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Benchmarking the performance of heavy earthmoving machines – a review

A desirable benchmark should be complete from all aspect, holistic in nature and conceptually universal as well as acceptable. This work reviews the related literature and conclude that different types of benchmarking methods are used in different organizations and institutions. The ever-increasing demand for continuous improvement of quality and performance in any field or organization leads to benchmarking. Benchmarking is an effective technique, which supports innovative ideas. The present study aims to provide an inclusive review of performance benchmarking. In this work, different types of benchmarking techniques are categorized, and their drawbacks and the research trends are provided to assist researchers and practitioners in conducting new research in this area. A new benchmarking methodology has been suggested which could be acceptable universally for all the heavy earthmoving machines (HEMMs) which provides numerical benchmarked value which can be easily used for the comparison purpose.

Keywords: *Performance, benchmarking (BM), categorization, HEMM, holistic benchmark (HBM)*

1.0 Introduction

Experts differ in the purpose and objective of benchmarking. Popular definitions of benchmarking give different insights. Vermeulen (2003) indicated that the benchmarking is the process of identifying, understanding and adapting best practices from within the company or other business to help in getting better performance. Being a relatively new management tool and technique, the benchmarking has been defined and understood in different ways. The widely used definition of benchmarking implemented by the Xerox Corporation and identified by Camp (1989) and McGaughey et al. (2005) is that the benchmarking is the continuous process of measuring products, services and practices against the companies those are accepted as industry leaders. Benchmarking cannot be performed once and ignored thereafter, in the faith that the task is finished. It must be a continuous process as industry practices constantly modify and industry leaders constantly get stronger (Chen, 2002). Also, benchmarking is viewed as a continuous process used to measure performance gaps, to establish where 'best practices' are and to initiate change capable of closing recognized gaps (Rohlfer, 2004). It adds an outer perspective to a total quality management system (TQM). Benchmarking ensures that the circle of continuous process improvement is turning in the direction of achieving higher standards of competitiveness. Numerous companies have adopted benchmarking as part of a total quality management (TQM) approach (Wynn-Williams, 2005). Benchmarking inherits from total quality management (TQM) a binding dedication to continuous improvement and monitoring (CMA, 1998). Moreover, the best practice does not remain constant; it changes over time as does an organization's own performance. Subsequently, the benchmarking needs revising to replicate internal changes and the changing competitive landscape (McGaughey et al., 2005). Benchmarking requires continuous learning to increase the full benefits of the benchmarking exercise (Codling, 1998). The more benchmarking is practiced, the more it can be useful to the next time. The decisive aim is the company in which benchmarking is just another facet of the culture, conducted with all at all levels. According to Dertouzos et al. (1989) and Hines (1998), the benchmarking seeks to build competitive capabilities in terms of technology, productivity, quality, and delivery to use against competitors. Benchmarking has been proved to be a valid tool for both domestic as well as international businesses. Benchmarking is a helpful tool for the empirical justification of enhanced operational and business performance outcomes in both domestic as well as global businesses (Voss et al., 1997; Luria and Wiarda, 1996; Lefebvre and Lefebvre, 1998). Benchmarking is used to get better performance by considering the methods and practices essential to attain world-class performance levels. The benchmarking's most important objective is to understand those practices that will provide a competitive advantage; target setting is secondary (Camp, 1995). Fig.1 shows the change of the focus of benchmarking with time.

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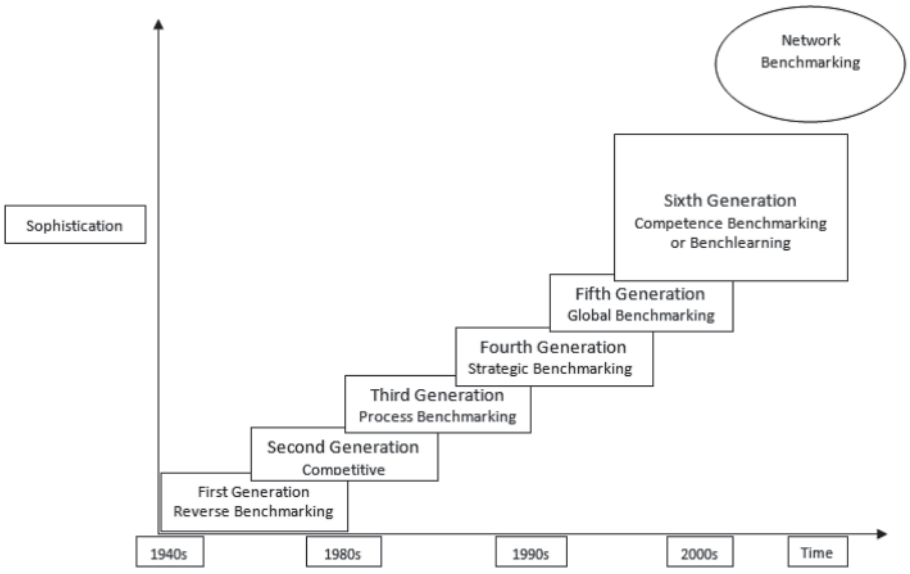


Source: Watson (1993)

Fig.1: Growth of benchmarking as a quality improvement tool

2.0 Concept of benchmarking

Targeting the best practices of the industry is considered as one of the tools of total quality management (TQM). The use of this tool is extremely important because firms need to measure their functions against the best practices in the global industries. Benchmarking is that a company would compare its products, prices, policies, programmes, or strategies to those of the best companies in the industry. It can be internal, comparing one department to another and external which would necessitate an organized benchmarking function. For an organization to maintain performance benchmarking, the function should be an organized and documented function completed on a perpetual basis. Thus, the aim of benchmarking is to build the most excellent in class target for the company, based on the information from both internal as well as external sources. The secret to benchmarking technique is "borrow – adopt – refine" the best attributes for continuous growth and development. According to Camp (1989), learning by borrowing from the best and adapting their approaches to fit your own needs is the essence of benchmarking. The theme of benchmarking concept is illustrated in Fig.2.

A benchmark is a point of reference against which things are measured for determining the status. In business, these points of reference can measure by questions about the product or service, e.g., how many, how much money, how much time by studying other industries and comparing the answers to these questions, we can compare our performance against to that of others. As a result, an organization will be able to set new goals and adapt the best practices to their organization. This helps them to assure their customers with the best quality, cost, product, and services. Benchmarking has broad application in problem-solving, process improvement, innovation, re-engineering, strategy setting, planning, goal setting, and in other contexts also. Quite simply, benchmarking is an elementary business skill that supports quality excellence. Benchmarking can help in developing realistic goals, strategic targets, and facilities for achieving excellence in operation and maintenance (Almdal, 1994). Benchmarking is a well-planned and organized process with clear objectives and mechanisms to measure, compare and discover innovative ideas, assess if these suit or adopt practices and implement improvement. Benchmarking provides a proper exchange of information within an objective structure and timeline and focuses on learning (Meade, 1998). According to (Learning and Teaching Unit, 2012),

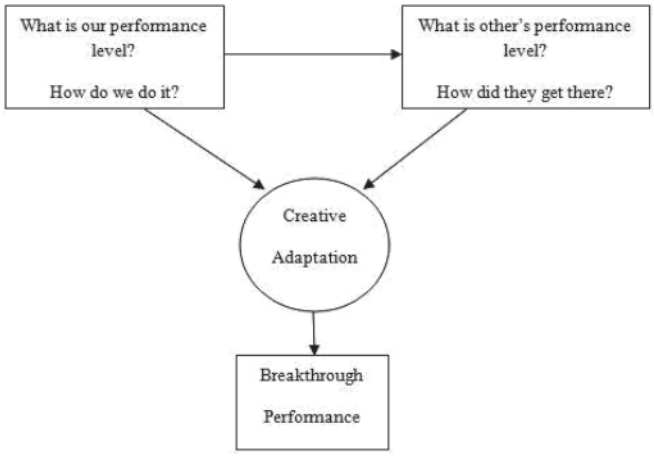


Fig.2: Concept of performance benchmarking

comparisons may be made against individual benchmarking partners or groups; sets of accepted standards; or data from past performance. Benchmarking has also been a widely used and commonly accepted business practice for many companies (Yaisn, 2002). It has also evolved into total quality management (TQM) and a powerful tool for performance analysis (Kirby, 2005). Finnigan (1996) names the key process steps in benchmarking as establishing the study plan, conducting the study, analysis of data, internalizing results and the closing gap with the competition, which includes integrating, action and implementing plans and monitoring progress. Elnathan, Lin and Young (1996) had defined benchmarking as the process by which an organization targets key areas of improvement, studies the best practices of others, and implements processes and systems to improve its own performance. According to Edith Cowan University (2011), benchmarking is a continuous and systematic process

of comparing products, services, processes and outcomes with other organizations or exemplars, for the purpose of improving outcomes by identifying, adapting and implementing best practice approaches. Benchmarking is different to using quality assurance models, as quality assurance models normally focus on least suitable standards and conformity and they are regularly imposed by management or external inspection requirements (Henderson-Smart, 2006). On the other hand, benchmarking sits within a broader framework of quality management and improvement (Wilson, Pitman, and Trahn, 2000). One of the most significant benefits of benchmarking is the discovery of innovative approaches and ideas. According to Meade, 1998; benchmarking highlights problem areas along with the potential for enhancement, providing inspiration to modify, and assists in setting targets and formulating policies and strategies. As a result of benchmarking, university leaders would know how their institution rates in definite areas in comparison with other ones, ascertain their competitive position relative to others, and also reveal the ways of enhancing their standard (McKinnon, Walker, and Davis, 2000). Benchmarking can make sure that plans are being carried out and exhibit areas of merit to stakeholders (Wilson and Pitman, 2000). Elnathan, Lin and Young (1996) define two dimensions for benchmarking classifications: information gathering methods and information sharing methods. Denrell (2005) points out the limitation of benchmarking execution, i.e., selection bias. Selection bias means "relying on samples that are not representative of the entire population." If companies consider only successful companies for a comparison, they will not have a total picture of success through implementation of remedial measures for failures.

Management support is a decisive factor in the success of benchmarking. Definitions of benchmarking vary in literature when the objectives invariably consist of measurement, comparison, and identification of best practices, implementation, and improvement. There are a large number of definitions available in the literature and according to Nandi and Banwet (2000) reported that Spendolini (1992) has found out 49 definitions for benchmarking. According to Maire et al. (2005), the multiple definitions express various stages in the evolution of benchmarking and based on the definitions they have concluded that benchmarking conceded four important stages of evolution. Experts have revised the definition in line with the objectives as were given by Bemowski (1991), Vaziri (1992), Lema and Price (1995), Epper (1999), Sarkis (2001), Dervitsiotis (2000), Freytag and Hollensen (2001), Maire (2002), to name a few. The extensively used definition of benchmarking states that: It is the process of identifying, understanding, and adapting excellent practices from organizations anywhere in the world to help an organization to improve its performance. Benchmarking is an activity that looks obviously to find best practice and high performance and then measures real business operations against those goals (Kumar et al., 2006). Benchmarking definitions vary in response to changing organizational goal requirements and their performance measures. Recently, the focus of benchmarking has shifted to address the issues on improving the benchmarking process, i.e. it focuses on in-depth study of benchmarking to identify the missing links. Dattakumar and Jagadeesh (2003) supported this fact and according to them, "it can be said that the benchmarking technique has seen a balanced growth and appears to be heading towards maturity level, considering the gamut of publications."

3.0 Perceived benefits of benchmarking

To be one of the best in any field, an organization has to practice benchmarking and should try to replicate the benchmark processes and styles. This practice helps companies to do their things in a better way. According to Allans (1997), the choice of practicing benchmarking is very helpful to organizations by starting a lot of ideas, processes, approaches, and concerns. Some of the perceived benefits of benchmarking are discussed below as:

Strategic tool

Leapfrogging struggle is another motive to exercise benchmarking as a strategic tool. A company's competitors can be stuck in the same rut as the company deciding to benchmark. It would be feasible to get a jump on competitors by using new-found strategies. This opens up an opportunity for growth that the competitors may not be aware of (Allan, 1997).

Vehicle to precede performance

According to Fuller (1997), benchmarking also assists companies to find out new and advanced approaches to the issues faced by the management and serves as the basis for training. Benchmarking acts as a medium to improve performance by supporting in setting feasible goals that have previously been confirmed successful.

Evaluation of performance tool

Allan (1997) suggested that by identifying the "best" practices, organizations know where they stand as compared to other companies. The other companies can be used as confirmation of problem areas, and make available probable solutions for each area. When organizations benchmark, its use partners to share information with and learn from each other. Benchmarking allows organizations to know their administrative operations better and marks intentional areas for improvement. It is a best way to learn from other organizations that are more successful in particular areas.

Enhancing individual design and productivity

Muschter (1997) noted that organizations are benchmarking for a variety of reasons. The reasons can be panoptic, such as rising productivity, or they can be definite, such as enhancing an individual design. By simply looking

outside itself, an organization can recognize breakthroughs in thoughts. A similar process used in a various way can shed light on new opportunities to use the original process.

ENHANCE LEARNING CAPABILITY

According to Brookhart (1997), another motive to benchmark is overcoming incredulity and increasing learning capability. Taking an example, selling or hearing about another organization's processes and how they are working will assist employees to think that there may be an enhanced way to participate and finish.

CONSTANT DEVELOPMENT TOOL

Benchmarking is increasing its popularity as a tool for continuous enhancement and development. Benchmarking establishes methods of measuring each area regarding units of output as well as cost. Lyonnais (1997) suggested that benchmarking can maintain the process of budgeting, strategic planning, and capital planning. In the early 1980s, Ford Motor organization required to alter a lot of aspects of its operations to reduce costs due to the suffering automotive market. The management of the company believed that it could advance processes in the accounts payable department. After assemblage data on Mazda's accounts payable operations, Ford examined and compared its own accounts payable operations. As a result, Ford cut down costs by 5 per cent.

4.0 Use of benchmarking in industries

Benchmarking is not a new tool; it is just a new name for the concept that existed prior in the public sector. Governmental entities were forced to execute a concept related to benchmarking in the 1970s, long before it was widely used in the private sector. Public sector companies had to benchmark themselves against similar organizations to show responsibility for the use of resources to the governmental authorities (Bowerman, Ball, and Francis, 2001). The term relative performance evaluation is another name to what is known today as benchmarking (Dopuch and Gupta, 1997). Benchmarking technique is used not only in economics and business organization but also in information technology, insurance, financial management, facilities management, human resources, utilities and education (Alstete, 2008). Azhar and Omar (2008) added that benchmarking is mainly useful in industries where cost effectiveness is important, and competition is strong. Benchmarking has been mostly applied in finance and accounting functions, including planning and budgeting, financial analysis, billing, accounts receivable, accounting systems development, credit collections, and internal auditing. Companies can compare practices, functions, activities, products or performance against a benchmark (Azhar and Omar, 2008). Comparing amongst firms, Xerox is regarded as the pioneer in the USA to have used benchmarking as a business practice. Ahren and Parida (2009) have used benchmarking data for the railway infrastructure and noted that benchmarking is an efficient tool that can support the management towards continuous enhancement. Benchmarking has been widely used by various industries worldwide, both for domestic as well as global businesses.

5.0 Benchmarking practices in various countries

In the early 1990s, 65% of the Fortune 1000 organizations used benchmarking as a management tool to gain competitive advantage (Foster, 1992). In France, benchmarking was so popular that 55 per cent of the French 1000 companies used benchmarking frequently and 80 per cent of them regarded it as a successful tool of change (Maire et al., 2005). According to Ball et al. (2000); Luu et al.(2008); Graham (2005); Jarrar and Zairi (2001), as being a competitive tool, benchmarking was embraced by firms cutting across different industries including education, manufacturing, healthcare sector, banking, financial services, construction, insurance and government along with others sectors. Researchers have also focused on performance measures and setting goals, and they establish that several companies rely on choosing the benchmarking performance measures that are linked with an organizational plan (Meybodi, 2009). The application of strategic tools by management to achieve competitiveness is forever aligned towards the organizational objectives and goals. According to Rigby (2001), by the year 1999, more than 70 per cent of company managers globally used the following four types of management tools: strategic planning, mission and vision statements, benchmarking and customer satisfaction measurement in descending order of their use. Consultants, practitioner journals, statutory and professional bodies suggest benchmarking as an explicit requirement for betterment of several organizations. However, there are facts that in some situations the costs may outweigh the profits. The exercise of benchmarking was not limited only to the western world. Japanese firms used benchmarking broadly as a planned tool to catch up with the world's best firm (Ohinata, 1994).

Benchmarking is completely consistent with 'kaizen' (Imai, 1986), constant performance improvement through process orientation and now adopted quite widely in the UK manufacturing sectors. One should keep in mind that benchmarking or analogous approaches were not the usual practice in all kinds of organizations. Thus, it is essential to separate out benchmarking from the myriad approaches to performance measurement (PM) and improvement which is really found in some form in the majority of UK organizations. According to Meybodi (2005), in the last four decades many research outputs on the application of benchmarking in various disciplines of industries and services were reported. Successful outcomes of the application of benchmarking in the British Royal Mail have been reported by Zairi and Whymark (2000). The application of benchmarking as an effective tool is suggested by Ford and Evans (2001), Evans and Dean (2003). Soni, et al. (2010)

argued that benchmarking is a tactic used to assist learning from outside. Though, implementing practices developed by one company often cannot simply be adopted by a different company. For instance, significant differences in the environment of different countries could make a few practices non-transferable (Tyler, 2005). As a result of such a situation, some of the benchmarking practices, such as cost and quality control, sales maximization and market share (Salem, 2005), which have been adopted by companies in one country, may not be easily prescribed to companies operating in different environment. Jarrar and Zairi (2001) have conducted a survey of about 227 organizations from 32 different countries and concluded that benchmarking had been applied in most of the sectors like manufacturing, health services, insurance, financial services, construction, banking, government, etc.

According to Wynn-Williams, (2005) and Yasin, (2002); much of the research and practice of benchmarking have found throughout the manufacturing and service companies, and have learned from practitioners rather than academics. According to Brewer (2003) of the Cooperative Centre for Construction Innovation (CRC CI), benchmarking is more than measuring performance. Its purpose is to improve performance by comparing different organizations to identify relative strengths and weaknesses. By systematically comparing the processes used by different organizations, benchmarking helps each organization involved in a benchmarking study to identify ways of improving performance. However, benchmarking is often dependent on the individual or organization carrying out the process. This is because the benchmarking process tries to realize what is already done and to obtain objective evidence or information about the level of performance a company should be pursuing. The final goal is to develop an action plan to close the gap between the poor and strong performers. The benchmarking process has to be externally focused, measurement based, information intensive, objective and action gathering. A study of benchmarking literature indicates that the key steps of benchmarking process are not considerably different from one another. A thorough self-analysis of benchmarking is very essential to enhance the advantages of it for comparing with other organizations (Epper, 1999).

6.0 Different models of benchmarking

Models of benchmarking are primarily contingent on the purposes and varies widely as presented in Table 1. According to Elmuti and Kathawala (1997), the benchmarking process should present the basic framework for action, with flexibility for adjustment to meet individual needs. The model chosen by the organization should be clear and basic, emphasizing logical planning and organization and establishing a protocol of behaviour and outcomes. The purpose of the benchmarking process models is to describe the steps that should be carried out while performing benchmarking. Although the core of different benchmarking approaches is similar, most of the authors have tailored their methodology or models based on their own experience and practices (Partovi, 1994). According to Bhutta and Huq (1999), benchmarking process may consist of many steps that vary in numbers; some companies have used up to 33 steps while others have used only four. Except pioneering ten-step benchmarking process of Xerox (Camp, 1989), other popular benchmarking models are Spendolini's (1992) five-step process, IBM five phase/14-step process (Eyrich, 1991), seven-step process of Filer et al. (1988) and many more to mention. Boxwell (1994) has suggested an eight-step benchmarking process, which has been used by Nath and Mrinalini (1995) to benchmark R&D organizations. Sole and Bist (1995) has modified the Spendolini's five-step process by adding one more step and emphasized that benchmarking assumes continual improvement as the goal of all corporations using the process and hence ensured that their model is circular. This model was used to benchmark the technical-writing departments producing sets of manuals for a product that runs on a diversity of operating systems. Similarly, Anderson and Moen (1999) have recognized 60 different existing models developed and planned by different researchers, consultants and experts academics in the field, while he was designing a new model – the benchmarking wheel. Deros et al. (2006) have reviewed some of the benchmarking frameworks and have classified the same into the following – academic/research-based models, consultant/expert-based models and organization based models. A brief definition for each categorization scheme of the models is detailed below:

TABLE 1: PURPOSES CHANGE THE SCOPE AND APPLICABILITY OF BENCHMARKING

Internal benchmarking	It can be used in same organizations having multi units around country or abroad in different aspects
External benchmarking	Comparing one organization to another is external benchmarking
Process benchmarking	Such type of benchmarking process focuses on process adopting by different organizations for producing different product and to manage their various schemes.
Descriptive benchmarking	This benchmarking uses data analysis to know the causes behind the superior performance of the competitors.
Competitive benchmarking	In competitive benchmarking, comparison is done with your products, services, processes and practices to a direct competitor using standard measurements
Generic benchmarking	Such type of benchmarking adopted better processes of other organizations independent of product types.
Standard benchmarking	It helps to motivate the staff by setting a standard specific goal.

ACADEMIC/RESEARCH-BASED MODELS

These are the models, which are developed mainly by academics and researchers mainly through their own research, knowledge, and experience in benchmarking. In these models, the academic/researcher tends to look at it from the theoretical and conceptual aspect, which may or may not have been implemented and validated through real-life applications (Deros et al., 2006).

CONSULTANT/EXPERT-BASED MODELS

These models are developed from personal views and decision through familiarity in providing consultancy to companies embarking on a benchmarking project. These models would be adequately tried and validated through implementation in the client's organization, and hence the approach taken by consultant/expert tends to be more practical oriented (Deros et al., 2006).

ORGANIZATION-BASED MODELS

These are the models, which were proposed by the organizations based on their own knowledge and experience. They tend to be extremely dissimilar, as each company is different in terms of its market, products, process, business scope etc. (Deros et al., 2006).

7.0 Phases of benchmarking

To understand and implement easily, the benchmarking has been divided into four different phases which are further sub-divided. Since it is a structural process, it is a step by step model. Benchmarking should encourage modifying the process according to the needs and requirements. The four steps of benchmarking are planning, analysis, integration and action as depicted in Fig.3 with their sub-steps as detailed below:

Planning: Identify the product, service or process to be benchmarked.

Analysis: Find out the gap between the firm's current performance and that of the benchmarked firms and explore the causes of significant gaps.

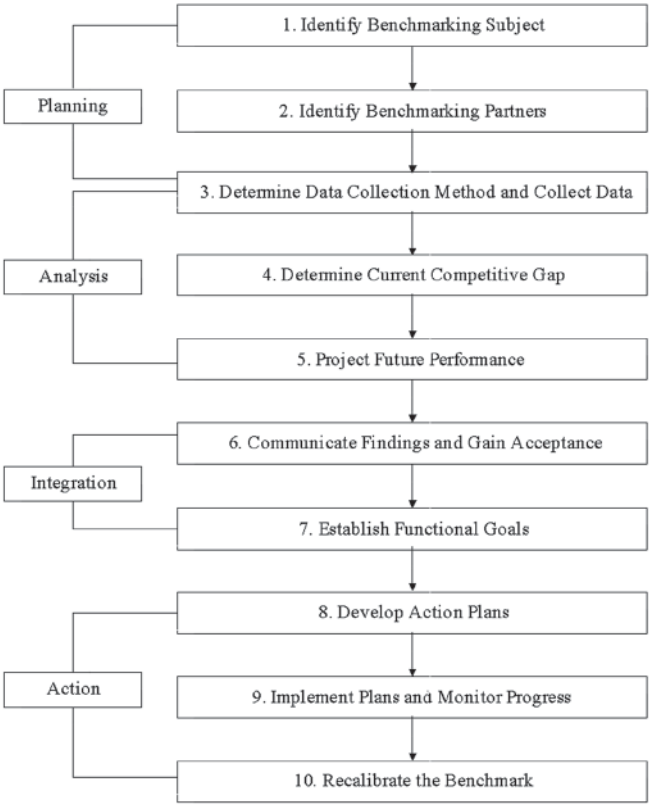
Integration: Establish goals and obtain the support of managers who must provide the resources for accomplishing the goals.

Action: Develop action plans, and team assignment, implement the plans, monitor progress and recalibrate benchmark as improvements are made.

For better use and advancement of benchmarking in future, it is necessary to know different benefits of benchmarking.

8.0 Need for a holistic benchmarking methodology for HEMM

The previous benchmarking methods are primarily based on theoretical applications, there is no any specific empirical



Source: Camp (1989)

Fig.3: Phases of benchmarking

benchmarking methodology, hence it is very necessary to develop such an empirical methodology which provides numerical benchmarked value which can be easily used for the comparison purpose and transform the tunnel view of benchmarking to holistic view by using data base. The following section gives a step by step methodology for fixing the benchmark of the Performance level of heavy earth moving machines.

Step 1: Calculate the performance of HEMM month wise.

Step 2: Classify performance figures of a month into five clusters with the help of k-means clustering in SPSS.

Step 3: Draw the demarcation boundary between the two adjacent clusters using the support vector machine (SVM) tool in MATLAB.

Step 4: Now, name each cluster from bottom to top as poor, marginal, average, moderate, and good performance levels.

Step 5: Calculate the average of good (AOG) performance of a month for fixing the performance benchmark for the respective month.

Step 6: Compute the average of the fixed twelve benchmarked values of a year for fixing the overall benchmarked value i.e., holistic benchmark (HBM) of the HEMM.

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