A METHOD FOR STORING LARGE LENGTH LOADS

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ABSTRACT

The paper proposes a survey of the existing methods for storing large length loads and considers a new storing method. The method is realized by the design of an original construction – an overhead S/R machine with shortened columns. The new construction yields decrease of the machine mass and the energy consumption of storehouse manipulations.

A method of finding the productivity of the new machine is also proposed. Recommendations for how to correctly choose the speed of the mechanisms that provide the hoist capability and drive of an S/R machine are given.

Keywords: storage, large length loads, S/R machine.

INTRODUCTION

Different methods for storing large length loads are known, depending on the load geometrical-mass characteristics, store-house reserves, load circulation (i.e. frequency of load deposition/take-out) and available store-house space [1-5].

The semi-vertical storage of loads on at-wall or internal pyramid racks enables one to better distribute loads, to take them out easily and one-at-a-time, and to easily perform stock taking. Note however that such an arrangement has some disadvantages. These are poor conditions for labor protection when introducing automated load storage, slow load motion, low coefficient of exploitation of the storehouse space. Hence, it is applied in storehouses with low rate of load circulation, large load nomenclature and prevailing single take-out of bars with limited length and small linear mass, but with large resistance moment of the cross section.

The horizontal load storage admits higher degree of mechanization and automation. Depending on the load nomenclature and circulation, and on the available storehouse space, one can apply different methods of horizontal storage.

Consider low-roof or open storehouses, served by universal load-lifting machines (i.e. cranes with universal or special load grippers, universal or specialized cars, etc.). Then, one can store loads right on the floor or on stands, special pallets and cradles, as well as on block racks designed for manual load storage and take-out. Regarding load storage on high block racks with frontal machine storage/take out, one can attain a higher degree of mechanization and automation and a higher coefficient of filling the store house space. At the same time, one needs wide corridors with length longer than that of the load pieces. Note that an effective exploitation of the storehouse space (in high-roof storehouses) and an easy approach to the loads can be attained when applying load storage on alder-like racks. Their service is performed by using stock cranes [6], storage-retrieval (S/R) machines for long loads, cars with lateral fork displacement, bridge cranes with forks for long loads, etc.
The use of load high-elevation cars requires comparatively wider corridors between the racks even when employing specialized machines. The bridge cranes can be used when redesigning the existing halls in storehouses for large length loads. However, since their productivity is low, those cranes are not appropriate when designing new storehouses. Storehouse service with stack cranes is possible when there is a sufficiently wide lateral corridor. The most appropriate solution to serve alder-like racks is the use of a portal S/R machine for large length loads.

Fig. 1 shows one of the constructions of an S/R machine [4], used at present. The main beam 1 is supported by columns 2 that are driven on rail road 3 mounted on the floor or on trestles fixed at a definite height over the store house floor. The load grippers – rotating four-horn forks or telescopic ones 4, are carried by a movable beam 5 and the pulley block system 6. The device passes over the racks 7 and when reaching the desired corridor, shifts downwards and occupies a position in front of the corresponding cell. When shifting downwards, the moving beam is driven in the telescopic sections 8 of the S/R machine columns. Usually, loads are placed in tub-like pallets (tubs) which do not function as carriers but contribute to the formation and stabilization of the load unit during machine operation and load storage.

Obviously, the use of a portal S/R machine provides good exploitation of the storehouse space. However, one can point out as a disadvantage the great eigen mass of the machine, especially when operating in high-roof store houses. Consider the modern tendency of more rational exploitation of the available space, i.e. increase of the storehouse floor-roof span and decrease of the exploitation expenses (including those for energy consumption). Then, it seems appropriate to look for a solution that would decrease the energy consumption.

**STATEMENT OF THE PROBLEM**

**Structural solution**

The proposed method of storage for large-length loads is based on the use of an original construction. This is a portal S/R machine with shortened columns which moves on a rail road mounted on the stands [7].

Fig. 2 shows the stand structure. The railroad 1 is carried by columns 2 which at the same time fix the end supports of the alder-like rack by means of consoles 3. Directing profiles 4 are mounted right under the railroad and in the middle of the space (corridor) between the racks. The load units 5 are transported to the feeding table 6 by means of internal transport.

It is also possible to fix the railroad to the hall walls if the storehouse would carry such a load.

Fig. 3 shows an exemplary structural solution of a portal S/R machine with shortened columns. Load elevators 2 of the pulley block 3 are mounted on the main beam 1. The pulley blocks occupy a position right at the frontal beams 4 whose driving wheels roll on a
railroad 5 fixed to the stand (Fig. 2). The load unit (tub) 6 is carried by two telescopic fork mechanisms 7 with bilateral displacement. They are fixed to a moving beam 8 which is driven on the directing profiles 9 by means of rolls 10. The S/R machine directing profiles are fixed to the frontal beams and the flanges are beveled or rolled at their lower end. A single-beam design, employing telphers (hoists), is also possible.

When lowering the movable beam, the S/R machine is positioned in such a way that its directing profiles stand right over those of the subsequent stand corridor (Fig. 2). The upper ends of the flanges of the corridor directing profiles are also beveled or rolled. The leading rolls of the movable beam pass from the machine directing profiles to those of the stand and vice versa. The beveling (rolling) of the profiles at the spot of roll transition (from one directing profile to another one) guarantees admissible inaccuracy (5 mm) of the driving mechanism positioning. It is desirable to synchronize the motion of the two pulley blocks. This could be done, for instance, by introducing a parasitic chain gearing. The eigen mass of the proposed machine does not depend on the storehouse floor-roof span, and it is significantly smaller than that of the SR machine shown in Fig. 1. This enables one to decrease energy consumption during the machine exploitation, at the expense of negligible increase of the cost of storehouse building. These expenses are needed to cover mounting of additional directing profiles between the stands.

**Determination of the machine productivity**

It is known [2] that the theoretical productivity of a load-lifting machine with cyclic performance is determined by the expression

\[ P_r = 3600 \frac{Q}{t_c}, \]  

where \( P_r \) is the productivity, t h\(^{-1} \); \( Q \) - mass of the maximal carried load, t; \( t_c \) - time of the working cycle (needed to process a unit load), s.

The cycle time of the SR machine under consideration can be expressed as a sum of the following times:

\[ t_c = 2t_{x1} + 2t_{x2} + 2t_{xj} + 2t_{LU} + \sum t_p \]  

where \( t_{x1} = const \) is the time of load elevation, starting from the feeding table and ending at the upper final position; \( t_{x2} \) - time from the start until reaching the \( j \)-th corridor (the driving mechanisms operate during this time interval); \( t_{xj} \) - time from the start until reaching the \( j \)-th floor (level). Here the elevating mechanism operates from the start until occupying the upper final position, and from the upper final position until reaching the corresponding level; \( t_{LU} \) - time of performing loading/unloading, including fork stretching and flexion, load storage/take out and the pause between those two operations; \( \sum t_p \) - sum of pauses between the actuation of the various mechanisms. Consider the sub-times of the working cycle. Then, the time of operation of the driving mechanism \( t_{x2} \) when reaching the desired corridor, and that of operation of the elevation mechanism \( t_{xj} \), when reaching the subsequent floor, affect most significantly the machine productivity. To attain the needed accuracy of positioning, both mechanisms have two speeds - basic speed \( v_b \) and micro-one \( v_{\mu} \). The following cases are possible, depending on the time of mechanism operation: attaining maximal value of the basic speed \( v_b \) (Fig. 4a); not attaining maximal value of the basic speed (Fig. 4b). This case is possible when the distance is shorter; operation
under micro-speed $v_{mp}$ only (Fig. 4c), for a short time of mechanism actuation.

Consider an S/R machine operating in storehouses for palletized loads. Then, both mechanisms operate jointly when reaching the desired address. Moreover, one should choose mechanisms basic speeds such that the load wheelbarrow move along the storehouse diagonal during their joint operation [2-4]. Consider now the outlined method of storing large length loads. Then, both mechanisms operate successively. Their basic speeds should be found on the basis of the admissible acceleration (retardation) requirements, and one should coordinate the speeds with one of the storehouse dimensions, only. When dealing with a large number of addresses, the magnitude of the mechanism driving speed $v_{m}$ avoids the miss-match of operation without attaining the maximal speed (Fig. 4b). The specificity of the elevation mechanism is that in all cases the load is at first elevated in the upper final position, and then is lowered to the specified addresses. Here the use of a larger basic speed $v_{mp}$ is justified.

$$v_{bp} = \sqrt{2\left[a_{x}\right] \cdot L \cdot K_x} ; v_{bz} = \sqrt{2\left[a_{z}\right] \cdot H \cdot K_z}$$ (3)

where $L$ and $H$ are the storehouse length and height, respectively; $\left[a_{x}\right] = 0.3-0.4$ m s$^{-2}$ and $\left[a_{z}\right] = 0.8-1.0$ m s$^{-2}$ are the admissible accelerations of the driving and elevating mechanisms, respectively; $K_x$ and $K_z$ - coefficients that account for load arrangement. For an arbitrary load storage, however, we have $K_x = K_z = 1/2$. For storage of loads with larger frequency of load take-out near the feeding spot, $K_x = 1/4$, $K_z = 1/2 - 1/3$. The above mentioned specificity of the elevation mechanism, i.e. load lift in the upper final position, regardless of the storage address, allows for the recommendation of greater speeds of the elevation mechanism.

CONCLUSIONS

The paper proposes a new method for maintenance of storehouses for large length loads.

An original construction of an SR machine with shortened columns for carrying large-length loads is presented. It allows for the decrease of the machine eigen mass and respectively - for the decrease of the energy consumption of the driving mechanism. The construction is especially effective for small load carrying capacity and for large floor-roof span.

A method of determining the productivity of the new machine is also proposed. The study gives recommendations to choose properly the speeds of the elevation and driving mechanisms.

REFERENCES

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