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Research Article

Design and Implementation of an Information System to Support Quality Management in Small and Medium Scale Enterprises

[1]R. Maheshprabhu and [2]M. Sakthivel
[1]Department of Mechanical Engineering, Karunya University,
[2]Department of Mechanical Engineering, Regional Centre, Anna University, Coimbatore, Tamilnadu, India

Abstract: Success of a quality management system in the ISO 9001:2008 certified small and medium scale enterprises (SMEs) were conquered by effective practice of ISO 9001:2008 procedures at all levels. The advantages contributed by ISO 9001: 2008 for the small and medium scale enterprises were focused in this study. When ISO 9001:2008 certified small and medium scale enterprises were assisted with an information system (DSS-EII) to create awareness and govern, then it results in improvement of the quality throughout the enterprise. In this study an information system was developed to facilitate the automation in documenting ISO forms and records, to identify the bottleneck regions and to provide the solution to overcome the predicted quality issues. It was found that the information system assisted to understand and achieve maximum benefits of ISO 9001:2008. The information system provided appropriate solution to the quality problems via Back Propagation Neural network (BPN). Developed information system was integrated to enterprises resource planning software used in the enterprise. Inputs were given to information system from daily records and enterprises resource planning database. Data were shifted to all the necessary ISO forms and records with necessary computation. Few data updating in ISO forms was accepted only when actual value was greater than or equal to and predefined target value. The developed information system performs function like documenting automation and provides solutions to be followed to solve an issue. This research work introduces a new system to facilitate QMS practices in SMEs and provides relevant solutions for frequently occurring problems using back propagation neural network. The proposed methodology assures integrated assistance, employees training, documentation automation and comfortable working environment.

Keywords: Back propagation neural network, documentation, ISO 9001:2008

INTRODUCTION

Economic development of the country includes contribution of SMEs and they should be ready to face the rigours of international competition as suggested by Charoenrat *et al*. (2013). Day wise SMEs schedule to execute production plans and adhere to delivery dates. The importance in manufacturing components is preferred and operators were motivated to work for it. Unlike in large scale industries, updating Quality Management System (QMS) documents and follow up of procedures as detailed in ISO manual are least preferred in SMEs. Floyde *et al*. (2013) indicated that organising and managing knowledge within organisation is an important factor for success. The Enterprises Resources Planning (ERP) software automates documentation and provides reports related to general records of each department. SMEs are manually documenting the QMS forms and records. Charoenrat *et al*. (2013) proposed that skill of workers' can be enhanced only by educating and training them in working skills. In an enterprise for verifying the effectiveness of the manual practice in documentation, management review report has to be analysed. Top management team of SMEs mainly analyse the performance of their enterprise from the information present in management review report. To study the problems and improve the efficiency of the management system, an Indian medium scale plastic manufacturing industry "Suba Plastics private limited" was selected and their review analysis form was considered as the initial step for this study. Data on the details of daily delivery adherence for a period of three months (January-March 2011) showed 18% lacking when compared to fixed target of the enterprise. The actual daily delivery adherence was ranged from 80.6 to 82.3% only over a period of three months.

Reason for the deviation is mainly due to shortages in quantities for despatch. Increased rejection rate and non-availability of raw materials during end period of production caused shortage in the delivery quantities. Possible reasons for the situation were predicted using

Corresponding Author: R. Maheshprabhu, Department of Mechanical Engineering, Karunya University, Coimbatore, Tamilnadu, India

scheduled questionnaire investigation. Kivijarvi (1997) insisted a much closer relationship between management theory and DSS development for good results. Many root causes were recorded and corrective action plan was proposed. But still a question raised was that accuracy of calculated percentage of actual delivery adherence. To get answer for this, the top management accepted to automate documentation and to visualize its benefits. Heras and Arana (2010) compared the effectiveness of two models generated for same purpose in an industry and concluded that benefits by applying both models are similar.

In any enterprise or in an Industry it is important to adhere the target date fixed for delivering end products and should not be deviated for each order. But in the selected Indian plastic components manufacturing enterprise the target was deviated by 18% for the year 2011. It needs an additional period of three months for completing pending orders which increased the financial requirement and consumed more time. This was the major problem identified in the enterprise and the question need to be answered here is to find out the optimum solutions in order to overcome this situation in future orders without any additional resources, as well as to reduce the target deviations and more investment for resolving.

Further evaluation of cost analysis revealed that an additional 10% of total production cost should be spent to produce remaining 18% of the components. For each order, a deviation occurred and overall cost involved also increased. Additional problems such as switching over of employees to other concerns due to increased work load were addressed. Hiring and training of the new employees was again a reason for delay in production. The responsibility and work load has to be shared by available employees till the new appointment has been made. It leads to stress among employees and results in uncomfortable situations. Based on the identified problems the objective of this study has been formulated to design and develop an information system for supporting ISO procedure and documentation as well as to implement the developed system and analyze the result.

METHODOLOGY

The design proposed by Hernad and Gaya (2013) for documentation of ISO forms and records was followed, which guarantees continuous improvement of the enterprise. Following are the steps used in solving the identified problems:

- Identification of ISO records and interrelation-ship evaluation
- Data entry methods and ERP
- Automation of documentation
- Implementation
- Analysis and comparison.

ISO RECORDS IDENTIFICATION AND INTERRELATIONSHIP EVALUATION

In the selected Indian plastic components manufacturing enterprise-'Suba Plastic Private Limited', all ISO documents were collected. A total of 165 documents that were available in all departments of the enterprise are listed in Table 1.

Records were categorised into groups according to their interrelationship with each other. Production holds the following documents-process sheet, component file, packing and labelling standard, work instructions, monthly production plan, daily moulding report and mould pick up sheet, mould drop sheet, mould correction report, tool history card, machine utilization chart and rejection analysis register.

First category was based on frequency of updating the Daily moulding report and rejection analysis report data that has to be entered on daily basis. All data related to each machine should be entered. A total of 4 modules were available in the enterprise and each module was equipped with a group of moulding machines. Out of the 17 available documents in production, daily moulding report data was used to compute four other reports as shown in Fig. 1. Rejection quantity data from daily moulding report assisted in finding the reason for rejections in internal

Table 1: Department wise total documents collected from Suba plastics private limited

S. No	Department	Total documents	S. No	Department	Total documents
1	Marketing	7	8	Tool room	8
2	Sales	6	9	Production	17
3	Purchase	4	10	QAD	20
4	Stores	12	11	Metrology	17
5	Maintenance	13	12	HRD	20
6	Accounts	4	13	MR	16
7	Engineering	4	14	APQP	17

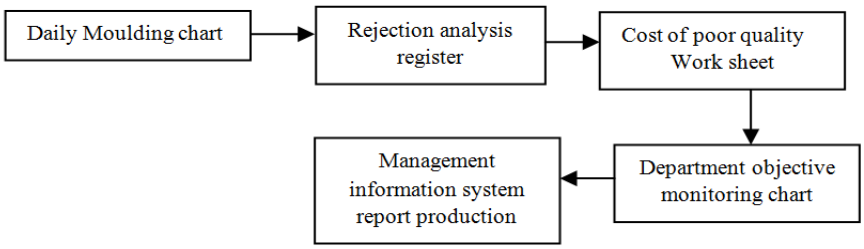

Fig. 1: Illustration for interrelation ship between documents-a sample

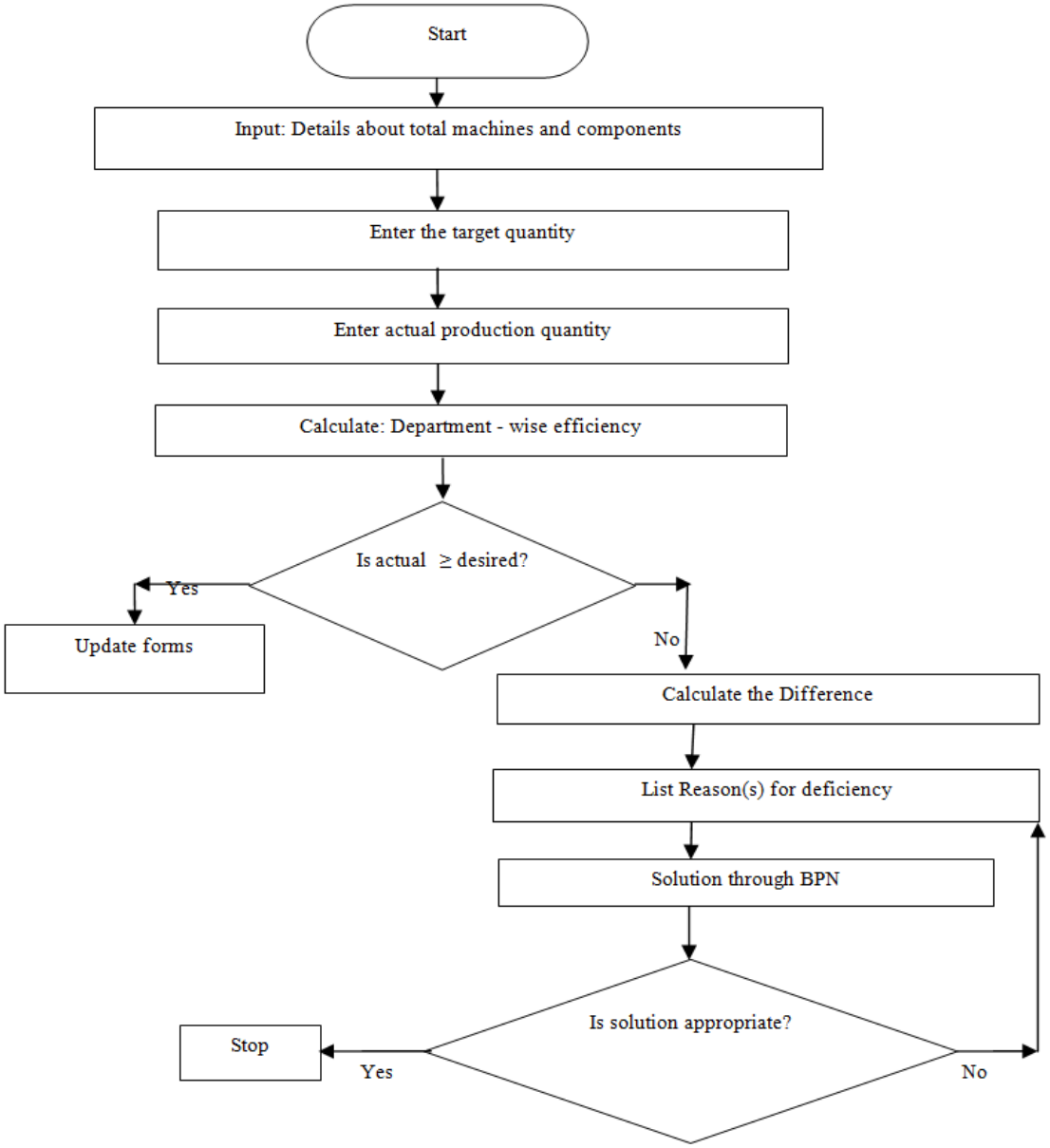

Fig. 2: Algorithm to demonstrate working mechanism

rejection analysis report and also the quantity of the production data in department objective monitoring chart for production. Similarly it calculates raw material rejection quantity from the cost of poor quality work sheet. Using data from daily moulding report, it computes, plan against actual percentage in the management information system form.

Based on above mentioned existing interrelationship, all the records were charted. Detailed mapping of interrelationship between documents in a square matrix was created.

Data entry methods and ERP: Data was recorded manually in each department. The operator in charge for particular record was used to fill the corresponding data observed. Most of available records were filled in paper mode and transferred to excel format. Data relevant to daily processes was also recorded in the available ERP software. Bose *et al*. (2008) integrated ERP with supply chain management to improve operations and to foster paperless environment. Chien *et al*. (2007) explained that ERP systems lead to satisfactory organizational outcome only through effective team work. While examining few reports automatically generated by ERP indicated that, reports were in the standard prescribed ERP formats and didn't support any ISO format. Three methods of data entry carried out are: the manual entry in printed document, excel format and through ERP. Among the three, ERP database supported ISO documents by issuing available

data directly. A link was established to enable data transfer from ERP database to ISO documents. Bose *et al*. (2008) further confirmed that ERP, when integrated with other systems lead to several tangible benefits. All individual excel document entries via local area network could be inter connected and the backup of electronic data was stored periodically.

Automation of documentation: Erdem and Goecen (2012) developed a model and integrated with decision support system for enabling fast decision making environment Fig. 2.

ISO forms and records as per the interrelationship was segregated category wise in MYSQL database. Using Hyper Text Pre Processor (PHP) as front end application and visual basic for computation as back end, an automation system named Decision Support System ERP Integrated Information (DSS-EII) was developed. DSS-EII holds features like data entry for ISO forms, worldwide online access enhancing data, process support, error free speedy calculations, report generation, warning through generated reports and solution generation. Petroni (2000) insisted the application of a supporting model for an already certified company to perform still better. Each module was categorised and facilitates the provision for comparing present target and actual values and enhanced the provisions to indicate the reason for the deviation Analytical formulas were set to calculate necessary form of values to reports. Production Plan Vs Actual percentage (Document number: SP/PRD/R11) calculation need planned quantity and actual quantity produced. Machine utilization percentage indicates required available machine hour and actual machine utilization details.

Production Vs Actual percentage = (Quantity Produced /Scheduled Quantity) × 100 (1)

Machine Utilization percentage = (Machine running hours/Available hours) ×100 (2)

Linking report with a set of formula and data base resulted in understanding accurate hourly production status of enterprises. Next task considered was about developing solutions to frequently occurring problems. A detailed study was made and problems were categorised according to its occurrence, into three types. Category I comprised of problems which occur frequently, Category II included problems that occur moderately and Category III included problems that occur very rarely. This study mainly focused in solving frequently occurring problems by providing appropriate solutions. These problems contributed more in terms of cost of poor quality. Some of poor qualities observed include, Cavity Damage, R/O and F/O Problem, Shining problem, Offset problem and Sleeve Flash, Rib Flash Found, R/O Problem and Dimension Problem, Offset Problem, ECN Correction, Dimension and Runner Gate Damage, Runner Gate Damage, Dimension Problem, Core Pin Problem, Cavity Problem and Flash Problem.

Solutions were different for each problem based on the reason for occurrence. Hence a detailed list of solutions for each problem was recorded. It consumed more time in recording solutions for each reason. Back propagation model was developed to automatically generate solutions for each problem. Shell (2003) explained effective functioning of back propagation in output time prediction model developed by Chen *et al*. (2010) who used multi-layer perception with an error back propagation method in deriving solutions for engineering models. BPN model computes local gradients using error terms multiplied with derivatives of activation function. Error was calculated in output layer jth neuron by using the following formulae as per (Sengupta, 2009):

$$e_j(n) = d_j(n) - y_j(n) \quad (3)$$

where,
$e_j(n)$ = Error at jth neuron at output layer
$d_j(n)$ = Desired output
$y_j(n)$ = Actual output:

$$E(n) = \frac{1}{2}\sum_{j\varepsilon C} e_j^2(n) \quad (4)$$

The instantaneous value of error is calculated by Average value of square energy is calculated by:

$$E_{avg}(n) = \frac{1}{2}\sum_{n=1}^{N} E(n)$$

$$V_j(n) = \sum_{j=0}^{1} wij(n) y_j(n)$$

The partial derivative is calculated using the following equations:

$$\frac{\partial E(n)}{\partial w_j(n)}$$

$$\frac{\partial y_j(n)}{\partial v_j(n)} = \emptyset'(v_j(n))$$

$$\frac{\partial v_j(n)}{\partial w_j(n)} = y_j(n)$$

$$\frac{\partial E(n)}{\partial w_j(n)} = -e_j(n).\emptyset'(v_j(n)).y_j(n)$$

Chen *et al*. (2010) used Gradient steepest method in BPN to adjust connection weights and reduces

inaccuracy of neural networks. Local gradient for 3 layer architecture, when j^{th} neuron belongs to output layer by multiplying error with derivative of activation function is computed:

$$\partial_j = \frac{\partial E(n)}{\partial v_j(n)} = \frac{\partial E(n)}{\partial y_j(n)} \cdot \frac{\partial v_j(n)}{\partial v_j(n)}$$
$$= \frac{\partial E(n)}{\partial y_j(n)} \cdot \emptyset'(v_j(n))$$

Change of weight is applied to current weight using chain rule so that:

$$\frac{\partial E(n)}{\partial w_j(n)} = \frac{\partial E(n)}{\partial e_j(n)} \cdot \frac{\partial e_j(n)}{\partial y_j(n)} \cdot \frac{\partial y_j(n)}{\partial v_j(n)} \cdot \frac{\partial v_j(n)}{\partial w_j(n)}$$

$$\frac{\partial E(n)}{\partial e_j(n)} = e_j(n), \frac{\partial e_j(n)}{\partial y_j(n)} = -1$$

BPN model is trained for desired output. Training for each pair and set of input patterns are provided. Gunasekaran *et al*. (2003) noticed that BPN being most widely used neural network, needs a distinct training to be imbibed for usage. Yin *et al*. (2011) has also given weights in random at the beginning stage of training.

IMPLEMENTATION

The developed DSS -EII model was demonstrated to the management and its benefits were explained. SME managers agree that the best benefits will be assured in enterprise through ISO procedures. Urbonavicius (2005) has also had the same opinion. DSS-EII was installed in top management members' computer and global access facility was enabled. All computers in enterprise were sharing data via local area network. Training was conducted to all data entry operators about the method of providing input, maintaining documents, report generation, input problem statements, viewing of appropriate solutions, identifying bottleneck areas using graphic models of interpreted data and decision making. Sample data were given and hands on training were conducted to input the data and verify user efficiency. All employees were instructed about providing right data to data entry operators. Importance of the developed system and its benefits were highlighted to employees at all levels.

Initially, data entered were verified and then stored in database. The initial sample reports generated were compared with manual calculations. All essential data stored in ERP was linked to the developed system to avoid multiple recordings of the same data. Batch files were generated to fetch data from ERP to DSS-EII. Fakoya and Poll (2013) proved that ERP integration leads to better results which were indicative from the firm's financial situations. ERP data was stored in accessible format and data was routed to DSS-EII database. ERP provided required data and supported for improvement of DSS-EII.

Decision Support System-dERP Integrated Information. The developed system set specification page to input data related to number of machines and number of components to be manufactured.

Fig. 3: Number of machines available and components to be produced

Fig. 4: Target per machine

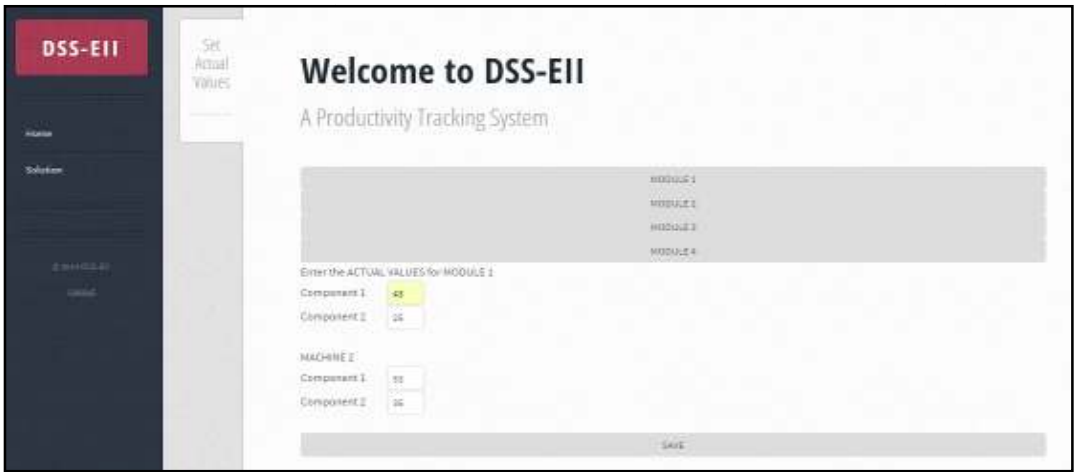

Fig. 5: Actual components produced

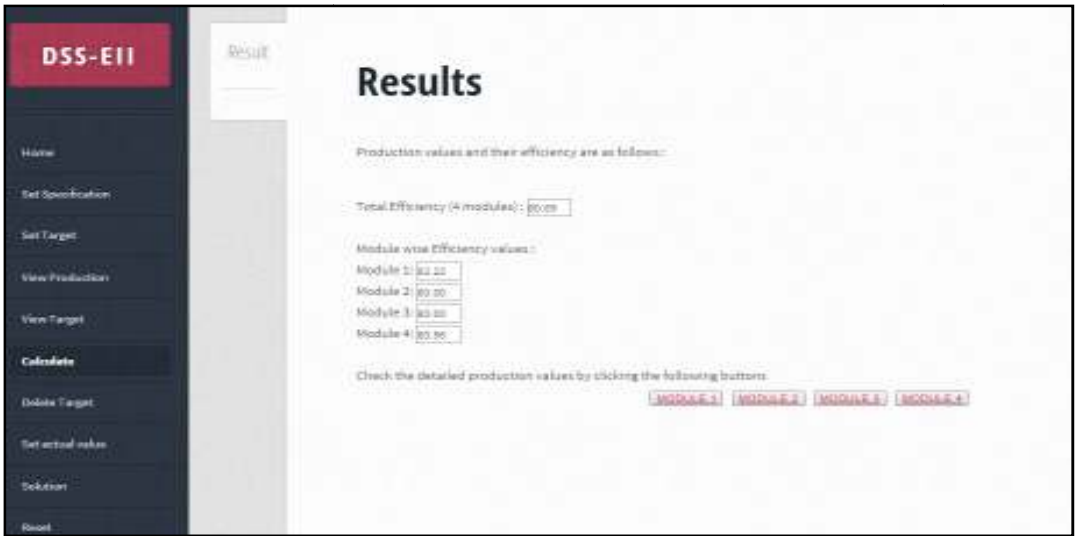

Fig. 6: Efficiency Module wise and overall

Fig. 7: Solution page

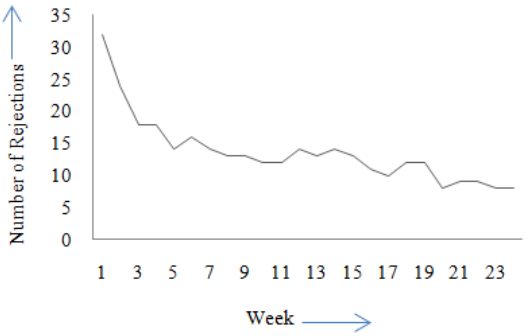

Fig. 8: Decrease in rejection quantity for a period of 24 weeks after implementation of DSS- EII

Table 2: Data on monthly internal rejections

Sl no	Month	Quantity inspected	Quantity rejected	% rejection
1	Apr-10	1197745	10339	0.8632
2	May-10	122422	858	0.7008
3	Jun-10	203266	751	0.3695
4	Jul-10	210087	6689	3.1839
5	Aug-10	104351	1036	0.9928
6	Sep-10	67147	1150	1.7127
7	Oct-10	125615	748	0.5955
8	Nov-10	81978	1000	1.2198
9	Dec-10	247005	1310	0.5304
10	Jan-11	569601	2701	0.4742

Table 3: Supplied components rejection and rework quantities

Quantity supplied	Quantity rejected	Quantity for rework
931056	392128	143612

Figure 3 shows the page in which total numbers of machines and components to be manufactured can be entered

Figure 4 shows the module wise assigned targets for each machine. Similarly individual machine operator provides data to data entry operator and enter from user login.

Figure 5 shows the module wise actual components produced from each machine. This page is accessible by each operator from user login. This enables the operator to update the quantity produced from respective machine each hour.

Figure 6 indicates the efficiency of each module and overall efficiency of enterprise. This calculation is based on the actual components produced and fixed target.

User can enter the type of problem in the "Enter the identified bottleneck". It assists the user to get automatic solutions for the problem (Fig. 7).

ANALYSIS AND COMPARISON

Information on the quantity of rejection before implementing DSS-EII was collected. Table 2 shows rejection percentage from April 2010 to January 2011. Rejected quantities inside enterprise as well as the supplied quantity rejection were observed higher as per records (Fig. 8 and Table 3).

DSS-EII streamlined all records and indicated hourly deviation from target values. It suggested solutions for the problems identified. The management viewed the status from their computer system and follow up actions were generated. Altogether, the developed system drastically controlled situations within the enterprise to a favourable level. As a result, after a period of three months, the rejection rate was less than 0.01% and the timely delivery of goods produced has been achieved.

CONCLUSION

Without disturbing the existing production system, a supporting system was implemented to govern the processes and to generate reports. This resulted in improvement of enterprise performance. Peres and

Stumpo (2000) mentioned that in some countries SMEs reached productivity, equivalent to that of large enterprises by following a new economic model. With minimum cost and ease of training, a medium scale enterprise's profit level was increased with minimum rejection quantities. Kengpol and Boonkanit (2011) proved that ISO integrated decision model supported decision making, assisted in manufacturing eco effective new product and reduce bias. Huge investment needed for training the employees to maintain the ISO Quality management System was eliminated by the developed model. Sen *et al*. (2009) introduced a decision support system for both qualitative and quantitative objectives of the enterprise. Similarly the developed DSS-EII model educates and trains the employees by providing current production quantities and descriptive solution.

Model developed created benefit of facing ISO surveillance unannounced audit scheduled twice in a year with all updated ISO documents. At any moment enterprise can provide details about the current rejection rate and details related to finished products. Also the management can view production status every hour through web based accessibility.

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