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Maintenance (Systemekonomi) Program*

## **Maintenance Perception in Swedish SMEs (A local study in Kronoberg County)**



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## **Abstract**

Recognition of maintenance management as a significant factor holds the key to competitiveness in the global market irrespective of the size of the business. Maintenance management practices are primarily found in larger and multinational companies but the purpose of this paper is to investigate the maintenance practices that are used in SMEs of Sweden (Kronoberg County). The study is expected to expose the level of maintenance perception in the Swedish industry via a postal (and web based) questionnaire. The survey covered 74 company chosen from different sectors and produced a response rate of 20.3 percent. The main results achieved from the study show us difference between the maintenance perception and awareness of the maintenance. The respondents are aware of the importance of maintenance, but maintenance is still perceived as a necessary expense. Because according to the results of the survey the percentage of maintenance budget in comparison to the companies' turnover is on average about 0.97% and it is very low. Again, when we look at the maintenance cost distribution of companies, spare parts and labour costs consist of 73 % of total maintenance cost, despite that they spend very little money for technology and training costs, their percentages in total cost are just 3% and 2%, also they still ignore statistical modelling (historical data) and condition monitoring. Moreover, just 27% of the participants use the maintenance key performance indicators (KPIs), and just 14% of them used basic KPIs which are used for measuring maintenance performance. There is a need to spend and invest more in maintenance especially they should invest more in technology and training to perform them. On the other hand, there is a need for choosing right maintenance strategy and service type, because these points are very important for an effective and economic maintenance management.

**Key words:** Survey, Maintenance management, SMEs, KPIs, Kronoberg

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## Table of Contents

1. Introduction .....	1
1.1 Background .....	1
1.2 Problem discussion.....	3
1.3 Presentation of the problem.....	6
1.4 Problem formulation .....	7
1.5 Purpose and goal .....	7
1.6 Related work and study relevance.....	7
1.7 Delimitations .....	8
1.8 Time frame .....	9
2. Research methodology .....	10
2.1 The scientific method .....	10
2.2 Research Approach and Data Collection.....	10
2.3 Reliability and Validity .....	12
3. Theory .....	14
3.1 Description of SMEs .....	14
3.2 Characteristics of SMEs .....	14
3.3 Maintenance and Maintenance Management .....	15
3.4 Maintenance organization .....	15
3.5 Maintenance Strategies .....	16
3.5.1 Corrective maintenance .....	16
3.5.2 Preventive maintenance.....	17
3.5.3 Condition-based maintenance .....	17
3.5.4 Total Productive Maintenance (TPM).....	17
3.6 Productivity .....	18
3.7 Cost-effectiveness .....	18
3.8 Interaction between Quality, Production and Maintenance .....	19
3.9 Strategic dimensions of maintenance .....	20
3.10 Impact of maintenance .....	22
3.11 Performance measurement and Key Performance Indicators .....	24
3.12 Utilized studies.....	24
4. Design of Questionnaire.....	26
4.1 Theoretical design of questionnaire .....	26
4.2 Technical design of questionnaire.....	27
4.3 Conducting the Survey .....	29
5. Representation of obtained data .....	30
5.1 General profile of participants.....	30

6. Analysis .....	37
6.1 Scope of Survey .....	37
6.2 Economic profile of companies.....	37
6.3 Organizational and strategic perspective.....	38
6.4 Maintenance perception and awareness .....	39
7. Results .....	41
8. Conclusion.....	44
Reference list.....	47
APPENDIX 1: Model of Questionnaire .....	53

## **1. Introduction**

*This chapter gives an introduction to the thesis. A background to the problem is provided which in turn leads to the purpose of, and the relevance for, this study. Also, in this part the research clarification occurs by explaining the problem formulation.*

### **1.1 Background**

Maintenance is the overhaul of industrial machinery (or equipment) and facilities (Licker, 2003). In the abstract, maintenance means to keep, sustain, hold, preserve, or carry on the physical assets such as equipment and facilities. All of these verbs concur in the same point. This point is providing availability of equipment and facilities. Bagadia (2006) describes this connection such as: “A good maintenance management system makes equipment and facilities available.” Availability means to reach any item such as light, gas, air, power, cooling, heating, or machine and machine tools in time, or when it is needed. Otherwise it causes time and money waste (Bagadia, 2006). Nowadays, the importance of maintenance, and therefore maintenance management within manufacturing organizations has grown; maintenance has become a support tool for organization and plays a significant role in achieving organizational strategies and goals (Parida, 2008). By breaking down the corporate goals into goals and strategies for the different processes such as production and maintenance processes it could be shown that maintenance is a crucial input for the basic (production) process of manufacturing companies (Kans, 2008). According to Kans (2008) the aim of maintenance management is to identify general goals on different levels of control using the terms of efficiency, effectiveness and cost effectiveness and where the general goal is to contribute to corporation profitability and competitiveness. Thence, companies should recognize the importance of maintenance for to meet customer and corporate demands, and equipment availability, efficiency, and productivity is central to achieving these (Baglee and Knowles, 2010). So, planning and implementing a correct maintenance strategy is essential for the competitiveness of a company. A maintenance strategy is a management method which establishes the sequence of maintenance activities to be undertaken in accordance with the deterioration level of the system and with regard to the acceptable exploitation thresholds (Ben-Daya et al., 2009). Each maintenance act consists of maintaining or restoring the system in a specified state using the appropriate resources and is used in for long term plans,

including all aspects of maintenance management which order to achieve the maintenance objectives (Ben-Daya et al., 2009).

Maintenance and maintenance management is important for big companies as well as Small and Medium Sized Enterprises (SMEs). SMEs provide employment to a lot of people and globally they constitute approximately 70% of gross national product (Ammenberg and Hjelm, 2003). By economic perspective SMEs can be defined as the backbone of economic growth in the world because they account for 80 percent of global economic growth” (cited in Singh et al., 2010). In manufacturing sector, SMEs are often as subcontractors for big companies. Because SMEs work as specialist suppliers of components, parts and sub-assemblies to big companies because these items can be produced at a lower price compared to the price large companies must pay for in-house production of the same components or parts (Singh et al., 2010). For this reason, improving maintenance management in SMEs is very important for big companies and the world economy as well as for the SMEs.

European Commission (2003) defines SMEs as: “enterprises which employ fewer than 250 persons and which have an annual turnover not exceeding EUR 50 million.” According to this definition data from Statistics Sweden show that 99.5% of Swedish companies are SMEs (Ammenberg and Hjelm, 2003). Managerial skills of manager (owner-manager) significantly affect organizational success or failure in SMEs. Because of their central function a greater apprehension of the role of the owner-manager will improve the understanding of small business itself. Most of owner-managers found and manage business for the principal purpose of furthering their personal objects. The business must be the primary source of revenue, and it will consume the majority of their time and resources (d'Ambois and Muldowne, 1988). Also maintenance management is one of the crucial managerial departments of organizations (Cocca and Alberti, 2010). Maintenance management plays a critical role in the company's strategic objectives and achieving the competitive advantages desired. Maintenance affects the company's internal effectiveness and also impacts other work areas such as production, quality, production cost, working environment, amount of work in progress and tied up capital (Al-Najjar, 2007). The costs of maintenance can diverge from 5 to 40 percent of the total cost of producing a product or service depends on kind and size of company (Hartmann, et al., 1994). However maintenance is only one of the costs related with total costs. There are also many functional areas can effect total cost except maintenance in a manufacturing process such as production, inventories, distribution, plant operations, marketing and sales, management, etc. Every element that is produced contains a share of these costs (Hartmann,

et al., 1994). This is why each manager has a significant responsibility to control costs. For this reason a maintenance manager is primarily concerned with managing labour, materials, and overhead costs. Inherently the overall maintenance cost of a labour-intensive industry will generally be lower than the overall maintenance cost of a capital-intensive industry where there is more equipment to maintain and support (Hartmann, et al., 1994). So, large or small all kind of enterprises require the same managerial functions within the maintenance function to keep costs under control.

## **1.2 Problem discussion**

Since began to increase competition in the market, the companies need to search new strategies and ways in which can differentiate themselves and get more profit and better competitive position. The effective maintenance management is one of these strategies, because Company's internal effectiveness is strongly affected by the maintenance role and impact on other working areas such as production, quality, production cost, working environment, amount of work in progress and tied up capital (Al-Najjar, 2007). But maintenance is usually perceived to have a minor rate of return than any other major budget item that is caused by lack of maintenance management and maintenance investment.

According to Al-Najjar (2007) lack of maintenance has significant negative financial results due to its technical impact on machinery, product quality, delivery schedule, production cost factors and customer satisfaction. Quantification of the impact of investments in maintenance on the company's business provides the user to reach reasonable optimisation and reliable decision-making procedures (Al-Najjar, 2007). However, most companies can decrease maintenance costs by at least one-third, and increase the level of productivity; it can be achieved by giving maintenance the management priority it requires, that priority should cover all levels of an organization's management structure to develop an understanding at each level of the significance maintenance can have upon the success or failure of organization objectives (Al-Hassan et al., 2000). Also, the maintenance processes can be efficient to eliminate waste and produce advance performance in areas valued by customers (Hammer and Champy, 1993).

On the other hand, equipment maintenance is a major component of the operating cost in transportation, utilities, mining, and manufacturing industries. The potential impact of maintenance on the manufacturing performance is significant. Maintenance is responsible for

controlling the cost of manpower, material, tools, and overhead (Pintelon and Gelders, 1992; Foster and VanTran, 1990; Ahuja and Khamba, 2008). In financial terms, maintenance can signify 20 to 40 per cent of the value added to a product as it moves through the plant (Hora, 1987; Eti et al., 2006; Ahuja and Khamba, 2008).

Another crucial effect of maintenance on total costs is that poor equipment reliability and poor equipment performance combine to affect product quality and production rate. Thus, insufficiency of maintenance can increase production costs that are many times bigger than those attributable to maintenance labour, materials, parts, and overhead (Hartmann, et al., 1994). So, we can say there is a direct proportion between the working areas such as production, quality or maintenance. If we look at the maintenance perspective, maintenance can affect production in two ways. First way is reducing production costs by elimination of stoppage, increased availability, and reduction of repair costs, increased service intervals lead to reduced product cost. Second way is increasing productivity by provide less maintenance actions and shorter (time) maintenance actions, thus production speed increases, as a result, all of them provide more product and longer production time. Also, it can affect product quality by well-maintained equipment and machines (Al-Najjar, 2007).

Despite all advances in maintenance management, maintenance still has negative image. Because a maintenance department is generally considered as a cost-centre, and benefits of maintenance management are ignored and the scope of maintenance activities has been limited to the operation phases. But as the paradigm of manufacturing move to realizing a sustainable society, enterprises should also be aware of the changing role of maintenance. The aim of manufacturing is no longer to make products in an efficient way, but rather to supply the functions needed by society while minimizing material and energy consumption. Product life cycle management is becoming a central issue in order to achieve this purpose (Takata, et al., 2004). For this reason the role of maintenance from the perspective of life cycle management is completely different, because in this perspective maintenance is in the centre of system and there are close relationships between maintenance activities and those in other phases of product life cycle, such as the design, production, and end of life phases. The main principle of product life cycle management is to control the conditions of products so as to supply the required functionality and performance. There are two causes why it is crucial to control the conditions of products. First cause is the change in product conditions due to corrosion. Second cause is the changing requirements of customers (Takata, et al., 2004). In

both states, the measure that should be regarded first is maintenance including improve, because maintenance generates less environmental load. At this point emerges importance of maintenance. If maintenance does not work well, next solution should be reproduction, and it should be the last measure taken. Because it is very costly and all enterprises avoid reproduction and it is considered as a last resort. Life cycle maintenance perspective shows us the benefits of effective maintenance on the products and customer requirements. That means all companies need to effective maintenance for to produce durable and functional products and to provide customer requirements. But the need of effective maintenance is not related to size of company or production system of company, it is related to maintenance appreciation and approaches of enterprises.

A lot of big companies apply different modern maintenance practices and technologies according to their needs to improve their production responsiveness and flexibility, and provide successful results (Baglee and Knowles, 2010). But we cannot say same thing for SMEs; they could not realize such strategies, and according to a recent study the majority of SMEs (according to senior management respondents (87%)) mostly used reactive maintenance and they had little knowledge or interest in other maintenance practices (Baglee and Knowles, 2010). Some of the reasons behind are that maintenance is still accepted as a “necessary evil” by most of SMEs, and their maintenance policy is still close to “fix when it failure”(Seow and Liu, 2006). On the other hand, recent studies have stated that many manufacturing systems are not performing as intended, so far as cost effectiveness with respect to their operation and support (Chan, 2005). The most of SMEs often operate at less than full capacity, with low productivity, and the production costs are high (Baglee and Knowles, 2010). This claim can be interpreted such as: SMEs can not apply cost effectively maintenance practices and this can cause low profitability and low competitiveness. Whereas, profitability and competitiveness of company’s can be improved by cost effective maintenance (Al-Najjar, 2007), because cost-effective maintenance affects the mean effective life length of the equipment and its failure patterns, which in turn affects production, product quality, delivery time, production cost and as a result customer satisfaction, so all of these factors provide high profitability and competitiveness (Al-Najjar, 2007).

A lot of researchers conducted survey for the purpose of to investigate the maintenance practices. For instance Jonsson (1997) and Alsayouf (2009) conducted survey in Swedish industry and they reached similar results. Jonsson chose manufacturing firms that have more

than 50 employees and Alsyouf chose manufacturing firms that have more than 100 employees. When we look at results of these works we can see a lot of similarities for instance: according to both of these works 48 % of firms have a written maintenance strategy or policy.

### **1.3 Presentation of the problem**

SMEs have distinctive characteristics that separate them from big companies (Carson, 1990). These diversities are usually originated from administrative factors. Because the organization structures of SMEs are usually based on owner/manager, this structure can be reason of some managerial problems. In the very small companies these owner managers are generally responsible of few or all departments of the company such as production, maintenance, marketing, etc., or owner managers prefer to employ the few managers required from family and friends (Kotey and Slade, 2005). For this reason the maintenance perception of an owner/manager and a maintenance manager (of a corporate firm) cannot be same. Because one is responsible of different department or probably is unskilled manager who is appointed by owner manager and other one focus on just one area and he or she is professional. Also perception of maintenance is related to application and efficiency of maintenance strategies. This unprofessional approach can cause low performance, low product quality, low profitability, etc. There are a lot of studies in literature about this issue, but most of these are inadequate and they are not comprehensive, because most of these studies have some gaps, and they missed some points about maintenance. For this reason, this study aims to fulfil the gaps in the previous studies. The main question of this study is to find the level and perception of maintenance in SMEs. But we try to investigate maintenance from different perspectives. These perspectives are:

- Managerial (structure and methodology)
- Economical (investment and impact)
- Technical (support systems)

Measuring of these perspectives is very important for identifying the problems in maintenance and barriers in maintenance applications.

## **1.4 Problem formulation**

The problem formulation of this thesis is based on the above mentioned reasons. It can be expressed with these questions:

- What are the major maintenance applications in SMEs?
- How maintenance is apprehended in SMEs?

## **1.5 Purpose and goal**

The main purpose of this study is to understand how SMEs apprehend maintenance and maintenance management, and try to find out the barriers, deficiencies, and problems in maintenance practices in SMEs. For achieving the purpose the use, perception and attitude against maintenance will be studied. In addition, problems, barriers and trends in applying maintenance in the SMEs will be captured by conducting a survey on SMEs. The result finding is expected to be powerful information for future research directions especially as an indicator for the development of a suitable maintenance framework for the SMEs in Sweden.

## **1.6 Related work and study relevance**

Today big sized enterprises and global companies are aware of the impact of a maintenance strategy on the production line (production capacity, productivity, and production cost). Because with the change in production processes emphasising lean manufacturing, the reliability and availability of plant are headstones. Inefficient machine and equipment performance, downtime and ineffective plant maintenance lead to the reducing in the economic profit, miss of market opportunities, and loss of production and so on (Cholasuke et al., 2004). For this reason, they pay attention to maintenance management and strategies, and they provide economic and competitive advantage in market by applying professional approaches. But we cannot say same thing for SMEs, because most of the SMEs usually implement run-to failure maintenance strategy, as this mostly requires limited knowledge on why and how the equipment failed (Baglee and Knowles, 2010). In addition a lot of SMEs have not maintenance department. As well, majority of senior management within SMEs do not view maintenance as a strategic subject that will translate to an important contribution to the company profit margins (Baglee and Knowles, 2010). And this situation can be cause of huge economic losses in industry.

Improving maintenance management in SMEs will help companies for solving these problems which mentioned above and prevent economic losses and provide competitive advantage. Dunn (in Cholasuke et al., 2004) points out that effective maintenance helps to increase the revenues by increasing the equipment performance and plant capacity, which will in turn maximise the volume of sales. Also, national economies and global economy are affected by improving capacity and economic profits in SMEs. Because SMEs play a crucial role in the national and global economy, so there is a need to help them improve their competitiveness (Gunasekaran et al., 2000). When we look at literature we can find a lot of researcher who studied about SMEs and some of these researchers studied on maintenance practices in SMEs. The researchers such as David Baglee and Michael Knowles (2010), Rajes Kr Singh et al.(2008), James T. Luxhøj et al.(1997), etc. focused on maintenance practices in SMEs and they analysed the condition of SMEs and tried to understand maintenance perception in SMEs by conducted survey (some of these survey are local and some of them cover few countries). Also, Jonsson (1997) and Alsyouf (2009) conducted survey in Swedish industry for the purpose of investigate maintenance applications. These surveys were not only for SMEs, but also can be interpreted for SMEs, cause of 99.8% of Swedish companies are SMEs (EC Enterprise and Industry 2010/11). This study will try to correct the deficiencies in this area and to contribute to the current theory.

## **1.7 Delimitations**

In order to get an appropriate and workable scope on this project, the study has limited the research into the following areas:

- The Swedish SMEs: due to limited time and resources this research will only cover SMEs operating on the Kronoberg County (Sweden).
- Connection with work areas: also, the report will just focus on relation between maintenance management and productivity.
- Focused on basic maintenance practices: this study focused on corrective, preventive maintenance, and condition based maintenance(CBM) because of these are basic maintenance strategies and cover all other sub-strategies, and applying these sub-strategies depend on kind of companies and other different factors. So, in order to reach a general opinion the study is restricted with basic maintenance strategies.



## **2. Research methodology**

*In this chapter scientific research methodology approaches are presented. Applicable research methodology approaches used in the thesis will also be presented.*

### **2.1 The scientific method**

Simply, science can be described as a methodical and systematic approach to the obtaining of new knowledge (Marczyk et al., 2005). Besides, research can be defined as a search for knowledge in simple terms. Also research can be defined as a scientific and systematic search for proper information on a specific topic. In fact, “research is an art of scientific investigation” (Kothari, 2004).

Researchers generally apply to three main scientific reasoning methods (Kudo et al., 2009). These methods are inductive, deductive and abductive methods. Inductive method makes generalizations based on individual instances (general conclusion), deductive method tries to get pieces from whole (general truth), and abductive method uses both of inductive and deductive methods for the purpose of providing hypothesis (Kudo et al., 2009). As a scientific approach mixed method will be used in order to respond to the identified problem in the case study. That means inductive approach will be used in data gathering and empirical observation and deductive approach will be based on theory and it will be used for justifying empirical findings and results.

### **2.2 Research Approach and Data Collection**

Qualitative and Quantitative research are two basic research approaches used by researchers (Kothari, 2004). Quantitative research is based on numerical data; it focuses on gathering numerical data or information that can be converted into numbers. Key characteristics include formal and systematic measurement and the use of statistics (Marczyk et al., 2005). Also Quantitative approach can be sub-categorized into inferential, experimental and simulation approaches to research. The purpose of inferential approach to research is to create a data base from which to infer characteristics or relationships of population. This generally means survey investigation where a sample of the population is studied (questioned) to establish its characteristics and it is then inferred that the population has the same characteristics (Kothari, 2004).

On the other hand Qualitative method is based on verbal data; it focuses on gathering oral information. Qualitative research involves studies that do not try to quantify their results through numerical analysis. Qualitative researches typically involve interviews and observations without formal measurement (Marczyk et al., 2005). Also qualitative data are analysed in an interpreting and subjective way while quantitative data are analysed in an objective way.

There are a lot of data gathering methods for qualitative and quantitative researches. Individual interviews, structured and non-structured interviews, focus groups, documentary analysis, archival research, participant observation, etc. are qualitative (non-metric) based tools. On the other hand quantitative (metric) method uses tools such as questionnaires, surveys and other instruments to collect numerical or measurable data (Marczyk et al., 2005).

This research is carried out to check the current maintenance implementations and maintenance perception in SMEs. The quantitative approach will be applied in this research. And a survey will be conducted for data collection. Because as mentioned above the main idea of survey is to find out general characteristics of a population, and the aim of this study is to investigate maintenance apprehension in the SMEs population. For this reason survey seems to be the most appropriate method in this study. The scope of survey will be targeted to Small and Medium Size (SMEs) manufacturing industries in Kronoberg County. From this survey, the researcher will be able to investigate the situation of maintenance implementations in SMEs and to compare with previous studies.

In order to facilitate data collection, the survey method will be used. For this reason, a questionnaire will be developed. This questionnaire is a fairly popular method of data collection, especially in case of big surveys (Kothari, 2004). A questionnaire is composed of a number of questions printed or typed in a specific order on a form or set of forms. This method is well approved by private individuals, research workers, private and public organisations and even by governments (Kothari, 2004). In this method a pre-prepared questionnaire (according to aim and scope of survey) is sent (generally by mail) to the related persons with a request to answer the questions and return the questionnaire (Kothari, 2004).

Other critical point of this study is selection of questionnaire type, because the type of questionnaire can affect reliability, validity and generalization of the study. The literature

contains a lot of study about comparing questionnaire types especially between web based and postal survey (these types questionnaire are the most widely used and popular today). There are two important comparing criteria in the literature, first one is response time and second one is response rate. According to a lot of researcher the web based questionnaire has faster response time then the postal questionnaire, on the other hand response rate of the postal is more than the web based questionnaire. And the researchers focused on effect of response rate on validity and reliability (Kwak and Radler, 2002; Hoonakker and Carayon, 2009). Thus the postal questionnaire was selected with the aim of to increase the validity, reliability and generalization. In this way we can provide higher quality in the study.

### **2.3 Reliability and Validity**

The principles of Validity and Reliability are headstones of the scientific method. Reliability and validity are very important criteria for acceptance of a study by the scientific community.

There are many definitions of reliability and validity, but these can be simply defined as following:

**Reliability:** The measure of how stable, dependable, trustworthy, and consistent a test is in measuring the same thing each time (Worthen et al., 1993). Reliability belongs to the consistency or dependability of a measurement method, and it is related with the consistency or stability of the score obtained from a measure or assessment over time and across settings or conditions. If the measurement is reliable, then there is lower chance that the obtained score is due to random factors and measurement error (Marczyk et al., 2005). Then reliability decreases obtained score is due to random factors and measurement error (Kothari, 2004). Nevertheless reliability is a crucial and essential consideration when selecting a tool or measurement approach, it is not adequate in and of itself (Kothari, 2004).

Validity is another significant case of measurement that must be accepted as part of an overall measurement strategy (Kothari, 2004). Validity can be described as the degree to which they accomplish the purpose for which they are being used (Worthen et al., 1993). Whereas reliability means the consistency of the measure, validity points out the quantity to which an instrument measures what it is supposed to measure (Kothari, 2004). There are three kinds of validity. These are face, content and construct validity. Siniscalco and Auriat (2005) describe these kinds of validity as follow:

Face validity: evaluation of content by an expert jury.

Empirical validity: how well the assessment corresponds to all aspects of the phenomena under study.

Construct validity: how well a measurement fits to the theoretical constructs.

Generalization can be understood that to make report about the overall results achieved from investigations. It is based on findings in both quantitative and qualitative approaches. The generalization has three types, i.e., generalization of the results from the participants in a study to the larger population, generalization of the results of the study over time, and generalization of results from study setting to other field settings (Grazino and Raulin, 2007).

The postal questionnaire will be used for the purpose of to provide high response rate. The aim of providing high response rate is to increase reliability, validity, and generalization of the study. Also after initial mailing we try to follow up non-responses by re-posting, phone contact and email for the purpose of increasing response rate, also to increase the validity and reliability. On the other hand the questionnaire will be tested before survey goes live. The aim of testing the survey is to measure validity and reliability survey.

Consequently, all data obtained from questionnaire together with the literature review shall be analyzed and finally come up with the conclusion. In order to reach the high estimation, all the factors involved i.e., reliability, validity, and generalization, shall be investigated. Carefully records of survey data have a crucial importance for effective work. Also it affects the validity and reliability of analysing data. On the other hand choosing software is very important for collecting and analyzing survey. Because the software should meet researchers' needs. For instance, for this survey Artologik were selected. Because of this program can provide very detailed statistical analysis with graphics. Also there are a lot of data entry pages such as SPSS, SNAP, SAS etc. are available for survey data analysis. If necessary: also can utilize from these programs.

### **3. Theory**

*This chapter will describe the methodology that will be used in this study. Applicable research methodology approaches used in the thesis will also be presented.*

#### **3.1 Description of SMEs**

There is no single and standard definition of Small and medium-sized Enterprises (SMEs), because they are a very assorted and complexity group. They comprise a large range of firms as grocery's, gas stations, handicraft makers, car repair shop, restaurants, computer software firms, construction sector, textile sector, etc. SMEs have a wide range working area and they work in very different markets and social environment. We can see this diversity in the measure of size such as number of employees, sales turnover, profitability, etc. these are used for identifying size of firms (Storey, 1994). For this reason definition of SMEs may vary from country to country or from region to region. In this study, we will use definition of European Commission, because it comprises a large area and a lot of countries. European Commission (2003) defines SMEs as: "enterprises which employ fewer than 250 persons and which have an annual turnover not exceeding EUR 50 million."

#### **3.2 Characteristics of SMEs**

According to Carson (1990), SMEs have unique characteristics that separate them from conventional marketing in large organizations. In addition to size, there are a lot of qualitative characteristics which serve to highlight the difference. These characteristics may be caused by the inherent characteristics and behaviours of the entrepreneur or owner/manager; and they may be caused by the inherent extent and stage of development of the enterprise (Gilmore et al., 2001). Gilmore et al. (2001) summarized such limitations of small to medium firms as:

- Limited resources such as finance, time and marketing knowledge.
- Lack of specialist expertise (owner/managers tend to be generalists rather than specialists).
- Limited impact in the market place.
- Marketing in small to medium firms tend to be disorganized and informal, because of the way the owner/manager does business, they make decisions on their own; respond to current opportunities and circumstances and so, decision making tend to be disorganized and chaotic.

### **3.3 Maintenance and Maintenance Management**

Nowadays, maintenance and Maintenance Management have become a vital part of organizations; Maintenance has become a support tool for organization and plays a significant role in achieving organizational strategies and goals (Parida, 2008). There are a lot of similar definitions of maintenance in literature. The British Standards Institution (BSI, 1984) defines maintenance as: “A combination of all technical and associated administrative activities required to keep equipment, installations and other physical assets in the desired operating condition or restore them to this condition”.

Also, Marquez (2007) defines Maintenance Management according to definitions of maintenance like this “all the activities of the management that determine the maintenance objectives or priorities, strategies and responsibilities and implement them by means such as maintenance planning, maintenance control and supervision, and several improving methods including economical aspects in the organization.” These definitions show importance of maintenance for organizations especially for production companies. Therefore, regardless of the type of production system, maintenance processes comprise specific activities that must be done by responsible department staff in any organization to secure the availability of tangible worth or machinery. These activities are, but these activities should not be limited to, maintenance (corrective, predictive etc.), should include another activities like inventory and supply, training, financial optimization, availability ratio of equipment, maintenance cost per running time or units, and another related factors (Moayed and Shell, 2009). The maintenance management can be divided different subdivides such as; predictive, preventive, corrective, total quality etc.

### **3.4 Maintenance organization**

The maintenance organization is an organization that manages maintenance by controlling, planning, organizing, and implementing the maintenance activities. Also, it is defined by Garg and Deshmukh (2009) as “Maintenance organizations now a “profit contributor” need to be equally flexible as the manufacturing systems to meet the maintenance challenges in a fast changing flexible manufacturing scenario”. The maintenance organization’s structure is identified after planning the maintenance capacity. The maintenance capacity is heavily influenced by the level of centralization or decentralization adopted (Ben-Daya et al., 2009). Consequently two organization structures that are common are: Centralized and

Decentralized. A decentralized structure would probably experience a lower utilization than centralized one but would be able to respond quickly to breakdowns and would achieve higher plant availability. In practice, one may have a mix of these two. A maintenance organization can be considered as being made up four necessary and interdependent components.

The usual resources connected with a maintenance organization include:

- Human (personnel, intellectual talent)
- Financial (capital, budget, cost)
- Physical (plant, equipment, land, materials, parts, etc.)
- Information

Right management of each of these resources is headstone to successfully providing overall goals and objectives of organizations (Hartmann, et al., 1994).

### **3.5 Maintenance Strategies**

A lot of work has been done in the field of maintenance policies of deteriorating equipment. A maintenance strategy may be defined as a management method which establishes the sequence of maintenance actions to be undertaken according to the wear (deterioration) level of the system and with regard to the acceptable utilization thresholds. Each maintenance action consists of maintaining or restoring the system in a specified state using the appropriate resources and is used in for long term plans, including all aspects of maintenance management which order to achieve the maintenance objectives (Ben-Daya et al., 2009).

#### **3.5.1 Corrective maintenance**

Corrective maintenance (CM) can be defined as the maintenance, which is needed when an item has spoiled or wear out, to bring it back to operating condition. Corrective maintenance is performed after failure identification, so called on-failure maintenance (Marquez, 2007). Corrective maintenance should consist of repair, restoration or replacement of components according to the type of problem. Because, in some conditions corrective maintenance may not be efficient, and it may cause of bigger problem, where significant and high cost equipment has failed. So, corrective maintenance can be effective if executed correctly. It should not be used for critical and high cost equipment, or when other strategy is possible (Sulvian et al., 2004).

### **3.5.2 Preventive maintenance**

Preventive maintenance (PM) is defined as “series of pre-planned tasks performed to counteract the known causes of potential failures of the intended functions of an asset.” PM approach is preferred to apply on the asset management for these reasons (Duffuaa et al., 1999)

- Prevention of premature failures and to reduce their frequency.
- Reduction of severity of failures and to mitigate its consequences.
- Provision of warnings for some incipient failure to help planned repair.
- Reduction of the overall asset management cost.

PM is a broad set of the domain for both condition based maintenance and historical data of equipment failure. PM is used with condition-based tasks and time-based tasks. The maintenance will be performed on time-based tasks if the items have an average identifiable life and it will be performed on condition-based tasks when it is possible to detect degraded condition or poor performance of an item.

### **3.5.3 Condition-based maintenance**

Condition-based maintenance (CBM) is defined by British Standard International (1993) as: “the maintenance carried out according to the need indicated by condition monitoring.” It can be further stated as “the PM based on performance and/or parameter monitoring and the subsequent actions” as described by (Marquez, 2007). The monitoring of performance and parameters can be done in schedule, on-request or continuous. Condition monitoring is done to obtain data of the condition of an item. So, CBM will correct the equipment at the right time in accordance with the analysis of data obtained. This result in saving spare part cost, extension of an item life cycle time and reduces system downtime.

### **3.5.4 Total Productive Maintenance (TPM)**

Total Productive Maintenance (TPM) is one of the major concepts in industry which is considered as an integrated life-cycle approach to factory maintenance and support (Kodali et al., 2009). TPM has been developed by the Japanese for the purpose of to provide both effective, efficient, and productive maintenance in reply to the needs of Just-In-Time (JIT) manufacturing and Total Quality Management (TQM). In fact, if organizations want to use JIT and TQM, they also have to use TPM. Because, it has been said by one of TPM’s inventors that JIT and TQM are just not possible without TPM. TPM puts forward importance

of people, and the main ideas of TPM are continuous improvement by improving the personnel and equipments and prevention of maintenance by eliminating related problem, improving design and reliability of organization (Kelly, 2006).

### **3.6 Productivity**

Productivity can be defined as a measure of goods or services. In the Dictionary of engineering Licker (2003) describes productivity as: "the ratio of output production to input effort, it is an indicator of the efficiency with which an enterprise converts its resources (inputs) into finished goods or services (outputs)". According to Alsyouf (2007) the productivity affect profitability and it is function of the production process efficiency and effectiveness. On the other hand Al-Najjar (2007) and Khan and Darrab (2010) argue that productivity can be increased by applying effective maintenance policy and strategy.

### **3.7 Cost-effectiveness**

The improvement of a system or product that is cost effective, within the constraints of customer operational and maintenance requirements, is a prime objective. Cost effectiveness relates to the measure of a system in terms of task performance and total life-cycle cost. Cost effectiveness can be explained in different ways depending on the particular task or system parameters that one desires to measure (Blanchard, 1993).

Implementing successful maintenance aims to increase company's profitability and competitiveness through continuous cost-effective improvement of production process efficiency, effectiveness and productivity, which can be obtained by maintaining and enhancing the quality of all the elements contribute in the production process continuously and cost-effectively (Al-Najjar, 2007). On the other hand, companies can provide competitive advantage by selection of most cost effective maintenance strategy and policy, because cost effective maintenance can provide a lot competitive advantages. Al-Najjar (2007) explained these competitive advantages such as: the mean effective life length of the equipment and its failure patterns, which in turn affects production, quality, time of delivery, production cost (and product price) and as a result customer satisfaction.

### 3.8 Interaction between Quality, Production and Maintenance

Cooperation can be described as working and/or acting together. Oseland et. al (2011) mentions that cooperation can be done for making decisions, generating ideas or solving problems. In a manufacturing company, this cooperation can be done between main activity fields such as; quality, production and maintenance.

Maintenance, quality and production are companions (Khan, and Darrab, 2010). In the literature, Ben-Daya and Duffuaa (1995) shows that maintenance and quality can be jointly optimized. Also, the outcome of quality and productivity can be enhanced if effectiveness is improved by proper and adequate maintenance of equipments (Khan, and Darrab, 2010). Guceyu and Johansson (2009) mentions the importance of integrating maintenance planning into production planning for increasing utilization and reliability of production system. In this sense, cooperation of these components is necessary in improving the overall system.

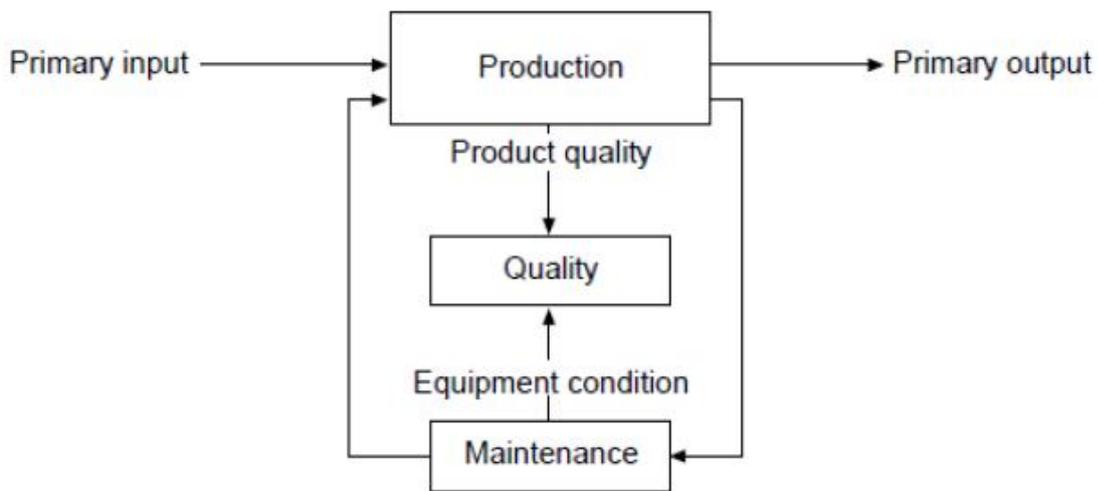


Figure 3.6: Quality, maintenance, production dependences (Ben-Daya and Duffuaa, 1995)

The dependences between these three important components of any production system are shown in Figure 3.6. Ben-Daya and Duffua (1995) defines maintenance as a secondary output of production, whose output is increased production capacity. The quality of the final product is affected by both the production process and the quality of the maintenance work which, in turn, affects equipment condition.

### 3.9 Strategic dimensions of maintenance

Traditionally, maintenance is not considered as a strategic unit in the organization and therefore maintenance planning generally was done at the midterm range (Al-Turki, 2011). Nevertheless, in recent years the strategic dimension of the maintenance has got the attention of the researchers with the increase in the competition at a global level and with the increase of the maintenance cost relative to other costs in the organization. In the input-out model of Visser (1998) maintenance is put at the centre of the enterprise as shown in figure 3.7. This model shows us the impact of maintenance on the other functions, for this reason maintenance should have its own plan that aligns its objectives and goals with the objectives of the whole system (Al-Turki, 2011).

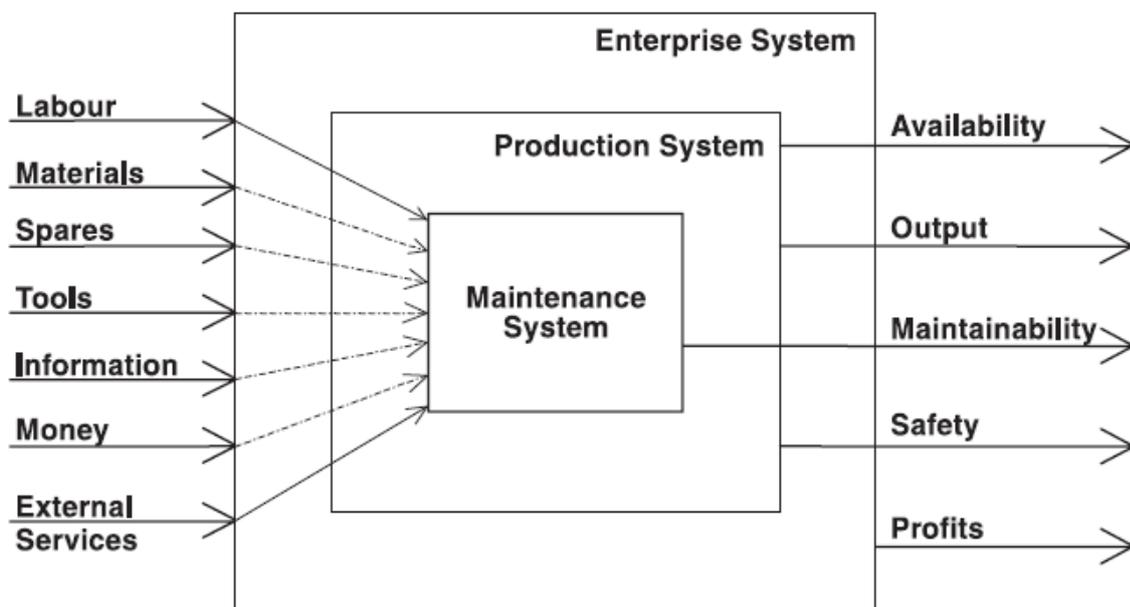


Figure 3.7: Input-out model for enterprise system (Visser, 1998).

As many researchers, Tsang (2002) used input-output model as a reference in his study. Also, he identified four strategic dimensions of maintenance based on input-output model. These strategic dimensions of maintenance can be listed as follow:

**Service-delivery options:** the choice between outsourcing or in-house maintenance. The decision of service-delivery should be made in the context of company's overall business strategy. If companies think outsourcing of their maintenance activities as a strategic option, they should to reply three key questions:

- What should not be outsourced? The maintenance service should be aware of their capacity and skills, and according to their capacity they should identify their requirements for outsourcing.
- What type of relationship with the external service supplier should be adopted? Choosing type contractual relationship is very critical point for utilizing of outsourcing, when the company signs a contract with a maintenance service provider they should be careful and the contents of contract should reply their requirements.
- How should the risk of outsourcing be managed? Outsourcing provides a lot of benefits to companies, it also exposes some risks. But these risks can be eliminated or minimized by a good management.

**Organization and work structure:** organization of the maintenance function and the way maintenance tasks are structured. These tasks should be structured by considering factors such as workload characteristics, plant location, cost of unavailability, production policy, skills and knowledge required, and human resource.

**Maintenance methodology:** the selection of maintenance policies. There are four basic approaches to maintenance: run to failure, preventive maintenance, condition based maintenance and design improvement. Also, RCM and TPM are more popular and successful approaches. The choice between these methodologies is a strategic decision that should be made based on the organizational objectives.

**Support system:** design of the infrastructure that supports maintenance. The last dimension of strategic maintenance management is the choice of the support system that includes information system, training, and performance management and reward system. Each element should be carefully selected to support the overall objective of the company (Tsang, 2002).

According to Input-output model the first dimension is related to the inputs, second and third dimensions are concerned with design and control of processes in the maintenance system, and fourth one is about improving outputs.

### **3.10 Impact of maintenance**

The intention of maintenance is to extend equipment existence, or at least the mean time to the next failure (IEEE/PES, 2001). Moreover, it is expected that effective maintenance policies and strategies can decrease the frequency of service stoppages and the many unwanted problems and outcomes of such stoppages (IEEE/PES, 2001). Besides, Al-Najjar (2007) emphasized role and impact of the maintenance on other working areas such as production, quality, production cost, working environment, amount of work in progress and tied up capital, and that can strongly affect company's internal effectiveness. According to IEEE/PES (2001) maintenance obviously affects component and system reliability and focused on inverse ratio between reliability and maintenance cost, and claims that "in a cost effective scheme, the two expenditures must be balanced". Otherwise, Al-Najjar (2007) extends the impacts of maintenance and these impacts are categorized such as financial and technical impacts (see Figure 3).

Finance (Maintenance investment areas: to invest in one or more of these areas)						Technical impact of investments at the operative level					
(6) Better use of the available technologies (more training, experience and knowledge)	(6) Better prediction of the time to the maintenance action (better fault identification & localisation, and modelling of time)	(6) Better diagnostic techniques	(6) Less failure-related accidents (when maintenance covers personnel, machine and environment safety)	(6) Higher faith in maintenance system	Less failures and unplanned stoppages	Shorter time to repair	Less short stoppages	Better working environment	Higher performance efficiency	Higher availability	Higher quality rate (more stable production process, less variation in quality and less defective items)
▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
-----	◆	-----	-----	-----	◆	◆	-----	◆	◆	◆	◆
-----	-----	◆	-----	◆	◆	◆	◆	◆	◆	◆	◆
-----	-----	-----	●	●	●	●	●	●	●	●	●
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Financial impact at the operative level						Impact of investments at the strategic level (market)						Data sources		Quantification of the impact	
Less expenses of personnel & environment damage	Low insurance premium	Lower direct maintenance cost	Lower production cost (longer production time, more production & less economic losses)	Less tied up capital (due to less redundancies)	More savings	More profit	Less delivery delay and penalties	Satisfied customer	Bigger market share	Higher stake value	Required data can be found in the company's database	Part of data can not be found in the database and should be estimated	Formulas See Fig. 3		
▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲		
◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆		
◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆		
●	●	●	●	●	●	●	●	●	●	●	●	●	●		
-----	□	□	□	□	□	□	-----	□	□	□	□	□	□		

See Fig. 3	
▲	▲
◆	◆
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-----	□

Figure 3.8: Mechanisms of maintenance impact on the plant other activities (Al-Najjar, 2007).

### **3.11 Performance measurement and Key Performance Indicators**

Performance measurement is prevalently used by business units and industries in order to measure improvement against set goals and objectives in a measurable way for effectiveness and efficiency (Parida, 2007). Also, performance measurement affects the decision making, because it ensures the necessary information to the management for effective decision making (Parida, 2007). On the other hand, Parida (2007) claims that performance cannot be managed without measurement, as measurement can only point out the current status of performance. Performance is a result of complex activities which can be evaluated by proper indicators to measure both the actual and desired results (BS EN 15341, 2005). These key performance indicators (KPIs) of maintenance performance are divided into three categories (economic, technical, and organizational) by BS EN 15341(2005), in order to cover all aspects of maintenance. Any KPI can be evaluated as a ratio between factors measuring actions, resources or events, in accordance with a given formula. The KPIs are used to calculate any quantitative aspect or characteristic of an agreement level and for homogeneous comparison (BS EN 15341, 2005). The main aims of using KPIs can be expressed such as: measuring the status, evaluating the performance, comparing performance, identifying strengths and weaknesses, setting objectives, planning strategies and actions, sharing the results in order to inform and motivate people, controlling progress and changes over time. There are a lot of KPIs in which are formulated, but some of these KPIs are basic and they are used extensively by companies. For instance Røstad and Schjølberg (2002) used some of this maintenance KPIs for survey in their study, these maintenance KPIs are as follows:

- Budgeted maintenance costs / Real costs,
- Does not measure maintenance-effort,
- Maintenance costs / Produced units,
- Produced units / Time,
- Maintenance costs / Production costs, and
- % Preventive maintenance of total maintenance.

### **3.12 Utilized studies**

During this study we made use of the works of different authors at different times. For instance works of Jonsson (1997) and Alsayouf (2009) were used for comparing with the results of study. Both of these studies (questionnaire) were conducted in Swedish industry, but

they were applied in different times. Jonsson conducted a wide survey and it was sent to 747 companies, with more than 50 employees, and more than 50% of these were mechanical engineering firms (366). For this study, 284 relevant responses were received; it is equal to a 38% response rate. The main result of this survey show us that the Swedish firms are not aware of importance of maintenance management and only half of the respondents of the survey had any written maintenance strategy, and all of these had not linked the maintenance strategy to production or corporate strategies. The study of Alsyouf was very comprehensive, the survey was sent to 1440 Swedish firms that have at least 100 employees, but for increasing validity he restricted the study to a limited member of industries. The size of the restricted population was thus 539 and the total number of respondents was 118, it is equal to about 22% response rate. Also 55% of these firms were in mechanical engineering. According to Alsyouf (2009) “the main results achieved from the study show that the role of maintenance is not highly recognised.” Also the survey published in Kans and Williamsson (2010), Kans and Ingwald (2013), and Kans (2012) was used for design of the questionnaire. These studies which used for design of questionnaire provided different perspectives to this project. The main purpose of the survey was to describe IT practices within maintenance in Swedish firms. The questionnaire was sent to 196 firms and 71 responses were received, response rate of this survey is 36%. If we compare with other studies, the participant firms were more evenly distributed, with respect to operating areas. They found that the main part of the respondents of this study represents organisations that traditionally would be characterised as mature regarding IT use. And the main part characterizes a traditional maintenance organisation, where the focus is put on the implementation of maintenance activities.

## 4. Design of Questionnaire

*The aim of this chapter is to explain technical and theoretical design and properties of questionnaire.*

### 4.1 Theoretical design of questionnaire

The questionnaire is based on the theory part, and the questions were prepared in parallel with the theory. The questionnaire took final form, after discussions with supervisors during tutorials. The questions in the survey are categorized in accordance with two parts of theory; these are strategic dimensions (service-delivery options, organization and work structure, maintenance methodology, and support system) of maintenance and impact of maintenance, also there are few questions in the survey which can be categorized as background variables of company. The details of relationships between questions and theory, and distribution of questions are explained in the following table (Table 4.1).

Table 4.1: The distribution of survey questions according to relationship with theory.

<b>Category of Questions</b>	<b>Theoretical relationships</b>	<b>Related questions</b>
Background of Company	There is no theoretical relationship. Inspired by previous works of Kans and Ingwald.	Q1, Q2, Q3, Q4, Q5,Q6, Q7, and Q8
Service-delivery options	Chapter 3.9 Tsang (2002)	Q9,
Organization and work structure	Chapter 3.3, Chapter3.4, Chapter 3.5, and Chapter 3.8 Parida (2008), Ben-Daya et al. (2009), Hartmann, et al. (1994), (Marquez, 2007), Khan, and Darrab (2010), and Ben-Daya and Duffua (1995)	Q9, Q10, andQ30
Maintenance methodology	Chapter 3.5, Chapter 3.4, Chapter 3.7, and Chapter 3.8 Ben-Daya et al.(2009), Marquez (2007), Khan, and	Q11, Q12, Q13, Q14,Q15, Q16, Q17, Q18, Q19, and Q20,

	Darrab (2010), and Al-Najjar (2007)	
Support system	Chapter 3.5, Chapter 3.9, and Chapter 3.11 Tsang (2002), Marquez (2007), and Parida (2007)	Q28, Q29, Q31, Q32, Q33, Q34, Q35, Q36, Q37, Q38, Q39, Q40, Q41, and Q42
Impact of maintenance	Chapter 3.3, Chapter 3.6, Chapter 3.7, Chapter 3.8, Chapter 3.10, and Chapter 3.11 Parida (2008), Marquez (2007), Al-Najjar (2007), Khan, and Darrab (2010), and Ben-Daya and Duffua (1995), Al-Najjar (2003), and Parida (2007)	Q21, Q22, Q23, Q24, Q25, Q26, Q27, and Q30

## 4.2 Technical design of questionnaire

The questionnaire was being arranged after determining the kind of approach and method that is proper for the survey. A lot of arrangement goes into a survey. First of all, the questions must be prepared in such a way that covers the scope and objectives of the research. For this research, the questions are developed with a purpose to check on the perception level of maintenance and performance of maintenance practices in Sweden SMEs.

Two significant aspects of questionnaire design are the construction of the questions and the decisions on the types of response formats for each question. Survey questions can be classified into three structures: closed, open-ended, and contingency questions (Siniscalco and Auriat, 2005). These question types can be described as below:

**Closed-ended questions:** a closed-ended question provides the respondent with several answers from which to choose.

**Open-ended questions:** an open-ended question does not provide the respondent with a choice of answers. Instead, respondents are free to answer the question in any way they choose, usually by entering a number, a word, or a short text.

Contingency questions: a contingency question is an occasion of a closed-ended question because it applies only to a subgroup of participants. The consequence of the question for a subgroup is determined by asking a filter question. The filter question directs the subgroup to answer a relevant set of particular questions and instructs other participants to skip to a later section of the questionnaire (Siniscalco and Auriat, 2005).

Also, Likert scale was used in the questionnaire. Likert scaling is the most frequently applied approach scaling technique in educational research, and it asks respondents to provide a response along a continuum of possible responses (Marczyk et al. 2005).

Basically, the questionnaire is divided into 4 main parts. These sections and question are described in Table 4.2. (Also the full questionnaire is given in Appendix 1)

Table 4.2: Types of Questions.

<b># of Ques.</b>	<b>Type of Question</b>	<b>Section</b>	<b>Reference</b>
1	Closed-ended	Background of Company	Kans and Ingwald, (2012)
2-8	Open-ended	Background of Company	Kans and Ingwald, (2012)
9	Open-ended	Service-delivery options/ Or. and work str.	Tsang (2002)
10	Closed-ended	Organization and work structure	Hartmann, et al. (1994)
11	Open-ended	Maintenance methodology	Marquez (2007)
12	Open-ended	Maintenance methodology	
13	Closed-ended	Maintenance methodology	
14-20	Likert scale	Maintenance methodology	Kans and Ingwald, (2012)
21-27	Likert scale	Impact of maintenance	Al-Najjar (2007)
28	Yes/No	Support system	Tsang (2002),
29	Yes/No	Support system	Tsang (2002),
30	Yes/No	Impact of maintenance	Al-Najjar (2007)
31-42	Yes/No	Support system	Parida (2007)

First section keeps tracks on the general information of responding companies. In this part, the background aspects of the respondent such as number of employees, types of industry involves by respondent companies, financial data, etc. will be obtained.

In the second section, information about the main maintenance strategy of the respondent companies will be obtained.

The third section of the questionnaire consists of scaled questions and the aim of these questions to find out perception of maintenance in the respondent companies. Scaled questions measure the real feelings of respondents about the questions; also they are easy to collect data and analysis.

And the final section consists of “yes/no” questions, and these questions are based on maintenance support. Also some of them are supported by open questions, when the yes or no options are not enough.

### **4.3 Conducting the Survey**

The empirical study was performed by conducting a regional survey to obtain information from the maintenance or production managers of companies in Kronoberg County that have fewer than 250 employees. The list of respondents was created with respect to definition of SMEs and all of them were in the border of Kronoberg County. We obtained 74 companies which met the criteria from websites that provide information of Swedish companies (<http://www.foretagsinfo.se/> and <http://www.allabolag.se/>). After creating the list of respondents the questionnaires were posted. From these 74 companies, only 7 companies returned the questionnaire completely, 4 set of questionnaire was returned back due to different reasons, and other companies did not give any feedback.

A comprehensive follow-up was conducted, in which 63 non-respondents were telephoned, but we could not reach a lot of the respondents due to various reasons. We got just 5 affirmative answers from respondents who we reached. Other respondents said they were not interested in answering. We also reposted the questionnaire to respondents who answered in affirmative. After that, we sent email to respondents who could not be reached by telephone. But just 3 of them answered questionnaire completely. Finally we got 15 answers from 74 companies.

## 5. Representation of obtained data

*This chapter presents the information provided by the participant companies and the survey results about Maintenance Management implementations in SMEs in Kronoberg County.*

### 5.1 General profile of participants

The survey covered 74 companies all over Kronoberg County, which involved in small and medium enterprises in the various industries. In this way, 15 useful responses were gathered for analysis. This constituted a response rate of 20.3 percent. The questionnaire provided to be concluded by the person responsible for maintenance in the company. They were mostly the Managing Directors, Maintenance Managers, or Production Managers since they directly concerned in the process and have first-hand information of maintenance implementations in these SMEs.

Table 5.1: Data about participants

Type of Industry	No. of total responses	<50 (Employees)	Between 51 and 250	>250(Employees)	Total response Rate (%)
Metal	11	2	9	0	78.6
Automotive	0	0	0	0	.0
Chemical	0	0	0	0	.0
Wood	2	1	1	0	14.3
Food	0	0	0	0	.0
Energy	0	0	0	0	.0
Other	2	0	2	0	7.1
<b>Total</b>	<b>15</b>	<b>3</b>	<b>12</b>	<b>0</b>	<b>100</b>

Data about participants regarding to their size and business area is shown in Table 5.1. This table represents the distribution of the types of industry involved by the participant companies. As can be seen in the table, most of the participants are involved in metal industry, which contributed 78.6 percent, 14.3% of the respondents are involved in wood industry, and 7.1% percent of respondents are involved in other industrial areas. When we look at the distribution of the companies according to their size of industry, a large proportion (80%) of the organizations was categorized as medium sized enterprises employing between 51 to 250 employees, and 20 % of the organizations were small enterprises with fewer than 50 employees (see Figure 5.1).

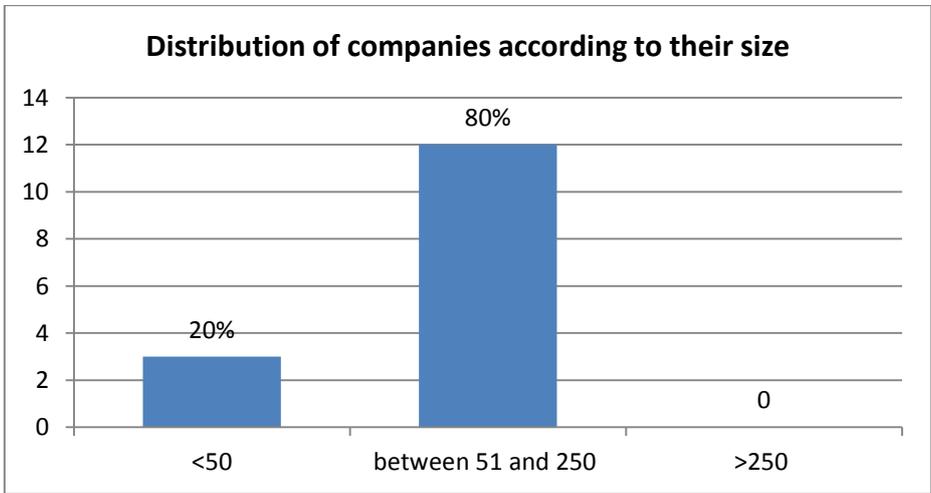


Figure 5.1: Distribution of companies according to their size of industry.

**5.2 Investment in maintenance**

The turnover of the companies that owned the participants enterprises, in the year 20011, ranged from 88.8 to 600 millions of Swedish Kronor (MSEK), and the average of their turnover is 255.5 MSEK. And the average of their total cost is 182.6 MSEK. But the average of maintenance cost is just 2.47 MSEK. This means that the percentage of maintenance budget in comparison to the companies’ total cost is on average about 4.51% and it in compression to the companies’ turnover is on average about 0.97%. Also, a question was asked about the distribution of maintenance cost in percent. According to the answers spare parts is the item that spent the most money with 48%. It is followed by labour and outsourcing costs with 25% and 18%. On the other hand, technology and training costs are just 3% and 2% see Fig. 5.2. Results of this question show that spare parts and labour costs are the main items of maintenance cost for the companies, because just these options are marked by all

respondents, that means the response rate of these items are 100%. After these, outsourcing comes with 66.6%. But training and technology have just 33.3% response rate.

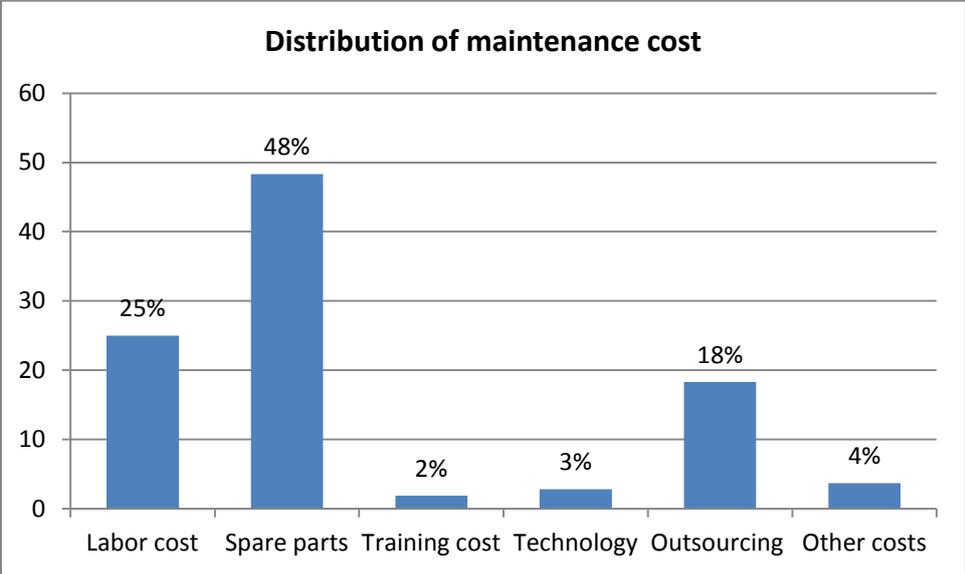


Figure 5.2: Distribution of maintenance cost.

### 5.3 Maintenance Perception

#### 5.3.1 Maintenance organization and strategy

According to the results of questions about the maintenance organization and strategy, 27% of the companies have corrective maintenance (CM) as main strategy, 53% have preventive maintenance (PM), 13% have both of them, and 7% have no maintenance strategy or policy. Also, it was found that about 26% of the companies have a maintenance department that is organisationally independent of the production department, while in about 60%, maintenance is organised as part of the production department. In about 7% of companies outsources, and about 7% have other organizational relationships, for instance maintenance is a part of Development and Industrialization department, see Fig. 5.3.1. On the other hand, it was found that 40% of the firms have a centralised organisation, and 60% have a decentralised organisation. Besides, allocation of maintenance time according to tasks like as: about 73% of the maintenance time is spent on planning, about 15% is spent on carry out, and 12% is allocated for follow up.

It was found that about 67% of the respondents believe that their current maintenance strategy is the most suitable method for their companies. But also, 67% of them believe that the current maintenance strategy needs to be improved.

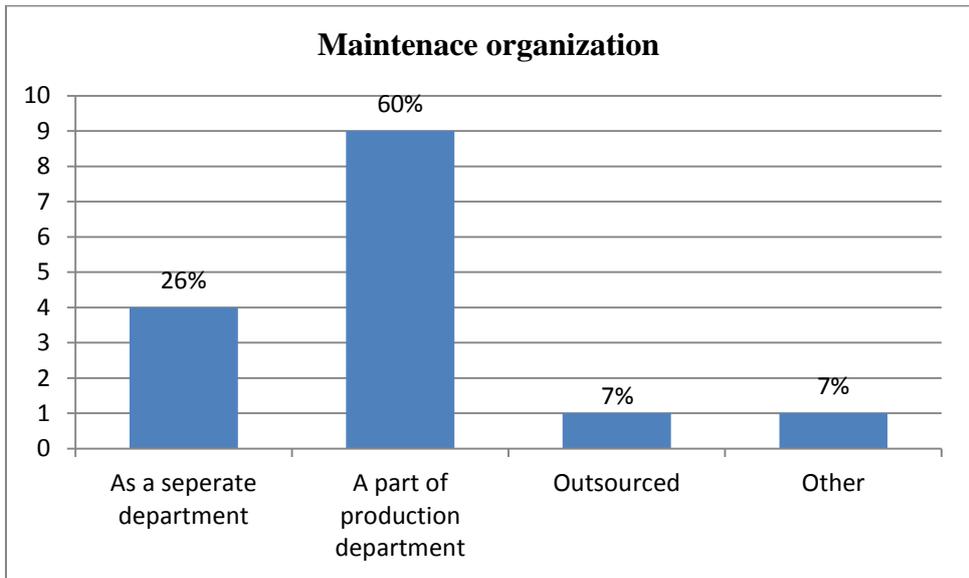


Figure 5.3.1: Maintenance organization in the companies.

### 5.3.2 Degree of triggers on maintenance activity

The respondents were asked about how they perceived the importance of triggers in their maintenance activity by using a 5-point Likert scale. The scale used ranged from (1= Not at all) to (5= Very much). Table 5.3.1 represents mean degree of importance of triggers on maintenance activity, rely on respondents votes on each triggers. There are three levels of degree in the table Low is between 0-1.9, Moderate is between 2-3.9, and over 4 is High. These degrees are assessed with respect to 5-point Likert scale. 3 is accepted as a middle point (moderate degree) and 1 point from up and down are accepted as limits of High and Low degrees.

Table 5.3.2: The mean degree of maintenance triggers on maintenance activity.

Triggers	Mean	Degree of importance
Sudden failures (Unplanned maintenance)	3,6	Moderate
Machine manufacturer´s recommendation (Planned maintenance based on machine manufacturer)	3,6	Moderate
Experience on machinery(Planned maintenance based on experience)	3,3	Moderate
Problems that are reported by operators(Unplanned	3,7	Moderate

maintenance based on personal experience)		
Routine inspections(Planned maintenance)	3,3	Moderate
Statistical modelling (Planned maintenance based on historical(recorded) data)	1,7	Low
Condition monitoring(Planned maintenance based on electronic devices)	2,1	Moderate

### 5.3.3 Impact of maintenance management on other functions

The questions in this part were about the impact of maintenance management on other functions in the organization. It was found that about 73% of the respondents said that “there are collaboration between the maintenance department and other departments.” Moreover there is used same method (5-poin Likert scale) as previous part. The respondents of the survey were asked about how they perceived the impact of maintenance management on other functions. Table 5.3.3 shows mean degree of effect of maintenance management on other functions in the organization.

Table 5.3.3: The mean degree of effect of maintenance management on other functions.

<b>Interactions</b>	<b>Mean</b>	<b>Degree of importance</b>
System and equipment reliability can be increased by improving the maintenance management.	3,9	Moderate
System and equipment availability can be increased by improving maintenance management.	4	High
Productivity can be increased by improving the maintenance management.	3,9	Moderate
Product quality can be increased by improving maintenance management.	3,7	Moderate
Total production cost can be decreased by improving maintenance management.	3,9	Moderate
Profitability can be increased by improving maintenance management.	3,9	Moderate
Maintenance contribution to corporate strategic goals, such as profitability and competitiveness.	3,7	Moderate

<b>General Maintenance Awareness</b>	<b>3,9</b>	<b>Moderate</b>
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### 5.3.4 Maintenance support in the organization

The rate of respondents that have any CMMS or IT program is 60%. But the rate of respondents that have maintenance training program is just 20%, analysis that why the training cost has just 2% in distribution of maintenance cost.

On the other hand, the respondents of the survey were asked about maintenance key performance indicators (KPIs), according to results just 27% of respondents use maintenance KPIs for measuring maintenance performance in their company. Also, the Tab.5.3.4 represents percentage of maintenance KPIs are used in the companies.

Table 5.3.4: Usage rates of maintenance KPIs.

<b>Maintenance KPIs</b>	<b>Usage rate</b>
Time taken to answer maintenance calls ( time from call for maintenance to time of repairing)	14%
Mean Time to Repair (MTTR) (MTTR is average time between the occurrence of an event and its resolution.)	14%
Mean Time Between Failure(MTBF) (The average time between equipment failures over given period)	14%
Preventive maintenance time (Total hours of preventive maintenance per year)	43%
Percentage of maintenance hours of operating time (maintenance hours is the actual maintenance hours spent maintaining an item of equipment)	71%
Schedule Completion Effectiveness (actual maintenance hours planned / maintenance hours planned to complete schedule tasks)	14%
Number of breakdowns (total breakdowns per year)	57%
Total maintenance cost per year	57%
Maintenance cost per unit (Total maintenance cost / number of produced units)	43%
Budget compliance (total budget implemented / budget planned)	71%
Do these KPIs correspond with your targeted subjects?	43%

According to results the most used maintenance KPIs are percentage of maintenance hours of operating time and budget compliance with 71%. The percentage of total maintenance cost per year and number of breakdowns are 57%. But using other maintenance KPIs are under the 50%. On the other hand, just 43% of participants think these KPIs correspond with their targeted subjects.

## **6. Analysis**

*In this chapter the results of the questionnaire will be analysed according to previous studies and theory part.*

### **6.1 Scope of Survey**

The survey covered 74 companies all over Kronoberg County, which involved in small and medium enterprises in the various industries. But the previous surveys Jonsson (1997) and Alsyouf (2009) were all over Sweden and covered SMEs and large companies. If we compare the survey with earlier studies, we can say this study is a local survey. When we look at the industry types of participant companies: 76.8% of participant companies from metal industry, but in the previous studies represented different data about industry types, in the study of Jonsson (1997) 46.1% of companies were from mechanical engineering and just 3.1% from metal industry; also we can see similar results from Alsyouf (2009), 55% of companies were from mechanical engineering and just 12% from metal industry.

### **6.2 Economic profile of companies**

One of the most important perspectives of maintenance is economy. But unfortunately the previous studies did not represent data about economic perspective of maintenance; just Alsyouf (2009) gave some information about maintenance cost. According to Alsyouf (2009) the average turnover of participants is 678 MSEK, and maintenance cost is on average 4% of turnover. Also, he touched on the training of personnel working in maintenance, and he said that 17% of respondents did not spend anything for training of maintenance staff. On the other hand, the average turnover of respondent companies in this study is 255.5 MSEK. And the average of their total cost is 182.6 MSEK. But the average of maintenance cost is just 2.47 MSEK. That means the percentage of maintenance budget in comparison to the companies' total cost is on average about 4.51% and it in comparison to the companies' turnover is on average about 0.97%. According to results, the respondents in the first study spend 400% more than this study. This could be due to size of companies. Because the first study covered SMEs and larger companies, but this study just covered SMEs. Probably the large companies

increased this difference, because the large companies are managed more professionally than SMEs, and they more care about maintenance than SMEs.

Consequently, according to data above, respondents focus on spare parts and labour cost and they ignore importance of technologic maintenance support and training of maintenance staff.

### **6.3 Organizational and strategic perspective**

According to the survey results, 27% of the companies have corrective maintenance (CM) as main strategy, 53% have preventive maintenance (PM), 13% have both of them, and 7% have no maintenance strategy or policy. The percentage of companies which have no maintenance strategy is 23% in Jonsson (1997) and 28% in Alsyouf (2009). Also, it was found that about 26% of the companies have a maintenance department that is organisationally independent of the production department, while in about 60%, maintenance is organised as part of the production department. In about 7% of companies outsources, and about 7% have other organizational relationships, the percentage of the companies have independent department is 34% in Jonsson (1997) and 39% in Alsyouf (2009). On the other hand, it was found that 40% of the firms have a centralised organisation, and 60% have a decentralised organisation, but Alsyouf (2009) gathered different results about organization types, 41% had a centralised organization, 15% had a decentralised organization, 41% had a combination of centralisation and decentralisation, and 3% had other types of organization. If we compare the maintenance organization of companies with respect to the data above, the percentages of companies have independent maintenance department in Alsyouf (2009) is 5% higher than the result of Jonsson (1997), the reason of this is probably difference between survey dates, because there is 12 years between two surveys, so a 5% increase is logically, because the importance of maintenance is increasing and the organizational structure of the companies is improving day by day. Besides, the result of this survey is less than both of them and this case can be explain with scope of the survey, because this survey is a local study and just cover SMEs but other studies were more extensive and comprehensive. For this reason, we can say that the percentage of independent maintenance department in these surveys (Jonsson and Alsyouf) may have been increased by larger companies, because corporate structures of big firms are more advanced than SMEs.

Furthermore, unlike other studies, it was found that about 67% of the respondents believe that their current maintenance strategy is the most suitable method for their companies. But also, 67% of them believe that the current maintenance strategy needs to be improved. These results can be interpreted such as: majority of respondents are satisfied with the kind of maintenance strategy, but they are not satisfied with the results and want to develop their current maintenance strategy.

#### **6.4 Maintenance perception and awareness**

Unlike previous studies, there are some questions for the purpose of to understand the common maintenance perception of the companies and to measure their awareness level about importance of maintenance. These questions are divided into three categories, these are: degree of triggers on maintenance activity, impact of maintenance management, and maintenance KPIs.

As we have seen in the previous chapter (Table 5.3.2) the common degree of the triggers on the maintenance activities is moderate, according to answers of participants 7 of the 8 triggers have moderate degree, and just 1 trigger has low degree. This trigger is statistical modelling (Planned maintenance based on historical data). Also, another trigger (condition monitoring) is very close to low level. The low degree of these triggers show us that the participants still ignore the importance of modern maintenance methods and devices, because both of these triggers are related to condition monitoring and electronic devices and these are ignored by participants, despite that other triggers are related to classical methods and they are generally based on experience. And these 6 triggers are adopted more as compared to the other two.

On the other hand, when we inspect the results of interaction between maintenance management and other functions in the Table 5.3.3, the common degree is moderate and the level of 1 of the 7 question is high and other 6 are very close to high level, besides 73% of the respondents said that “there are collaboration between the maintenance department and other departments.” For this reason we can say that the participants are aware of the positive effects of the maintenance management on the other functions.

Another significant issue is supporting of maintenance and using the maintenance KPIs. The results of survey showed us that just 27% of participants use the maintenance KPIs for measuring maintenance performance in their companies. According to Table 5.3.4 the most used maintenance KPIs are percentage of maintenance hours of operating time and budget compliance with 71%. The percentage of total maintenance cost per year and number of breakdowns are 57%. But using other maintenance KPIs are under the 50%. There is an interesting point here, usage rates of Mean Time to Repair (MTTR) and Mean Time Between Failure (MTBF) are just 14%, but these are two of the most important and basic variables for measuring maintenance performance. Also, just 43% of participants think these KPIs correspond with their targeted subjects. This means that they are not satisfied with their KPIs and reasons for this is probably underutilize and/or mischoose of the maintenance KPIs. Moreover, 60% of the respondents have any CMMS or IT program, but just 20% of them have maintenance training program, and this explains that why the training cost has just 2% in distribution of maintenance cost.

On the other hand, the 53% of the participants have preventive maintenance strategy, but when we look at the results of question regarding maintenance triggers, we can say they do not correspond. Because they are not aware of importance of statistical data and condition monitoring, and they ignore these triggers which are very crucial for a successful preventive maintenance management.

## **7. Results**

*In this chapter the results of the questionnaire will be determined.*

This research has tried to bring out the level of perception of maintenance in SMEs. It has also identified areas lacking in implementation in the maintenance management. Maintenance management can effect on other functioning areas such as production, quality, working environment, production cost, etc. There are a lot of studies in the literature about interaction between maintenance and other working areas especially between maintenance, production and quality. For instance Al-Najjar (2007) clearly explains how company's internal effectiveness is influenced and interaction between maintenance, production, and quality. With respect to the results of the survey, there is a difference between the maintenance perception and awareness of the maintenance. The respondents are aware of the importance of maintenance, because according to the results of the survey 73% of respondents are accepted relationship between maintenance and other working areas, also their maintenance awareness recorded mean of 3,9 on a 5-point Likert scale. But there is a contradiction here, because maintenance is still perceived as a necessary expense, and this contradiction is clearly reflected in the survey results. For instance they still ignore statistical modelling (historical data) and condition monitoring, the percentage of maintenance budget in comparison to the companies' turnover is on average about 0.97% and it is very low. Again, when we look at the maintenance cost distribution of companies, spare parts and labour costs consist of 73 % of total maintenance cost, despite that they spend very little money for technology and training costs, their percentages in total cost are just 3% and 2%, the reason for this is that the maintenance is still regarded as a necessary expense. Moreover, just 27% of the participants use the maintenance KPIs, and just 14% of them used basic KPIs which are used for measuring maintenance performance.

Also their maintenance strategies do not match with the maintenance triggers. For instance 53% of companies have preventative maintenance strategy and 13% of them have mixed (corrective and preventive) strategy, totally 66% of companies apply preventive maintenance

but this does not correspond their triggers because the average degree of condition monitoring is 2.1 and statistical modelling is just 1.7, and these results contradict with preventive maintenance approach.

Furthermore, from an organizational point of view the maintenance department still belongs to the production department, because only 26% of the companies have a maintenance department that is organisationally independent of the production department, while in about 60%, maintenance is organised as part of the production department. In about 7% of companies outsources, and about 7% have other organizational relationships. That is another result which explains the maintenance perception of the companies. Meanwhile, about 67% of the participants are satisfied with their current maintenance strategy and they think that is the most suitable method for their companies. But also, 67% of them are not satisfied with the results and they believe that the current maintenance strategy needs to be improved. These results can be interpreted such as: the majority of respondents can select the proper maintenance strategy, but they cannot implement this strategy and cannot get result.

Also following table (Table 7) represent comparing results of this study with previous studies (Jonsson (1997) and Alsyouf (2009)).

Table 7: Comparing the study with previous studies.

<i>Comparing areas</i>	<i>Jonsson (1997)</i>	<i>Alsyouf (2009)</i>	<i>Current study</i>
Scope of Study	Whole of Sweden	Whole of Sweden	Local (Kronoberg )
Size of participants	SMEs and larger	SMEs and larger	SMEs
The main industry type of participants	Mechanical engineering (46.1%)	Mechanical engineering (55%)	Metal industry (76.8%)
Average maintenance cost	-	-	2.47 MSEK
% of maintenance cost in turnover	-	4%	0.97%
% of the companies have independent maintenance department	34%	39%	26%

% of the companies have no maintenance strategy	23%	28%	7%
Using CMMS	36%	67%	60%
Using maintenance training program	-	83%	20%
% training in total maintenance cost	-	4%	2%

In general, we can make the following determinations about the survey:

- The respondents are aware of positive effects of the maintenance management on other working areas, in spite of that
- The main perception of maintenance is still as a necessary expense,
- Their maintenance budgets are not adequate,
- The maintenance departments are not supported adequately (technological and educational supports are ignored),
- They prefer classical maintenance methods (based on personal experiences) to modern methods,
- The maintenance performance is ignored and is not measured efficiently,
- The maintenance KPIs are underutilized and/or mischosen.

As it was mentioned previously, the companies' face some barriers during they apply their maintenance strategy and policies, also these determinations which explained above are directly related to implementation problems. These barriers can be explained as follows:

- Lack of financial resources
- Lack of technical resources
- Lack of qualified labour
- Organizational and managerial deficiencies

## 8. Conclusion

In consideration of the significant contribution of SMEs to the economy, this research is designed to identify the current level of maintenance management implementation and perception among SMEs in Kronoberg County. As mentioned above they face some difficulties and barriers during maintenance applications. The source of these barriers and problems relies on the characteristics of SMEs. With respect to characteristics of SMEs, these barriers can be evaluated as follow:

**Lack of financial resources:** most of SMEs can just earning livelihood, and their profit margins are not very high. We can say that most of SMEs work as subcontractor of big companies. For these reasons they cannot invest adequately in maintenance. But they can solve this problem by providing maintenance support from their business partners, if they provide good service to their business partner. Because a lot of big companies aware of importance of subcontractors for their business especially delivery time of work is very important for big companies, therefore they can support maintenance service to their subcontractor for the purpose to provide advantage themselves. So, they can pay off a bit higher maintenance budget.

**Lack of technical resources:** SMEs usually prefer classical maintenance method, and they do not utilize technological supports. There are two reasons for this, first is lack of financial resources because they cannot afford some technological supports, that's why the technological support of SMEs are limited to some simple software. Second is lack of qualified labour, because they do not have enough qualified personnel to use these technologies. This problem can be resolved by outsourcing maintenance service.

**Lack of qualified labour:** most of SMEs suffer from qualified personnel. This is usually due to the negligence of education. They can overcome this barrier by improving training education programs.

**Organizational and managerial deficiencies:** this may be defined as the greatest obstacle. Most of SMEs are quite small and have only a very few employees. And they are managed by owner/manager. These limited staffs is required to complete all necessary responsibilities including production, maintenance, marketing, sales and accounting for the entire business; for example, the owner/manager of the company may also be the multimanager who manages all the departments of the company. This can be a disadvantage if employees do not have the essential skill sets to achieve multiple tasks well. The correct allocation of tasks within the company can eliminate this problem.

Despite all these difficulties, SMEs can improve their maintenance management by taking some measurement or can create a new maintenance strategy which is more appropriate to their corporate strategy. For this purpose a procedure is derived from the data gathered from survey and the theory. SMEs can apply following steps for the purpose to provide an effective and proper maintenance management:

**Choosing service type:** first they should prefer their maintenance service type: outsourced, in-house or mixed. They should identify their maintenance requirements according to production type and capacity, after that they can compare with their financial and labour resources, so they can see their capacity “what we can do and what we cannot do”? Thus they can select most effective and economic maintenance service.

**Choosing maintenance strategy:** after the identified service type they should select their maintenance strategy. In this step, first they should define maintenance objectives and strategy with respect to corporate strategy and objectives. After that they should assess importance of assets and determine critical assets, and then they should identify response and measures for critical assets. And finally they can choose their basic maintenance strategy.

**Design of maintenance strategy:** in this step they should design plans, schedule, resources, etc. of the maintenance strategy.

**Implementation:** the chosen strategy should be executed with respect to identified plans and schedules.

**Performance measurement:** the executed maintenance plans should be measured and controlled.

**Periodical evaluation:** the maintenance performance should be evaluated periodically, for instance weekly or monthly. Thus they can control their condition and they can take measure and add new techniques or redesign the strategy, if necessary. In this way, they can provide continuous improvement.

Apart from these steps, the companies can improve their maintenance management by taking small measurements or modifications. Especially, the respondents who are satisfied with their maintenance strategy, but are not satisfied with results. For instance they can improve the skills and ability of their maintenance labour resources by sharing accumulated knowledge and experience or training programs. Also, they can simplify their maintenance tasks by helping technological supports such as CMMS, IT systems, e-maintenance, etc. On the other hand, they should invest more in technology and training to perform them.

**Criticism of the study:** the proportion of respondents is to be considered as the other critical point of this study. Because the survey participation rate was below expectations, initially participation rate of survey 40% was targeted for the purpose of provide high reliability and validity. But the number of respondents was highly below expected result, despite all of efforts rate of participants could not exceed of 20.3%. There were several reasons for this. But probably the main reason was language of the questionnaire. Because the survey was in English and this was a justification for some of the companies which did not respond to the survey.

**Future research:** the main concern for the research was only limited to investigating the perception of maintenance in Kronoberg County. It has found only the perception of maintenance as well as area lacking in implementation of maintenance in Kronoberg County. It is suggested that studies on other counties should be carried out simultaneously for the purpose of to reach a general opinion in Sweden. In doing so, the researcher hopes that future research will involve a group of researchers who are interested in this topic. This will

definitely enhance the chances of providing a thorough and correct outcome on the perception of maintenance and maintenance implementations in Sweden with shorter time, resources and costs needed.

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## **APPENDIX 1: Model of Questionnaire**

Dear Sir / Madam,

### **Survey on Maintenance Management implementations in SMEs**

I am currently conducting a research on Maintenance Management in Small and Medium-sized Enterprises (SMEs). The purposes of the study are to investigate the current maintenance implementation as well as to determine the deficiencies and to identify the requirements of the SMEs. The information gained from the survey will hopefully be of use in developing suitable strategies and guidelines for successful and cost-effective maintenance management.

I would be very grateful if you could spend a few minutes answering the attached questionnaire. All the questions are designed for quick and easy response; they just require a tick only. Your contribution in implementation the questionnaire and commenting upon it would be very critical as the success of my research depends upon a good level of response at this stage.

I would also like to promise you that all responses given will be regarded as classified and used for research purposes only. If you need further explanation, please do not hesitate to contact me at address below. I would like to thank you for your kind cooperation.

Thank you in advance.

Yours sincerely,

Talip Ablay

Life Cycle Management of Industrial Assets,

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- 1 What is the company size in terms of employee size?
- <50
  - between 51 and 250
  - >250
- 2 In what year did company start production its in current form?
- 
- 3 What is the company's turnover in 2011 in SEK?
- 
- 4 What is the company's Total Cost in 2011 in SEK?
- 
- 5 What is the percentage of maintenance cost in total cost in 2011?
- 
- 6 What is the maintenance cost allocation in percent?(Total 100%)
- Labor cost
  - Spare parts
  - Training cost
  - Technology
  - Outsourcing costs
  - Other
- 7 What is the maintenance time distribution in percent, according to following tasks?(Total 100%)
- Planning
  - Carry out
  - Follow up
- 8 Which industry does the company belong?
- Metal industry
  - Automotive industry
  - Chemical industry
  - Wood industry
  - Food industry
  - Energy

**9 How is maintenance organised within the company?**

- If other, specify
- As a seperate department
- A part of production department
- Outsourced
- If other, specify

**10 What is the main structure of maintenance?**

- Cenralized maintenance organization
- Decentralized maintenance organization

**11 What is the company's main maintenance strategy?**

- Corrective maintenance
- Preventive maintennace
- If other, specify

**12 Do you as a manager believe that this strategy to maintenance is the most appropriate method for the company?**

- Yes
- No

If No, please specify:

**13 Do you as a manager believe that this strategy needs to be improved?**

- Yes
- No

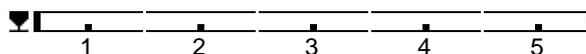
**What triggers a maintenance activity? Please state how likely a maintenance acting is triggered by the followings.**

The following questions (13-19) are based on maintenance activities. For your convenience is using a scale from 1-5, where 1 means lowest level and 5 highest level. (There are two tools for the answering the questions. So, the value could be inserted either using the scale or the text box according to your convenience.)

**14 Sudden failures (Unplanned maintenance)**



**15 Machine manufacturer's recommendation (Planned maintenance based on machine manufacturer)**



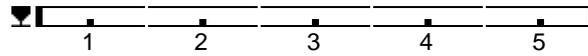
**16 Experience on machinery(Planned maintenance**



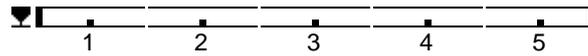
based on experience)

1 2 3 4 5

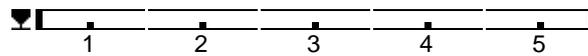
17 Problems that are reported by operators(Unplanned maintenance based on personal experience)



18 Routine inspections(Planned maintenance)



19 Statistical modeling(Planned maintenance based on historical(recorded) data)



20 Condition monitoring(Planned maintenance based on electronic devices)



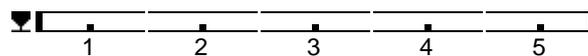
**Benefits of Maintenance management: the following questions (20-25) are based on effects of maintenance management on other functions.**

To what extent do you support the following statements?

21 System and equipment reliability can be increased by improving the maintenance management.



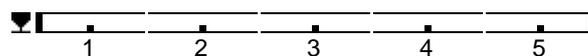
22 System and equipment availability can be increased by improving maintenance management.



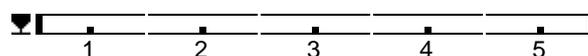
23 Productivity can be increased by improving the maintenance management.



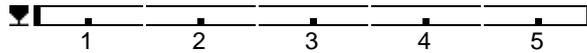
24 Product quality can be increased by improving maintenance management.



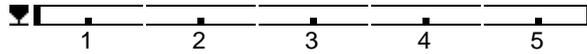
25 Total production cost can be decreased by improving maintenance management.



26 Profitability can be increased by improving maintenance management.



27 Maintenance contribution to corporate strategic goals, such as profitability and competitiveness.



Following short-answer questions are based on maintenance support.

28 Does the company has any CMMS program or similar IT systems for maintenance management?

- Yes
- No

29 Do you have such a maintenance training program for current employees and/or new employees?

- Yes
- No

30 Are there any collaboration between the maintenance department and other departments?

- Yes
- No

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If yes, please specify:

### Key Performance Indicators (KPIs) for measuring maintenance performance

Following short-answer questions are about maintenance KPIs are used in the company.

31 Do you use any KPIs for measuring your maintenance performance?

- Yes
- No

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If yes, please answer the following questions based on KPIs uses.

32 Time taken to answer maintenance calls ( time from call for maintenance to time of repairing)

- Yes
- No

33 Mean Time to Repair(MTTR) (MTTR is average time between

- Yes

- the occurrence of an event and its resolution.)  No
- 34 Mean Time Between Failure(MTBF) (The average time between equipment failures over given period)  Yes  No
- 35 Preventive maintenance time (Total hours of preventive maintenance per year)  Yes  No
- 36 % of maintenance hours of operating time(maintenance hours is the actual maintenance hours spent maintaining an item of equipment)  Yes  No
- 37 Schedule Completion Effectiveness (actual maintenance hoursplanned / maintenance hours planned to complete schedule tasks)  Yes  No
- 38 Number of breakdowns (total breakdowns per year)  Yes  No
- 39 Total maintenance cost per year  Yes  No
- 40 Maintenance cost per unit (Total maintenance cost / number of produced units)  Yes  No
- 41 Budget compliance (total budget implemented / budget planned)  Yes  No
- 42 Does these KPIs correspond with your targeted subjects?  Yes  No

Thank you for taking your valuable time to answer my questions.