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Single closed form travel time model based optimization of flow rack AS/RS

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Abstract

This paper focus on optimizing the dimensions of a new flow rack AS/RS using a single machine for storage and retrieval operations in order to minimize travel times of this S/R machine. The goal is to find the number of horizontal, vertical and in depth storage segments to minimize travel times. In addition to that, the system is studied according to variation of load rate and dual cycles' occurrence proportion. A general model of travel times involving single and dual cycle times was developed; the occurrence of dual cycle versus single cycle is introduced in this model by using a parameter named δ. This model is used to determine optimal dimensions. The dimensions of our AS/RS represent integer numbers, so enumeration method could be used to find those dimensions, this is done using a JAVA software developed for that purpose. In this work wide variations in system sizes (from 200 to 20000 storage segments system), load rate, S/R machine speed and double cycle proportion relative to the single cycle have been tested.

Keywords:

Optimization, AS/RS, travel time, enumeration, 3D rack, single cycle, dual cycle.

Nomenclature

$\overline{E(SC)}$ expected storage time

$\overline{E(DC)}$ expected dual cycle travel time

$\overline{E(RC)}$ expected retrieval cycle travel time

M number of storage segments in a locker

N storage capacity (i.e., total number of storage segments)

N_l number of lockers on each row

N_h number of lockers on each column

T normalization factor

t_h horizontal travel time from the pickup/drop-off point to the farthest column

t_v vertical travel time from the pickup/drop-off point to the farthest row

t'_h horizontal travel-time between two consecutive lockers ends (bins) (it should be noticed that horizontally, if a locker end (bin) is dedicated for storage, the next one is dedicated for retrieval).

t'_v vertical travel-time between two consecutive lockers (it should be noticed that vertically, all locker ends (bins) are either dedicated for storage, for retrieval)

ρ load rate

b shape factor

t'_p travel time from storage to retrieval ends of a locker: $t'_p = max(t'_h, t'_v)$

δ occurrence proportion of dual cycle

S/R Storage/Retrieval

AS/RS Automated Storage and Retrieval System

1 Introduction

The current world economic situation is animated by competition, race for profits and market share, as well as companies engaged in ruthless wars using all contrivances in order to ensure their sustainability.

This circumstance obliges them to find the necessary competitiveness factors in order to get a place in the market and that by acting on the organizational, technical and human aspects.

Therefore the technical competitiveness involves the possession of high-performance equipment in addition to a flawless technical know-how at all levels and functions of the company, which leads inevitably and rightly to consider the possession of powerful storage and retrieval system as evidence.

In this paper, we initially intended to find the optimal dimensions of flow rack AS/RS using a closed form equation which was developed referring to a previous work done by Sari and Bessnouci [1], in which equations that express different travel times were implemented.

Then these optimal dimensions will be studied in order to determine their variations according to the occurrence proportion of the dual cycles and load rate fluctuation. This work will allow decision makers to know if flow rack AS/RSs accept standard dimensions that minimize their travel times regardless of their future functioning (ie: single versus dual cycles, load rate. This study is performed on a wide range of configurations for systems ranging from 100 to 20,000 storage segments.