Human Machine Interface Device for AS/RS

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***Abstract*- This work addresses the large AS/RS domain in the industry, and treats two of the most important problems that this kind of equipment can be confronted with, which are the travel cycle time minimization and the efficient management of expiry dates. The main contribution is the development of a Human Machine Interface Device for AS/RS, the considered system is the single machine flow rack AS/RS. In fact, the device is composed of two principal parts, the first one is a package of computer programs which represents the software part, and the second one is an electronic circuit which represents the hardware part. Some studies were done to investigate the advantages offered by the utilization of HMIDA in comparison to a random management policy for the considered AS/RS.**

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

I. INTRODUCTION

Before talking about profit, turnover or stock quote, each company has to assure its sustainability, its existence in the middle of the arena, to assert itself at the center of the global economy, which is today ruthless, and when all companies wants to pull the cover to themselves, each one has to play its cards. Consequently for that a company can get a place in the sun, it must combine between effectiveness, efficiency, foresight, strategic vision and operational performance. However come to embody all these performance factors is not easy, that why researchers are constantly innovating new management techniques, new machines, new systems and new organizations that make converge every company that wants well towards its goals. Among these revolutionary machines and systems: automated storage and retrieval systems (AS/RS).

II. LITERATURE REVIEW

The reported studies founded in the literature and which are related to automated storage and retrieval systems are very varied. As well as, some deal with new AS/RSs types designing, others with determination of mathematical models and optimal AS/RSs dimensions, performing ingenious storage policies and finding right combination of performance factors (scheduling rules, dwell points locations etc.).

Concerning storage policies and performance factors investigations, many interesting contributions can be mentioned. Chen et al. (2010) [1] investigated the location assignment and interleaving problem in an AS/RS with shared storage, proposing a Tabu search algorithm in order to improve the solution for medium and large size problems. In (Sari et al. 2007) [2] the effect of dwell point station and restoring conveyor positions on the travel time models was studied for flow rack AS/RS, and a classification of the best positions that minimize storage and retrieval expected times has been given. Still on flow rack AS/RSs, Sari (2010) [3] conducted a comparative study between flow rack and unit load AS/RS. He considered two comparison parameters: space utilization and travel time. Bessnou et al.(2012) [4] considered metaheuristics based control of flow rack AS/RS, they investigate the scheduling on retrieval requests to minimize system response. And in order to optimize flow rack AS/RS performances, Meghelli-Gaouar and Sari (2010) [5] and Cardin et al. (2012) [6] used class-based storage policies. For the firsts, they defined at the same time classes of products sorted according to their request, and a subdivision of the rack, each bin being affected to the storage of a class, in order to decrease the expected retrieval time. However, the seconds considered an in-deep class based storage for the flow rack AS/RS, they noticed that this technique gives better results than classical class based storage.

Determination of mathematical models and optimal AR/RS dimensions is also an interesting study topic, In Kouloughli et al., (2010) [7], the authors tried to determine a useful region where the cycle times are close to their optimal values. They optimized a three variables continuous mathematical model with constraints. Some variable changes allowed the relaxation of some constraints and the reduction of the function to a parameterized one-variable function that permits analytical optimization derivation. De Koster et al., (2008) [8] and Yugang and de Koster

(2009) [9] studied 3D compact storage rack (multi-deep), they determined the optimal dimensions of this AS/RS under different storage policies by using analytical mathematical model. Parikh and Meller (2010) [10] investigate on person-onboard order picking system, an analytical model based on probability models and order statistics results, for a random storage policy was developed, this provides a more accurate estimation of order picker throughput and it also permits an examination of the tradeoff between the length and the height of the aisles. Fukunari and Malmborg (2008) [11] developed a heuristic model using closest open location load dispatching in order to determine travel time for random storage systems. Ghomri et al. (2009) [12] Presented new models for single and dual cycle times of multi-aisle AS/RS. Their study was based on a continuous rack face and aisle approximation. The closed form models they developed were compared to more complicated models for validation. Lerher et al. (2010) [13] proposed analytical travel time models for unit-load double-deep AS/RSs, considering the real operating characteristics of the S/R machine and the condition of rearranging blocking loads to the nearest free storage location during the retrieval operation. In Sari et al. (2005) [14], an investigation was performed on flow-rack AS/RS, closed form travel time expressions were developed based on a continuous approach, those were compared with exact discrete models.

Nevertheless, the flow rack AS/RS is not the only object of studies, there are many new AS/RS designs, and autonomous vehicle S/R system is one of them. The AVS/RS is a new variation of AS/RSs that uses autonomous vehicles for storage and retrieval transactions in addition of lifts, unlike classic AS/RSs that use cranes as S/R devices. Ekren & Heragu (2010) [15] performed simulation-based regression analysis for the rack configuration of an AVS/RS. They developed mathematical functions that reflect the relation between the input variables which are factors that determine the dimensions of the system and the output variables which are five performance measures. In another paper (Ekren et al. 2010) [16], the authors tried to determine main effects and interaction effects of dwell point, interleaving rule, scheduling rule and I/O location, on cycle time and utilization rate of vehicles and lifts.

Yet in new AS/RSs conceptions, a new kind of flow rack AS/RS was introduced by Sari and Bessnouci (2012) [17], this AS/RS, unlike classic flow rack, use only one machine for storage and retrieval operations. This could be possible by changing the bins shape from a parallelepiped form, to a U form that allows having only one face for S/R operations. This work deals with this type of AS/RS, other details and characteristics are presented in the following sections.

III. DESCRIPTION OF THE ONE MACHINE FLOW RACK AS/RS

A new design of storage systems could see the light of day thanks to the work of Sari and Bessnouci [17] (Fig 1), it is certainly based on a single machine but its ingenious architecture makes it significantly better than its previous. This is a summary of their work in order to shed light on the optimality of such a system.

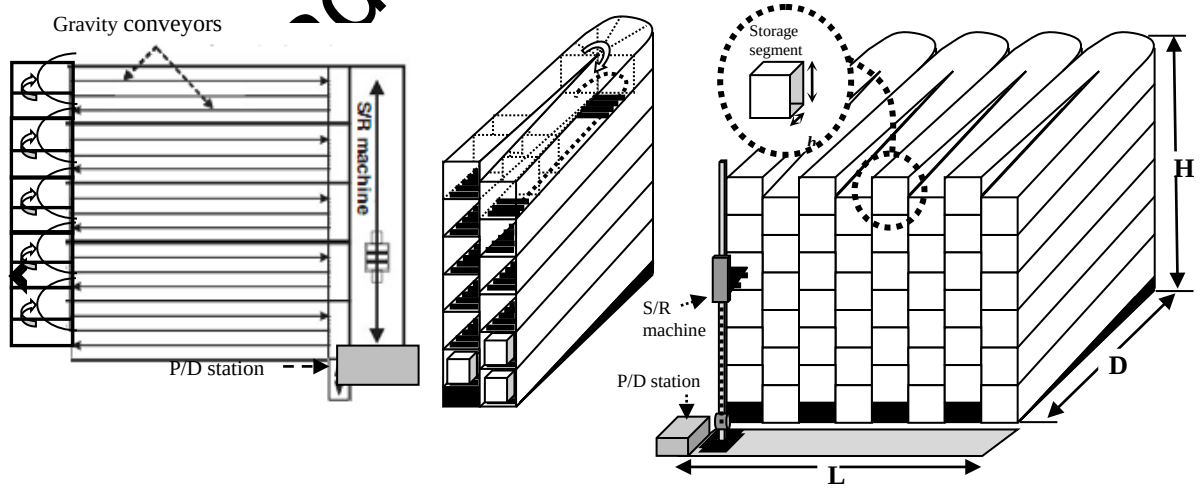

Fig. 1.Configuration of a single machine flow-rack AS/RS (top view, a series of vertically arranged bins and 3-D schematics)

The envisioned system is an AS/RS composed of a multitude of U shaped double bins lockers, distributed vertically and horizontally. They are composed of a plurality of storage segments which, thus, determine their depth.

The two bins that compose each locker are offset with respect to one another, such that one of them (eg: the left one as is the case in Fig. 1.) is raised relative to the other. The height difference between them will let the stored product slip from the highest bin to the second one under the gravity effect.

This particular design can significantly reduce the average travel time, since storage will be systematically done from the raised end of the system lockers and retrieval from the lower end.

Withal, if the entity to be retrieved is not within the reach of the S/R machine (Which means that it is not in the first position in the retrieval bin) the system will proceed to a multitude of consecutive retrievals and storages in order to reach the piece to be retrieved.

Since the retrieval of the piece located at the first position will cause the slippage of the piece that is in the second position towards the first, the repetition of this operation will lead to that the searched piece will be accessible for the S/R machine.

This operation principle, in addition to minimizing the cycle time allows the storage of several types of products, since the retrieval of a particular product is not a problem because they are all accessible.

IV. HMIDA PRESENTATION

HMIDA (Human Machine Interface Device for AS/RS) is a device that permits the interfacing between the AS/RS and the manager in order to store, retrieve and get information concerning the products stored in the system. The developed device is dedicated to the one machine flow rack AS/RS, even if it can be parameterized to work with different sizes of this system with different characteristics, as it will be presented later.

The developed device is composed by software and hardware parts. The first one is in fact a package of three computer programs, the second one is an electronic circuit which will dispatch electric signals to different S/R machine actuators.

Concerning the three programs, the main one of them is the AS/RS Manger (Fig 2). This program will allow to the manager to store, retrieve and get information concerning the products stored in the system. AS/RS Manager offer ergonomic and easy to use interface, thanks to a modular layout of the program functionalities.

The green module “STOCKER” allows to the manager the storage of articles, by introducing their noun, code, incremental number and expiration date. Then the manager has to choose between random storage in any vacant locker or dedicated storage in a chosen locker.

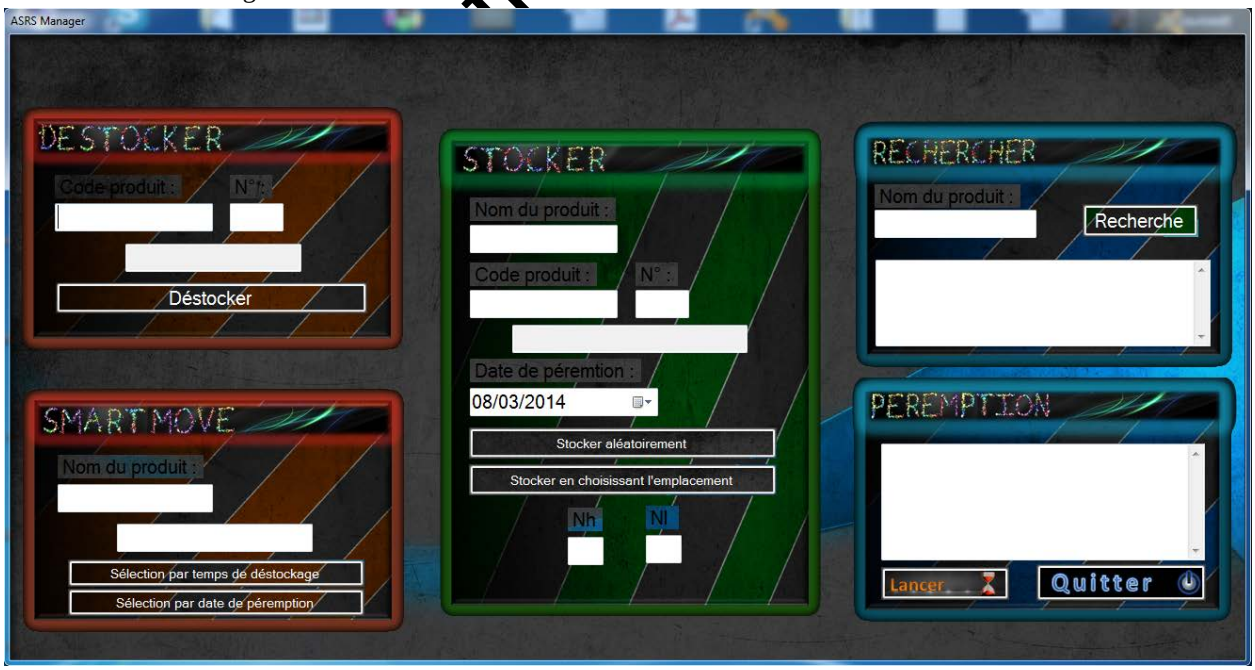

Fig 2: AS/RS Manager

The red module “DESTOCKER” allows the retrieval of articles from the system, and this by introducing their relative data which are code and incremental number. However if the manager want to retrieve any article from a set of same type articles scattered in the system, he has the choice between the retrieval of the fastest to be retrieved or the one that its expiration deadline is closest, all this thanks to the “SMART MOVE” module.

On the other hand, there are two additional modules, which are “RECHERCHER” and “PEREMPTION”, whom are blue modules. The first one displays all articles with their noun, code, incremental number and expiration date whom have the same noun that the researched item. However the second one displays all the products that are already obsolete and those that their expiry deadline is less than one week.

All this was concerning the first program, but there is a second program which is linking between AS/RS Manager and the electronic circuit, this program is named S/R Controller.

The S/R Controller (Fig 3), according to the received data which are location of the treated item and transaction type (storage or retrieval), sends other data to the electronic device via RS232, these data are characters ("h" for top, "b" for low, "d" for right, "g" for left) in order to activate different outputs of the electronic circuit at different moments. The activation of those outputs (which are connected to the S/R machine actuators) will make the S/R machine move in order to carry out the desired transaction.

Fig 3: S/R Controller

In addition to data relative to treated item, S/R controller needs information concerning the S/R machine positions, in our work we could not have a S/R machine and its different captors, however we performed a emulation in the S/R Controller, which generates fictive positions according to the directions taken by the fictive S/R machine.

Having said that, we arrive to the last program, which is the AS/RS Installer (Fig 4), this program allows the adaptation of the device for a multitude of single machine flow rack AS/RS, and this by introducing their relative characteristics, which are number of storage segments, number of horizontal and vertical lockers, dwell point position…etc. These parameters in addition to some calibrations let HMIDA work correctly.

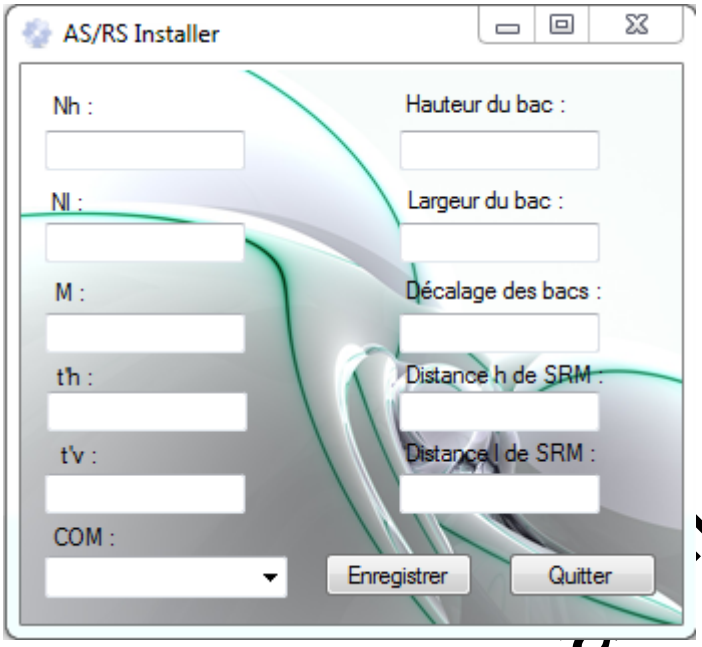

Fig 4: AS/RS Installer

Finally we arrive to the electronic circuit; this hardware part will only translates the computer data coming through RS232 into electric signals directed to the S/R machine actuators. The circuit is mainly composed of a microcontroller, a MAX232 and a RS232 port.

V. HMIDA TESTING

We would know on our work what is the influence of the utilization of HMIDA on travel times and expiry dates compared with a random management policy for the AS/RS. To do so, we implemented our device on a fictive AS/RS according to a predefined scenario. The scenario said that we have a 500 storage segments system which was filled with 350 items. The items are grouped in seven sets (products types) dispatched on all the system. Each one has its own expiration date and cycle time of course.

We supposed that after six month 50% of the items will be retrieved. For the random policy, we retrieved randomly 50% of each type of product. However when we used HMIDA, the retrieval was done first according to the expiration dates "Sélection par date de preemption", and then it was done using "Sélection par temps de déstockage" in order to retrieve the fastest item, and a comparison was done between its cycle time and average cycle time for each type of items.

After doing that some comments were noted:

- The product dedicated storage was made very easily thanks to the affected module.
- The random storage policy generated 68 expired items after six month of utilisazion.
- Utilization of "SMART MOVE" and specifically "Sélection par date de preemption" has not generated any expired product.
- The random storage policy reduced the average expiry deadline from 9 months to 3.36.
- Utilization of "SMART MOVE" reduced the average expiry deadline from 9 month to 6.6.
- The inflation between the average cycle time of an item type and its minimal value can be very large, in our scenario this inflation varied from 230% until 716%, this variation should be taken in consideration.

CONCLUSION

It was revealed in this paper that the utilization of an AS/RS can considerably ameliorates stock management, and more precisely using the developed device HMIDA, which allows, as it was seen, to save time in retrieval transactions and to avoid to have many expired item in AS/RS. However this work can be ameliorated, because there are several mechanisms to adjust to make it more robust, efficient and flexible.

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