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MANUFACTURING AUDIT TO IMPROVE QUALITY PERFORMANCE – A CONCEPTUAL FRAMEWORK

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ABSTRACT

Manufacturing process audit is one of the many quality tools to assess the effectiveness of manufacturing process and quality performance. They are commonly used in the effort to diagnose, maintain and improve quality management system. It is made compulsory for the organization to maintain their quality management system based on ISO9001 standard to conduct an internal audit. However, similarly to any other physical or conceptual system, they may fail to achieve the objectives set forth, to assess effectiveness and at the same time fail to recognized area for improvement. Based on an extensive literature review, the issues relevant to manufacturing audit and quality performance are examine, and discussed the several issues to identify the conceptual framework of manufacturing audit.

Keywords: Auditing, Quality audit, Manufacturing industries, Performance improvement.

INTRODUCTION

The need to improve quality performance has been a major discussion issues due to competitive pressure in manufacturing industries. In order to achieve the higher competitiveness level, these organizations must be able to identify the current quality performance and realign their strategies, operations and processes to improve the quality performance.

Audit is one of the many tools that have been found useful to identify the current quality performance by diagnosing the opportunities for improvement and plan for improvement action. Audit is a tool with wide spread use throughout business in the area of financial, quality, technical, safety, project management, human resources and purchasing (Askey and Dale, 1994). Many organizations, have conducted the audit or been audited in order to comply with certain requirements for example financial requirements and quality management system requirements. But an audit has been traditionally regarded as an "added cost" activity (Hepner, Wilcock and Aung, 2004). In order to change that perception on audit, audit should focus toward improving the organization performance such as product quality, reduction of waste, improve service and delivery and cost reduction (Williamson and Rogerson, 1996).

The objective of this research is to identify the manufacturing process audit framework that should result quality performance improvement. The suggestion for future research is highlighted to validate the conceptual framework.

METHODOLOGY

The main goal is to identify the related issues either directly or indirectly with regard in manufacturing industries related audit. An exhaustive search on the literature related to auditing was conducted in the time frame from 1987 to end of 2006. The literature that was published before 1987 is also reviewed but is limited to cross checking the evolution of audit. The financial audit is ruled out from the review due to the different audit methodology, and qualification of an auditor. Summary from quality management system auditing trainings are also used to develop the audit framework.

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DEFINITION AND PURPOSE OF MANUFACTURING AUDIT

Manufacturing process is defined as a process of making and fabricating by converting the raw material (input) to finished goods (output) (ISO/TS, 2002). The definitions of audit in table 1 can be associated with examination, verification, evaluation, assessment, and check activities. Hence, manufacturing process audit can be defined as a process to evaluate the process and making and fabricating effectiveness and efficiency.

It is also important to understand the definition of audit before any audit is initiated to avoid confusion on how the audit should be conducted (or audit method) and the process of auditor selection. ANSI and ISO defined audit shall be conducted independently while others are not defined. For manufacturing process audit to improve quality performance, it is recommended to be conducted either by independently (ISO, 2002), internally (ISO, 2002) or self-assessment (Karapetrovic and Willborn, 2002) since the goal is to improve quality performance. We cannot limit on how to conduct the audit for manufacturing performance improvement since independent, internal or self-audit have the advantages.

Table 1: Definitions of audit

Source	Definition	Comments
ANSI/ASQC (1986)	Systematic examination of the acts and decisions by people with respect to quality in order to independently verify or evaluate and report degree of compliance to operational requirements of the quality program, or the specifications or contract requirements of the product or service	Used term verify and evaluate – degree of compliance to: - Operational requirement of quality program - Specifications - Contract requirements
IEEE 1028 (1988)	An independent evaluation of software products or processes to ascertain compliance to standards, guidelines, specifications, and procedures based on objective criteria that include documents that specify the form or content of the products to be produced; the process by which the products shall be produced; and how compliance to standards or guidelines shall be measured	The definition emphasize on evaluation of compliance to: - Audit criteria
Oxford Advanced Learner's dictionary (1990)	An examination of accounts to see that they are in order	The definition used the term examination
ISO 12207 (1995)	Conducted by an authorized person for the purpose of providing an independent assessment of software products and processes in order to assess compliance with requirements	Used the term assessment Audit by authorized personnel
ISO 19011 (2002)	Audit is systematic, independent and documented process for obtaining audit evidence and evaluating it objectively to determine the extent to which audit criteria are fulfilled	Used term evaluate

Purpose of the audit can be divided into compliance audit and management audit (Arter, 1994). Compliance audit look for conformance to the audit criteria, while management audit look for conformance to the audit criteria and the effectiveness of the process and opportunities for improvement in achieving organization goals. ISO (2002) used the term of audit criteria, which is refer to specification, guideline, and requirements. Example of conformance audit includes financial audit, tax audit, and regulatory audit. The management audits include manufacturing audit, product and process audit, and improvement audit. Both of compliance audit and management audit can be integrated but normally the organizations adapt the compliance audit based on audit criteria (i.e. compliance to ISO9001) before the auditor can suggest area for improvements, which is outside the audit criteria. Barthelemy and Zairi (1994) suggested the audit should evolve from compliance audit to continual improvement, thriving, ultimate and total audit. It can evolve from compliance to total audit that will cover more than quality performance. Russel and Regel (1996) suggested compliance audit is conducted during infancy stage and improvement audit is conducted during steady state stage due to the fact that it requires time to develop the auditor to suggest the opportunities for improvement.

The areas covered in manufacturing audit (see table 2) included manufacturing strategy, new product introduction, process optimization, flexible manufacturing, production system, performance measurement system, and technology audit. All of these areas interact with manufacturing process.

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Before any organization specified the area need to be audited i.e. the need for technology audit or process optimization, the organization shall identify the weaknesses point before detail audit can be conducted to improve the specific area. The manufacturing audit should able to diagnose each process elements that directly or indirectly contribute toward improvement of manufacturing process effectiveness and efficiency.

Table 2: Purpose of manufacturing audit from literature 1987 - 2007

Author	**Purpose of audit**	**Research method, sample size (n)**	**Type of Industry**	**Significant contribution**
Bobbit, 1989	Supplier Quality Audit	Nil	Nil	2 types of supplier audit. 8 categories for area to be audited
Askey and Dale, 1994	Internal Quality Management Audit	Conceptual	All	Proposed structured approach to efficient and effective audits.
Hum and Leow, 1994	Manufacturing strategy	Empirical, 55	Electronic in Singapore	Framework empirical studies of Hayes and Wheelwright, 1984
Martino, 1994	Technology	Nil	Nil	Framework for technology audit
Gardiner and Gregory, 1996	New Product Introduction	Action, 2	Telecommunication	Framework of NPI audit
Bitichi, 1997	Integrity of performance measure	Case study, 1	Small Engineering manufacturing firm	Workbook to conduct audit
Branney, 1999	Process Optimization	Action, 1	Fertilizer	3 phased of analysis. 86 improvements ideas. Potential hard saving of USD 2 millions
Das S. K.., Patel P 2002	An audit tools for determining flexibility requirements in a manufacturing facilities	Case Study, 1	Electronics	Audit tools for flexible facilities
Hepner,Wilcock and Aung, 2004	Use of auditing as a tool for continual improvement	Case study, 4	Meat industries	Application of audit
Gordon, 2005	Supplier performance measure	Nil	Nil	7 steps to measure supplier performance
Menda, 2004	The role of a manufacturing audit in crafting the production system	Case Study	1	Strategy to develop the production system
Meybodi, 2006	Benchmarking	Survey, 500	Variety large manufacturing firm	Benchmarking competitive priorities. Internal auditing guideline

MANUFACTURING AUDIT FRAMEWORK

Typical manufacturing audit problems or failures are due to lack of audit preparation, audit criteria elements or checklist driven, auditor skills and knowledge, commitment from the management, and bureaucratic reporting (Askey, Dale, Karapetrovic, Barthelemy).

Systematic approach to the auditing is the first element for successful manufacturing process audit. The audit activities framework in figure1 based on ISO19011 (2002) and VDA6.3 audit process is useful to provide guideline for the systematic approached to auditing. Karapetrovic and Willborn (2000a and 2002) develop the generic and self audit program framework that is useful for performance improvement related audit. The systematic audit program includes initiating the audit, preparing for on-site audit, conducting on site audit, report preparation and follow-up activities. The follow-up activities in this context are the improvements activities result from the audit finding.

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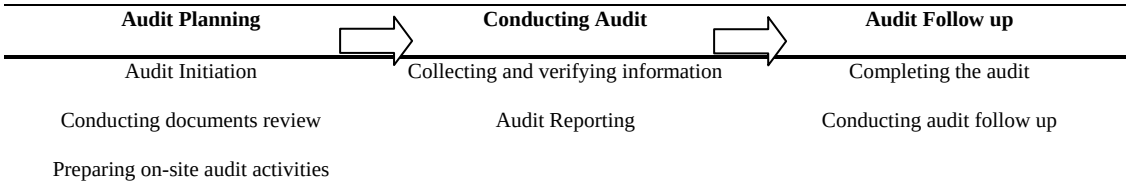

Figure 1: Audit program management

The second element for manufacturing process audit, the audit shall cover more than the manufacturing process, which shall include all supporting process in order the manufacturing to be effective. Series of interrelated audit outweigh the single performance audit (Willborn and Cheng, 1994). Karapetrovic and Willburn (2000b) and award based model (NIST and EFQM) suggest the audit shall cover the overall system that include policy making, product design, process management and all issues related to the manufacturing. The audit will loses it focus on manufacturing process improvement if the audit covers too much on overall management system and strategic management. The strategic management should derived based on weaknesses identified during the audit. Specific areas need to investigate in manufacturing audit so that the audit will focus on quality performance.

Table 3: Comments on audit framework

#	Source	Comments
1.	VDA 6.3, 1998	The most comprehensive framework for manufacturing process audit. Clearly define the audit process and manufacturing process structures. But the framework is too complicated.
2.	NIST, 1999 and EFQM, 1999	The framework covers overall organization performance. Difficult to adopt for manufacturing process because the criteria are general for overall organization.
3.	ISO 19011, 2002	Audit process framework for quality and environment. Useful to organize audit program.
4.	Karapetrovic and Willborn 2002	Expand from the framework from the ISO19011 to suit the performance improvement purposes. Guideline on developing the audit criteria was not discussed.
5.	Russel, 2006	Describe the process approached audit in detail. Adapt the turtle diagram for ISO/TS16949 process approached auditing from sanction training. The first papers sighted describe the turtle diagram.

The process approached auditing techniques is introduced to the ISO/TS 16949 auditor through sanction training and the process model adapt from ISO9001. Process audit are highly focus, but their effective techniques not always understood (Russel, 2006). Seminal work on process audit was done by VDA 6.3 and developed the most comprehensive audit framework, which considers all elements of the processes and audit steps. Major automotive manufacturing firms have been utilized the VDA 6.3 audit questionnaire to evaluate the manufacturing process quality performance either for internal or for supplier. The VDA framework is comprehensive and focuses on compliance audit. The need to develop the simple and easy to understand framework that can evolve from compliance audit to continual improvement audit is vital to avoid the manufacturing audit failures.

The conceptual framework for manufacturing process audit in figure 3 is developed from audit program management (figure1) and process approach audit (figure 2). The process approach model is simplified for manufacturing process adapted from process definition, structure and interface as per figure 2. The focus will be on the sequence of manufacturing process and their interaction to other supporting process and manufacturing process elements. The framework listed in table 2 agreed that the main priority in manufacturing process should be the performance measure indicators. Without the proper installation of quality performance indicators, the quality performance cannot be measured and manufacturing process effectiveness and efficiency will be evaluated subjectively. Tools, techniques and best practice can be shared in term of infrastructure used, locations, supplier management, logistic, human resources, procedures, occupational health and safety, social responsibilities, and financial as support either directly or indirectly towards effectiveness and efficiency of manufacturing process.

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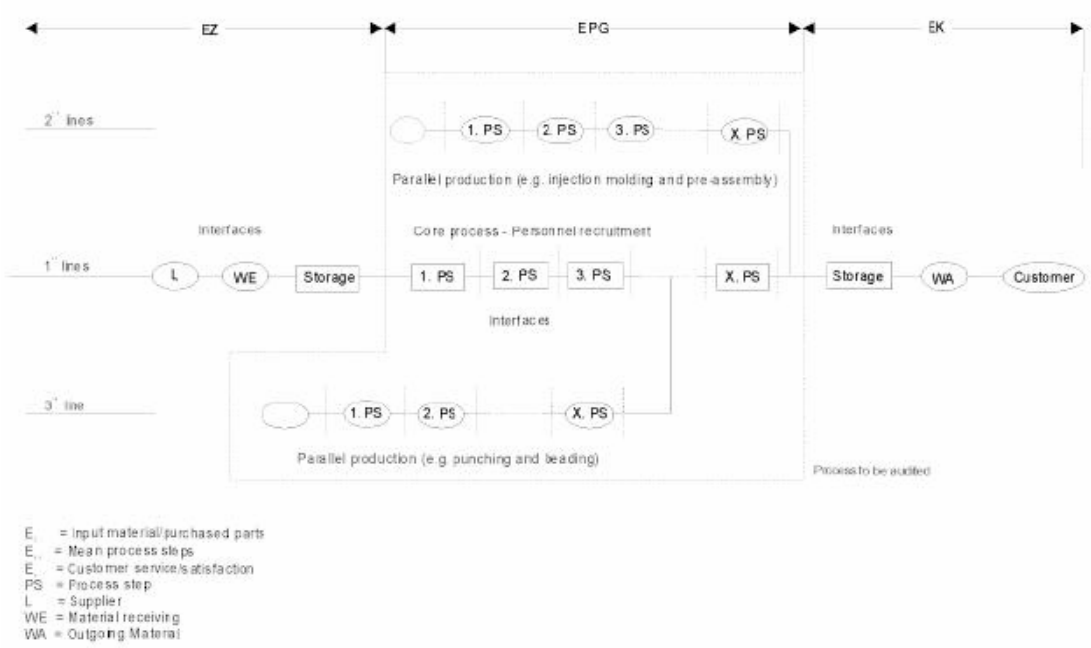

Figure 2: Process definitions, structure and interface (Source VDA 6.3)

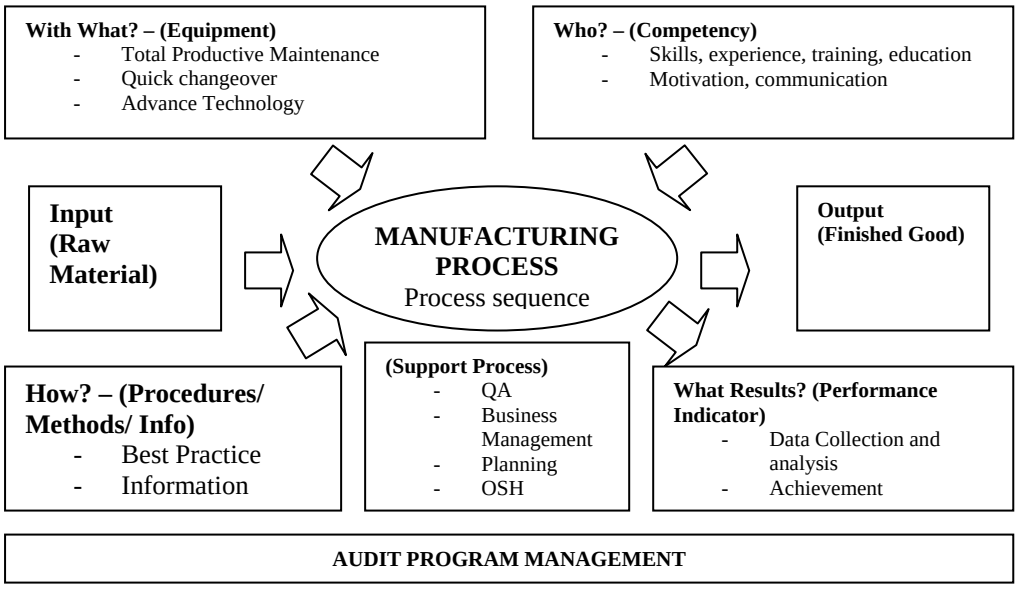

Figure 3: Conceptual manufacturing audit framework

The suggested conceptual framework divided the manufacturing process into seven elements, which are the effective supply (input), infrastructure (with what), personnel (who), operational control (how), support process (management system) and performance measure indicator for the output and related process. All this process elements can be benchmark and opportunities of improvement or weaknesses (audit findings) can be identified.

CONCLUSIONS

This conceptual framework is the first step to plan an effective quality improvement program for manufacturing process. The framework is combination of process approached auditing and audit program management that covered the main manufacturing process elements. The framework can be either used either by external or internal auditor, or self-assessment and assist the auditor or the assessor to develop the audit checklist or what to look for during the audit.

Development of generic and specific audit checklist for specific improvement activities based on the conceptual framework is suggested in order to assist the auditor to diagnose the current practice in

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manufacturing process and compare with the best practice. Empirical study should be conducted to verify the audit checklist effectiveness and the action research is recommended to validate that quality improvement.

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