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A thematic review of main researches on construction equipment over the recent years

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Abstract

A considerable body of literature has been dedicated to research studies on construction equipment. Many topics were discussed and analyzed and various conclusions have been reported. However, research papers published in relation to construction equipment, are highly diversified and there is a lack of systematic analysis and classification. Hence, a complete understanding of the topic is not possible, nor is the assessment of any future research direction. A meta-analysis of the latest journal papers dedicated to construction machinery would not only delineate the fields the academic research was concentrated on, but it would additionally reveal potential gaps for future research.

In the current study, through a systematic review of the academic literature that has been published over the last decade primarily identified via online databases, main research themes such as optimization, maintenance/downtime, productivity, robotics and automation, operator's competence, innovation, environment are determined and discussed and future research directions are proffered. The outcome of this paper will facilitate future researchers to develop a body of knowledge of progress on construction equipment and its potential functions and provide future research directions on this issue.

Keywords: construction equipment; optimization; productivity; maintenance; research

1. Introduction

"Construction equipment" (CE) or "Heavy equipment" refers to heavy-duty self-propelled vehicles, specially designed for executing construction tasks. Its use has a significant importance in the successful realization of civil projects; it therefore represents a major capital investment for the construction industry. In this research, the term CE refers to the machinery that is used especially for earth-moving operations (excavators, dump trucks, loaders, compaction rollers, graders, scrapers, etc.). Those earthworks mainly consist of four basic processes: excavating, hauling, spreading, and compacting [1].

There is a lot of research work on CE. However, research papers published in relation to CE, are highly diversified and there is a lack of systematic analysis and classification. A previous organized research on this subject can only be traced in the review conducted by David J. Edwards and Gary D. Holt [2]. In their work the authors highlighted, regarding the future research direction, the following:
- Machine maintenance might develop with more sophisticated predictive models that enable "just-in-time" component replacement,
- Plant location and spatial data might be expanded to embrace large fleet management,
- The concepts of autonomous machine control, automated systems and robotics might all be more inviting to researchers in the future given the advantages of "unmanned" machines,

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● The adoption of nanotechnology and the production of hybrids could be further possible avenues of development,

Given the above, an updated review on the latest published academic papers dedicated to construction machinery would not only reveal the fields the research was eventually directed to, but it would additionally delineate any potential gaps for future research. The paper begins by presenting the method employed to determine the major research outcomes, followed by a review of the academic papers. Principal research themes are identified; practices and possible gaps in research are discussed and future research directions are proffered. Finally, conclusions are drawn.

2. Methodology

A search (2016) via online databases such as SCOPUS, ASCE, ELSEVIER and EMERALD was carried out to determine the major research themes related to the field that have been published over the last decade. Search keywords like construction equipment, productivity, optimization, research, earthmoving operations, were involved in the title, abstract or keywords of the articles searched. Papers derived from editorials, books review, forums, article in press, conference/seminar reports, discussions and articles published more than a decade ago were excluded from this research. Nevertheless, where it was considered necessary for reasons of documentation, some extra papers were added. After collecting the published work, an analysis was performed in order to classify the main areas of interest. It must be clarified that the sample was indexed in a subjective manner and that some themes might present a lot of commonalities on account of the complex interrelationships among them (Fig.1). Moreover, it is acknowledged that the review is in no case exhaustive. The themes and number of papers falling within them are shown in Table 1:

Table 1: Number of papers falling within the seven Themes identified

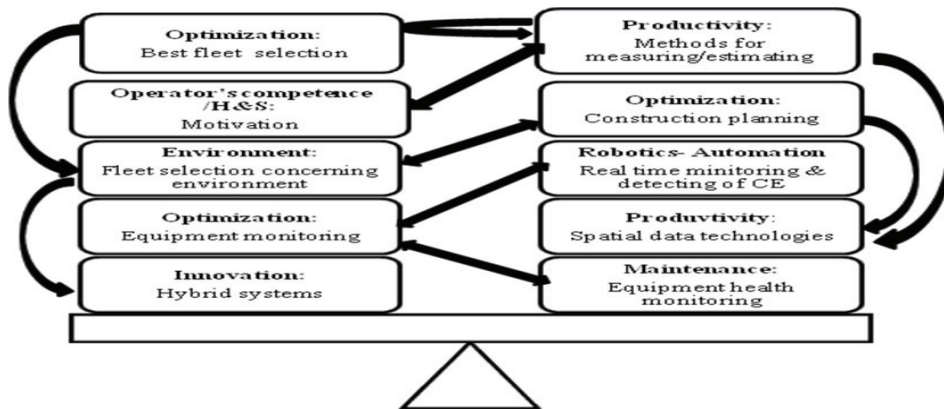| Themes identified	Number of papers detected
Optimization	12
Maintenance/ Downtime	11
Productivity	12
Operator's competence / Health & Safety	11
Robotics/ Automation	9
Innovation	10
Environment	8
Sum	73

Fig. 1. Indicative interrelationships between sub-themes

3. Literature review

3.1. Optimization

Optimization deals with finding optimal decisions under the given constraints considering the number of possible alternatives. This theme covers a variety of subjects that involve decision-making to increase resource use efficiency, minimize construction cost, reduce construction time and improve quality. Construction project scheduling has received a considerable amount of attention over the last years and many models were developed. For example, Moselhi and Alshibani [3] developed a model that utilizes genetic algorithm, linear programming, and geographic information systems (GIS) to support management functions. As such, Zhou et al. [4] presented a review of the methods and algorithms that have been developed to examine the area of construction schedule optimization. Appropriate fleet selection is a prominent issue, making it therefore significant for many researchers. Zhang [5]