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Research Article

Application of Key Performance Indicators in a Leather and Shoe Industry for Leanness Analysis Using Multicriteria Approach:A Pre Implementation Study

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Abstract

The purpose of this paper is to analyze leanness of shoe assembly lines using key performance indicators based on Multicriteria Decision Analysis (MCDA) before implementing Lean Manufacturing techniques . For this study, the leather and shoe manufacturing industry has been chosen. The leather industry is one of the most rapidly growing sectors in the Pondicherry union territory . To become more competent in the current economic dip and to ensure they are capable of future growth, this company initiated lean manufacturing concepts. The KPI includes Idle Manufacturing Cycle Time (MCT) ,Part per Labor, rework/rejection,and Amount ofd scrap are treated as criteria for pre leanness analysis of the four process lines. The weight values are assigned to KPIs by decision makers and the analysis are realized by the application of two different decision models, namely Simple Additive Weighting (SAW) and COPRAS methods.. The results show that Process line 2(L2) has 4.6% leaner than L3,8.3% leaner than L1 and 11.2% leaner than L4 and it is kept as the benchmark for continuous assessment.

Keywords: Process line, KPI, Leanness, SAW, COPRAS.

1. Introduction

Lean manufacturing is a combination of best techno social practices (Shah and Ward, 2007), which consists of the social aspects (people and society) and technical aspects (machine and technology).. Most of the lean practices are shop floor techniques that concentrate in eliminating non value added activity (Womak and Jones, 1996) in the production floor. The purpose of lean manufacturing (LM) is to attain higher quality, timely delivery and competitive cost for the customer delight.The LM focus on reducing the waste in human effort, space , inventory, time to market and manufacturing. Implementation of lean manufacturing is generally tool oriented . Lean manufacturing offers various tools and techniques at help to tackle different types of waste effectively and improve efficiency in different situations.
Each lean tool or technique usually focuses on solving a specific problem, such as high work-in-process level, low availability of equipment, long setup time, etc. Therefore, many of the tools are often applied simultaneously in order to improve the overall leanness of a system. To evaluate the degree of leanness key performance indicators is used in modern days. As mentioned above it involves different people and different criteria. Insufficient attention has been paid by researchers to support them in this field.

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The Leather Industry holds an important place in the Indian economy. This sector is known for its consistency in high export earnings and it is among the top ten foreign exchange earners for the country. The leather industry is an employment intensive sector, providing jobs to about 2.5 million people. As per the CLE (Council of Leather Exports) the annual turnover of over US$ 7.5 billion, the export of leather and leather products increased manifold over the past decades and touched US$ 4.86 billion in 2011-12, recording a cumulative annual growth rate of about 8.22%.The major production centers for leather and leather products in India are located in Tamil Nadu ,West Bengal, Uttar Pradesh ,Maharashtra , Mumbai , Punjab, Karnataka, Andhra Pradesh Haryana , Delhi, Madhya Pradesh and Pondicherry**.**
The rest of the paper is structured as follows, in the next section a brief overview of Leanness Key performance indicators,is presented.In section 3 an overview of MCDA,Copras method and SAW are given. Section 4.A real case study is presented to illustrate the application of the proposed method in next section..In the final section some conclusions are drawn.

2.Key Performance Indicators

A KPI is a measure or metric that helps a business monitor its performance and measure its progress towards specific

goals (Brian Varney 2010).It is a set of quantifiable measures that a company or industry uses to gauge or compare performance in terms of meeting their strategic and operational goals. KPIs vary between companies and industries, depending on their priorities or performance criteria. Natalia Andreeva 2009 indicates leanness indicator as follows
1.Manufacturing cycle time
2.Idle time
3.Part products/labor
4.Rework/Rejection
5.Amount of scraps

2.1Manufacturing cycle time

Manufacturing cycle time (D. Rajenthirakumar 2011) is an important measure of lean performance. Manufacturing cycle time is defined as The Amount of time required to turn raw materials into complete product is called Manufacturing cycle time. time or manufacturing cycle time is made up of process time, inspection time, move time, and queue time. Process time is the Amount of time work is actually done on the product. Inspection time is he Amount of time spent ensuring that the product is not defective. Move time is the time required to move materials or partially completed products from workstation to workstation. Queue time is the Amount of time a product spends waiting to be worked on, to be moved, to be inspected or to be shipped.only one of these four activities adds value to the product - process time. The other three activities - inspecting, moving, and queuing - add no value to the product and should be eliminated as much as possible.
Manufacturing cycle time = Process time + Inspection time + move time + Queue time

2.2 Idle time

It is a time during which no production is carried out because the worker remains idle even .In the middle of operations a machine may have to be stopped for some adjustments made. Each morning and on the resumption of work in the post-lunch period, some time will be lost before a job can be started. There may also be some waiting time in between finishing one job and the starting of another.Similarly even if a plant operates with a reasonable degree of efficiency, some allowance may be required for the loss of time due to occasional power failure, machines or tools break-down, delay in delivery of material and stores or of tools etc.Aim of LM is minimize the idle time.

2.3 Part products/labor

It is the ratio between total parts produced and a number of labor involved in this production in a particular time period.For this study 8 hour shift time was taken. This value will be minimized when employees who know the process best to identify unproductive activities and replace them with productive ones.

2.4 Rework/Rejection

Number of work pieces don't send to next process is calculated as rework/rejection.Aim of Lean manufacturing minimizes the rate.

2.5 Amount of scraps

Minimal scrap is the one of the objectives of the LM.This can be achieved by better material planning,maintenance of equipment,training .

3. MCDM methods

Multi-criteria decision-making (MCDM) refers (Mahmoud Saremi 2007)a to screening, prioritizing, ranking, or selecting a set of alternatives under usually independent,incommensurate or conflicting attributes (Hwang & Yoon, 1981). Over the years,some MCDM methods have been proposed. The methods differ in many areas—theoretical background, type of questions asked and the type of results given (Hobbs & Meier,1994). Some methods have been created particularly for one specific problem, and are not useful for other problems.Other methods are more universal, and many of them have attained popularity in various areas. The main idea for all the methods is to create a more formalized and better-informed decision-making process.There are many possible ways to classify the existing MCDM methods. Belton and Stewart (2002) classified them in 3 broad categories: Value measurement model such as multi-attribute utility theory (MAUT) and analytical hierarchy process (AHP); outranking models such as Elimination and (Et) Choice Translating Reality (ELECTRE) and Preference Ranking Organization METHod for Enrichment Evaluation (PROMETHEE) and at last, goal aspiration and reference level models such as Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). The fundamental assumption in utility theory is that the decision maker chooses the alternative for which the expected utility value is a maximum (Keeney & Raiffa,1976). However, it is difficult in many problems to obtain a mathematical representation of the decision maker’s utility function (Opricovic & Tzeng, 2007). The analytic hierarchy process (AHP) is widely used for tackling multi attribute decision-making problems in real situations (Chan & Kumar, 2007). In spite of its popularity and simplicity in concept, this method can deal with imprecision caused by the decision maker’s inability to translate his/ her preferences for some alternative to another into a totally consistent preference structure. In AHP, the so called consistency ratios are used in order to measure the consistency of the decision-making process. This consistency is calculated in every step of the procedure. In case pairwise comparisons in some steps appear to be inconsistent, the pairwise comparisons can be repeated. Afterwards the consistency ratio for the whole process can be calculated and, if necessary, some of the pairwise comparisons may be reconsidered (De Boer, Wegan, & Telgen, 1998). The outranking methods are normally not used for the actual selection of alternatives, but they are suitable for the initial screening process (to categorize alternatives into acceptable or unacceptable). After the screening process another method must be used to get a full ranking or actual recommendations among the alternatives (Loken, 2007).

3.1. COPRAS Methodology

The COPRAS (COmplex PRoportional ASsessment) method presumes direct and proportional dependence of significance and priority of investigating alternatives to a system of attributes.The significance of the comparative alternatives is determined on the basis of describing positive and negative characteristics of the alternatives.
The COPRAS method is a six-stage procedure
Stage 1.
Selecting the set of the criteria,describing the alternatives and constructing the decision-making matrix:
Stage 2.
Normalizing criteria.
Stage 3.
Formulation of weighted normalization table.
Stage 4.
Calculation of sum of weighted normalization(S).
$S_j^+ = \sum$ benefit values .
$S_j^- = \sum$ Non benefit values.
Stage 5.
Calculation of relative weights(Z_i)
$Z_i = S_j^+ + [\sum S_j^- / (S_j^- \sum 1/ S_j^-)]$
Stage 6. Determining the priority order of the alternatives

3.2 SAW method

The method SAW (Simple Additive Weighting) is the oldest, most widely known and practiced used method (Hwang, Yoon 1981; Chu et al. 2007; Ginevicius, Podvezko 2008;Ginevicius et al. 2008). The criterion of the method SAW clearly demonstrates the main concept of multi criteria evaluation methods – the integration of the criteria values and weights into a single magnitude. The advantage of this method is that it is a proportional linear transformation of the raw data which means that the relative order of magnitude of the standardized scores remains equal. Process of SAW consists of these steps:
Step 1:
Find the weights for each criteria
Step 2
Construct a decision matrix (m × n) that includes m process lines and n criteria
Step3
Calculate the normalized decision matrix
for positive criteria
$n_{ij}=r_{ij}/r^*_j$ i=1, ... m , j=1,... n
And for negative criteria
$n_{ij}=r_{ij}^{min}/r_{ij}$ i=1, ... m , j=1,... n
r*Is a maximum number of r in the column of j
step 4
Evaluate each alternative, A_i by the following formula
$A_i=\sum w_j x_{ij}$

here x_{ij} is the score of the i^{th} alternatives with respect to the j^{th} criteria,
w_j is the weighted criteria

4.Case study

The case study company is a shoe manufacturing firm located in Pondicherry.The company is an export oriented company .They produced international brands as per the specific requirement of clients.Now the management wants to implement lean principles to their process line.For find the initial leanness of the process and select the better lean process line two MCDA methods are used.In this study the following five KPIs is considered as criteria and four process lines as alternatives.
1.Manufacturing cycle time(MCT)
2.Idle time (IT)
3.Part products/labor(PPL)
4.Rework/Rejection(Re)
5.Amount of scraps(AS)
The methods use a fuzzy scoring approach that is a modification of the fuzzy ranking approaches proposed by Jain (1976, 1977), and Chen (1985)to find the weights of the criteria . The crisp score of fuzzy number 'M' is obtained are tabulated in table 1 .In table 2 the weights of each criteria derived from the plant managers linguistic term.

Table 1 Chen Fuzzy scale

Linguistic term	Fuzzy number
Low	M1=0.115
Below average	M2=0.295
Average	M3=0.495
Above average	M4=0.695
High	M5=0.895

Table2Wright Calculation

Criteria	Score	Fuzzy number	Weight
MCT	High	0.895	0.25
IT	Above average	0.695	0.19
PPL	Average	0.495	0.12
Re	High	0.895	0.25
AS	Above average	0.695	0.19

As mentioned above the 5 KPIs are kept as criteria .In this MCT,IT,Re,AS are negative that means the minimum is best.P/L is positive.
Units

MCT	Minutes
IT	Minutes
P/L	No Unit
Re	Number of Units
As	Kg

Table 3 Indicates the data for same model shoes .Table 3 to 7 illustrates the steps involve in COPRAS method

Table 3 Decision matrix

Process Line	MCT	IT	P/L	Re	AS
Wt	0.25	0.19	0.12	0.25	0.19
L1	168	46	15	12	1.6
L2	152	39	15.65	12	1.4
L3	170	32	15	11	2
L4	164	40	16.36	13	2.2

Table 4 Normalized decision matrix

Process Line	MCT	IT	P/L	Re	AS
Wt	0.25	0.19	0.12	0.25	0.19
L1	0.256	0.2900	0.24	0.25	0.22
L2	0.232	0.25	0.25	0.25	0.19
L3	0.26	0.20	0.242	0.23	0.28
L4	0.250	0.255	0.264	0.27	0.305

Table 5 Weighted Normalized matrix

Process Line	MCT	IT	P/L	Re	AS
Wt	0.25	0.19	0.12	0.25	0.19
L1	0.064	0.055	0.0288	0.0625	0.0418
L2	0.058	0.0475	0.03	0.0625	0.0361
L3	0.065	0.038	0.029	0.0575	0.0532
L4	0.0625	0.04845	0.0316	0.675	0.0579

Table 6 Sum Values

Process Line	Sj+	S^{j-}
L1	0.0288	0.2233
L2	0.03	0.2041
L3	0.029	0.2137
L4	0.0316	0.2360

Table 7. Relative Weights

Process Line	Z value	Rank
L1	0.2436	3
L2	0.2640	1
L3	0.2530	2
L4	0.2340	4

Table 8 and table 9 explains the SAW method

Table 8 Normalize Table

Process Line	MCT	IT	P/L	Re	AS
Wt	0.25	0.19	0.12	0.25	0.19
L1	0.9047	0.6956	0.92	0.92	0.875
L2	1	0.820	0.96	0.92	1
L3	0.8837	1	0.92	1	0.7
L4	0.9263	0.8	1	0.846	0.64

Table 9 Rank Table

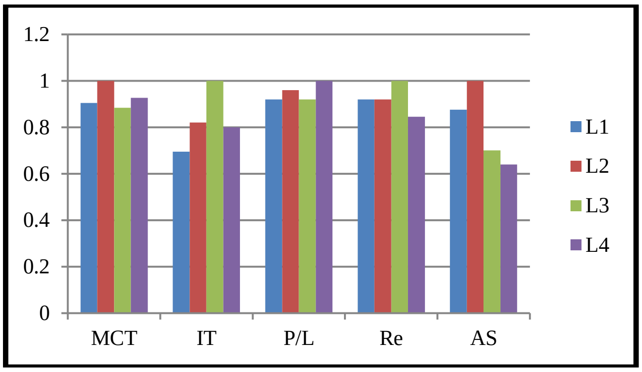
Process Line	A value	Rank
L1	0.864	3
L2	0.941	1
L3	0.904	2
L4	0.728	4

5. Results

Measuring performance of leanness is difficult,because it has many characteristics and tools.This paper has attempted to benchmarking framework .From the both SAW, COPRAS method the output indicates that the process line L2 has leaner than other lines.the process .

Chart 1

Comparison of process lines.



Comparison chart1 for all process lines provide clear ideas about the current status and also indicates L2 has 4.6% leaner than L3,8.3% leaner than L1 and 11.2% leaner than L4 and it is kept as the benchmark for continuous assessment.

6.Conclusions

Practitioners and academics have emphasized the advantages of lean manufacturing . In order to increase the competitive advantage, many companies consider that a well designed and implemented lean system is an important tool. In this study, the application of the COPRAS and SAW is presented for the analysis leanness of process lines in the leather industry. Four process lines are considered to illustrate the application capability of this method. It is clear that the top-ranked alternatives exactly match with methods.This paper not only built MCDA model to evaluation process lines, but also calculates the degree of leanness. This study reduces the risk involved in the omission of parameters. This work may be extended by using the other MCDA methods like TOPSIS,SMART,VIKOR .

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