)	0.5	1	0.95	0.475
Transportation	1. Transportation Management	1. Availability of right mode of transportation (Intangible 0-1)	0.4	1	0.80	0.32
		2. Adherence to companies policies (Intangible 0-1)	0.2	1	0.75	0.15
		3. Cost (absolute monetary terms)	0.4	1.9 L	2.5 L	0.5263

Finally, the actual values of each of the key performance indicators are then compared with objectivated values to determine the trend in productivity performance and growth rate. For qualitative PO's questionnaire was made for data collection. Through ranking and normalizing the respective variables, both actual and objectivated values were derived.

Table VII PI of KPA's

Subsystems	KPA's	PI
Procurement	Purchase Management	0.6281
	Pricing	0.9184
Finance	Cost Control	0.8078
	Accounts Receivables	0.8590
	Accounts Payable	0.9918
	Profitability	0.9965
Production	Manpower Utilization	0.9182
	Asset Utilization	0.9585
	Quality	0.9651
	Maintenance	0.444
Marketing	Sales	0.814
	Market Penetration	0.46
	Market Research	0.52
	Customer Experience	0.7946
Material	Inventory Control	0.8165
	Storage Management	0.8657
Technology	R&D Effectiveness	0.51
	Design and Development	0.925
Transportation	Transport Management	0.9963

Table VIII PI of Subsystem

Subsystems	Weightage Factor	KPA's	Weightage factor	PI of KPA's	PI of Subsystem
Procurement	0.181	Purchase Management	0.5	0.6281	0.7732
		Pricing	0.5	0.9184	
Finance	0.181	Cost Control	0.4	0.8078	0.9067

		Accounts Receivables	0.1	0.8590	
		Accounts Payable	0.1	0.9918	
		Profitability	0.4	0.9965	
Production	0.166	Manpower Utilization	0.4	0.9182	0.8921
		Asset Utilization	0.3	0.9585	
		Quality	0.1	0.9651	
		Maintenance	0.1	0.444	
Marketing	0.153	Sales	0.4	0.814	0.6805
		Market Penetration	0.2	0.46	
		Market Research	0.2	0.52	
		Customer Experience	0.2	0.7946	
Material	0.139	Inventory Control	0.5	0.8165	0.8411
		Storage Management	0.5	0.8657	
Technology	0.097	R&D Effectiveness	0.6	0.51	0.676
		Design and Development	0.4	0.925	
Transportation	0.083	Transport Management	1	0.9963	0.9963

A. PI of Corrugated Manufacturing Firm as a System

Productivity Index of the system

$$\begin{aligned}
 &= (0.181 \times 0.7732) + (0.181 \times 0.9067) + (0.166 \times 0.8921) + (0.153 \times 0.6805) + (0.139 \times 0.8411) + (0.097 \times 0.676) \\
 &+ (0.083 \times 0.9963) \\
 &= 0.1399 + 0.1641 + 0.1481 + 0.1041 + 0.1169 + 0.0656 + 0.0827 \\
 &= 0.8214
 \end{aligned}$$

V. CONCLUSION

As pointed in the book Productivity Management: Systems Approach [10], any model of productivity measurement should basically convert the objectives of productivity measurement into a measurable index but formulation of objectives is very important. Through application of PO-P approach, following KPA's are observed with low productivity index compared to the PI of the complete system of corrugated manufacturing unit:

- Purchase Management (Procurement Sub-system) : 0.6281
- Cost Control (Finance Sub-system) : 0.8078
- Maintenance (Production Sub-system) : 0.444
- Inventory Control (Material Sub-system) : 0.8165
- R&D Effectiveness (Technology Sub-system) : 0.51
- Sales (Marketing Sub-system) : 0.814
- Market Research (Marketing Sub-system) : 0.52
- Market Penetration (Marketing Sub-system) : 0.46
- Customer Experience (Marketing Sub-system) : 0.7946

The corrugated box manufacturing unit is required to look in all these areas. Their low performance is affecting whole organization. Among different identified and evaluated Sub-systems Marketing is having lowest PI. It is required to work on the factors involved with marketing as business and orders are only generated through pitching other industries. To come at forefront, huge improvement is needed but the direction and area is known now.

REFERENCES

- [1] Dubey, A. D., Verma, M., & Khandelwal, A. K., "Ergonomics Concerns (OHS) to Improve Productivity in Brick Industry", *Journal of Applied Mechanical Engineering* ; 1-5, 2014.
- [2] Maskell, B., *Performance Measurement for World Class Manufacturing*. Massachusetts: Productivity Press, 1991.
- [3] Maheshwari, P. V., Manwani, D. D., & Banerjee, D. S. , "In Search of a Suitable Productivity Measurement Model for Smes with Special Emphasis on Systems Approach", *International Journal of Engineering and Management Research* , pp. 200-207, 2014.
- [4] Wong, G. , *Handbook for SMEs Productivity Measurement and Analysis for NPO's*. Tokyo: Asian Productivity Organization, 2015.
- [5] Mishra, K. (2015), *MSMEs Contribute for more than 37% of GDP and employment for 805 lakh Indians*, [online] from SME Street Knowledge and Networking for Growth: <http://smestreet.in/msmes-contribute-for-more-than-37-of-gdp-and-employment-for-805-lakh-indians>.

- [6] Kennerly, M., & Neely, A. , “A framework of the factors affecting the evolution of performance measurement systems”, *International Journal of Operations and Production Management*, pp. 1222-1245, 2002.
- [7] Deshmukh, Y. P. , “Review of Productivity Measurement and Improvement procedures in Small and Medium Scale Manufacturing Industries”, *International Journal of Engineering Research & Technology (IJERT)* , pp. 2121-2123, 2014.
- [8] *Packaging: a new role packed and delivered ONICRA (credit rating agency of India)*, 2014.
- [9] Vrat, P., Sardana, G. D., & Sahay, B. S. ,Productivity Measurement for Business Excellence. New Delhi: Narosa publishing House, 2009.
- [10] Vrat, P., Sardana, G. D., & Sahay, B. S., Productivity Management: A systems Approach. New Delhi: Narosa Publishing House, 1998.