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Drop and Pull Transport Based on One Vehicle with Dual Use in Automotive Logistics

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Abstract: By further analyzing the present transportation of truck-load and spare parts in automotive logistics, this study innovatively proposes the concept of "micro container transport" based on drop and pull transport of one vehicle with dual use. Besides, the paper elaborates the merits of this concept in spare parts transportation as well: on the premise of without altering conveyance, through the combination of micro container and truck-load transportation, it will significantly achieve the benefits of increasing efficiency while decreasing transportation costs in the meantime.

Key words: Automotive logistics, drop and pull transport, micro container, simulation

INTRODUCTION

Currently, with in-depth open of domestic automotive logistics market, China is becoming a necessary part of global economy. The rapid growth of China economy drives the increase of automobile consumption, which in turn stimulates the development of automotive logistics (Anderson *et al.*, 2003). Regarding the importance of truck-load and spare parts transportation, how to facilitate the appropriate combination between them, is a bottleneck to be solved.

DEMAND ANALYSIS OF TRUCK-LOAD AND SPARE PARTS TRANSPORTATION

The primary problems involved in the processes of truck-load and spare parts transportation are as follows.

High transportation costs incurred in logistics process: In terms of automotive industry, a well-structured distribution system not only reduces transportation costs and the inventory, but also increases the sum of circulating funds in hand. Obviously, logistics costs have large impacts on automotive logistics industry. In reality, the small batches of components are required, This results in car-pooling, matching of vehicle size with components. The problems above increase the difficulty of loading, vehicle deployment and lead to cost increase as well (Ballou, 2011).

Transportation modes need to be improved: To improve the loading rate, a large amount of existing drop and pull transport modes choose to integrate transportation of truck-load with spare parts. Nevertheless, the compatible of truck-load vehicles with spare parts conveyances is a vexing issue to cope with. An increasing number of companies endeavor to achieve the integration by designing multi-use vehicles even the costs is extremely high. Additionally, to what extent the new transportation mode can reduce transportation costs, compared with previous one, is still a matter to be considered (Cooper, 2002).

Difficulty in loading and unloading of integrated transportation: Management of component bins and racks is a complicated systematic project in implementing milk run. What's worse, there is always low level of standardization in loading and unloading of workbins and racks. Such as, throwing goods can be found in daily operations. Such operation does harm to cargoes and results in low efficiency.

DROP AND PULL TRANSPORT MODE WITH THE COMBINATION OF TRUCK-LOAD AND SPARE PARTS TRANSPORTATION

The analysis above-mentioned obviously shows that efficiency will be significantly enhanced if "one car with dual use" can be achieved. The difference between truck-load vehicles with spare parts conveyances is regarded a bottleneck. Aiming at solving this issue, the paper puts forward a concept, micro container transport. The foldable micro container transport is mainly used for mixed transportation of parts and truck-load, which standardizes

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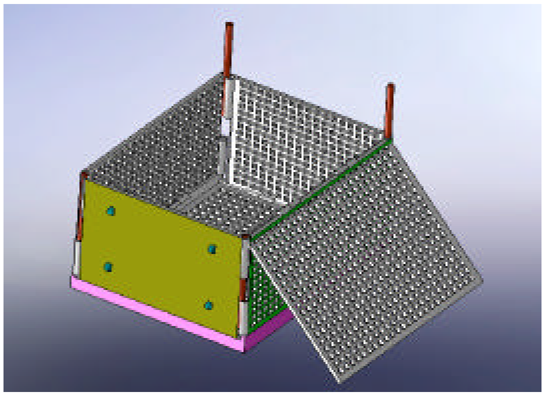

Fig. 1: Foldable micro container

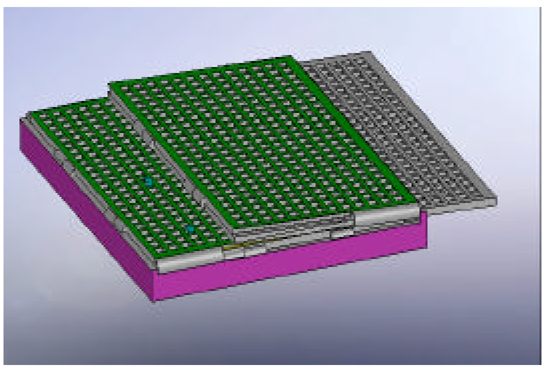

Fig. 2: Folding effect diagram

the loading unit during the transportation of spare parts (Cui *et al*., 2010). As a result, the combination with truck-load transportation is facilitated.

The flexible turn round of micro container transportation in the nationwide is beneficial in achieving the integrated management (Fig. 1). By this concept, with micro containers used as loading units and open trailers as transportation vehicles for spare parts, transportation of spare parts and truck-load in the same means of transportation can be achieved (Han, 2010). By introducing micro container concept, it helps to diminish no-load ratio as well as enhance transportation efficiency (Fig. 2).

The design ideas of micro container transportation can be summarized as follows.

Standardization: With the help of Auto Load simulation software, the stowage status of different size micro containers in mainstream automotives was studied. After comparing and analysis, we found that the most appropriate container size is 1000 mm×1200 mm×1500 mm

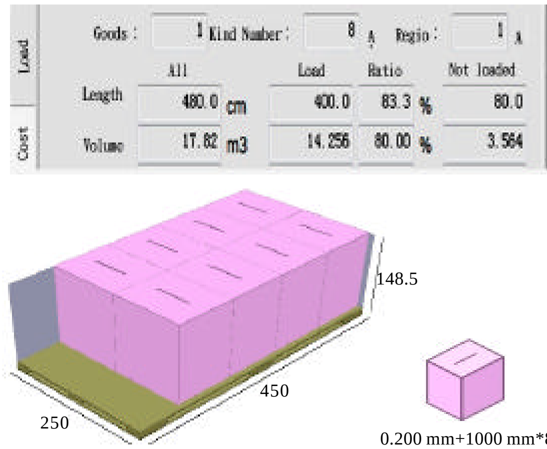

Fig. 3: JQC9160TCL Jinniu car transporter parking the 1200 mm×1000 mm specification's Micro Box simulation diagram

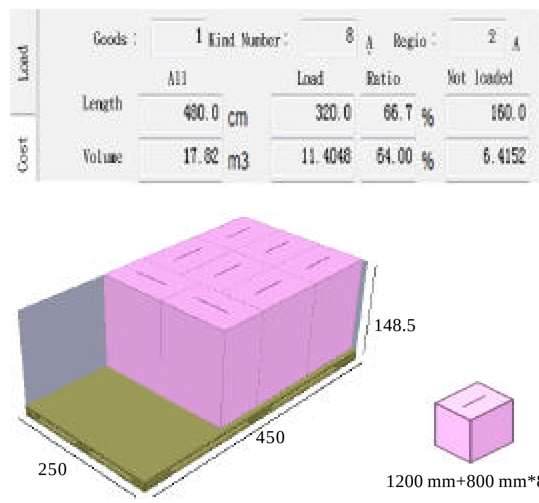

Fig. 4: JQC9160TCL Jinniu car transporter parking the 1200 mm×800 mm specification's Micro Box simulation diagram

(Fig. 3). Because it is adaptable to standard tray and the volume is reasonable, both of which will be conducive to widely application, loading and unloading.

During transportation, micro containers is loaded into the vehicle, various numbers of containers should be combined to occupy an ordinary parking space. Generally, it is recommended that each parking space be loaded with eight micro containers (Law and Kelton, 2000) (Fig. 4).

Convenience for temporary storage and transportation of return containers: Convenience should be taken into

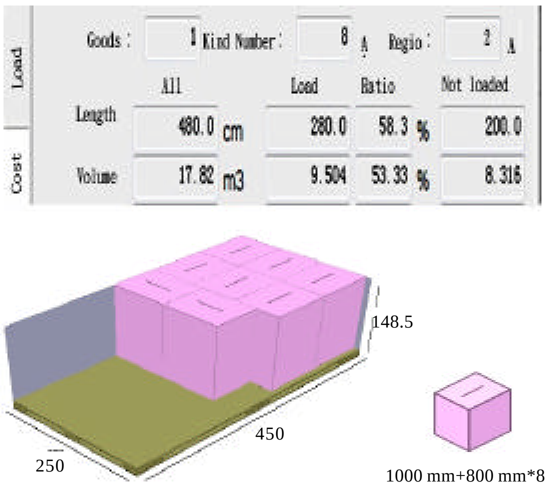

Fig. 5: JQC9160TCL Jinniu car transporter parking the 1000 mm×800 mm specification's Micro Box simulation diagram

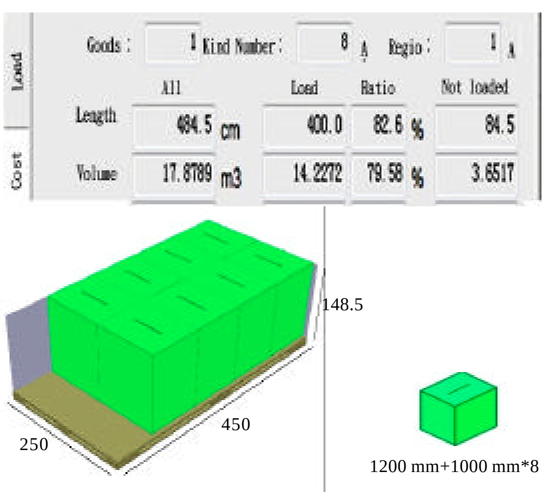

Fig. 6: PC5140TCLFXB Lingyang car transporter parking the 1200 mm×1000 mm specification's Micro Box simulation diagram

account when introducing micro containers concept. The new transit container is to be devised as foldable structure. Given handling, storage and return of containers, the bottom of micro containers will be equipped with wheels. The advantages of this design are to achieve reduction of occupied space, large range of applications, durable and lightweight, etc.

Practicality of the container unit: As standardized palletized units, micro containers can be both applied in mixed transportation and placed on the slaves, flow lines as well as other extended transport processes. Furthermore, they are stackable. Micro containers with wheels will be convenient and turn around quickly in the operation process.

For the sake of tracking micro containers, counting the number of containers damaged, obtaining lost reasons, accurately and timely, RFID technology is suggested to be introduced in the designed system (Li, 2010). Through the track for spare parts in storage and circulation stages, the system can define the real-time status of micro containers in the entire supply chain. Table 3 lists the strengths of micro container transportation.

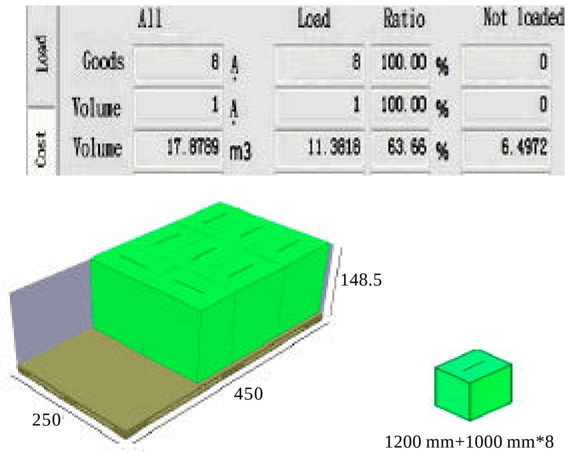

Fig. 7: PC5140TCLFXB Lingyang car transporter parking the 1200 mm×800 mm specification's Micro Box simulation diagram

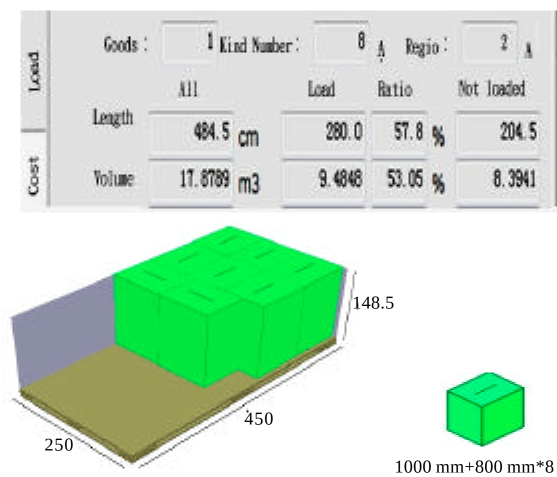

Fig. 8: PC5140TCLFXB Lingyang car transporter parking the 1000 mm×800 mm specification's Micro Box simulation diagram

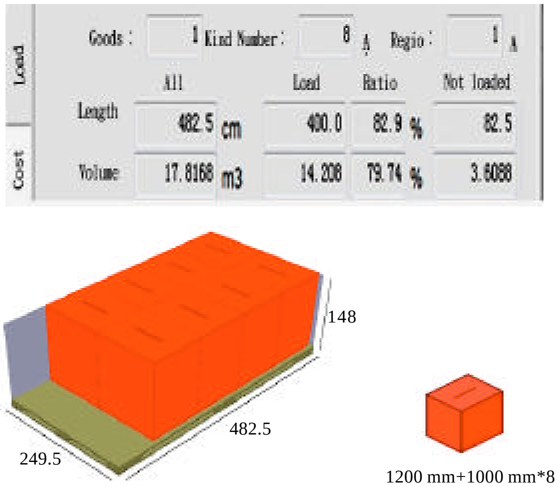

Fig. 9: THT9192TCL Anji car transporter prking the 1200 mm×1000 mm specification's Micro Box simulation diagram

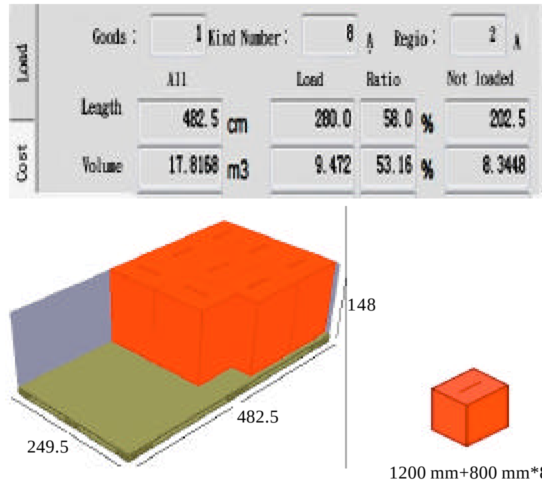

Fig. 11: THT9192TCL Anji car transporter parking the 1000 mm×800 mm specification's Micro Box simulation diagram

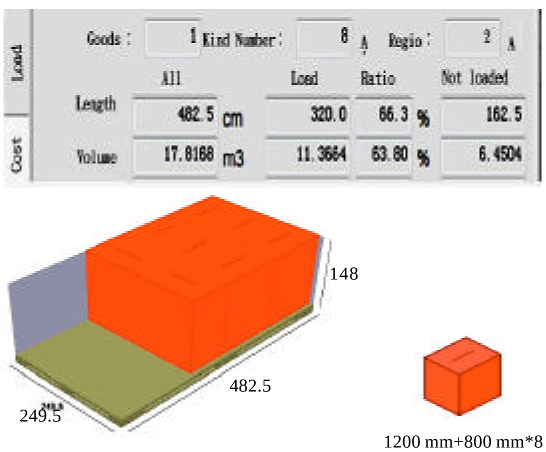

Fig. 10: THT9192TCL Anji car transporter parking the 1200 mm×800 mm specification's Micro Box simulation diagram

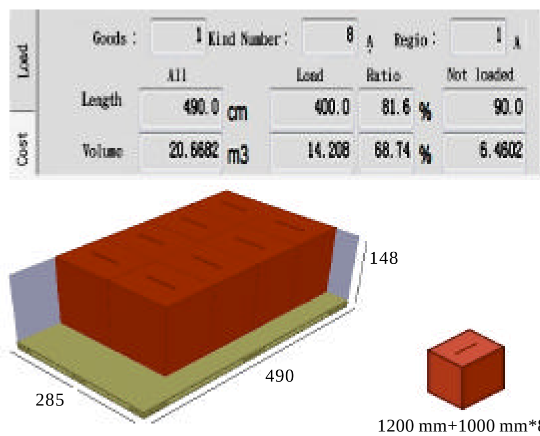

Fig. 12: Frame type semi-trailer transport vehicles 32.5 m car transporter Fuhua/BPW parking the 1200 mm×1000 mm specification's Micro Box simulation diagram

Table 1: Common model data table

No.	Commonly used in automobile transport vehicle	Vehicle loading size (unit: mm)	Parking can be loading size (unit: mm)
1	JQC9160TCL Jinniu car transporter	14000×2500×4000	4800×2500×1485
2	PC5140TCLFXB Lingyang car transporter	9000×2490×3685	4845×2490×1482
3	THT9192TCL Anji car transporter	13980×2495×3990	4825×2495×1480
4	Frame type semi-trailer transport vehicles 32.5 m car transporter Fuhua/BPW	32500×2850×3800	4900×2850×1480

Table 2: Simulation analysis table

		The utilization rate of the corresponding micro box specification of the parking area		
No.	Commonly used in automobile transport vehicle	1200 (mm)×1000 (mm) (%)	1200 (mm)×800 (mm) (%)	1000 (mm)×800 (mm) (%)
1	JQC9160TCL Jinniu car transporter	80.00	64.00	53.33
2	PC5140TCLFXB Lingyang car transporter	79.58	63.66	53.05
3	THT9192TCL Anji car transporter	79.74	63.80	53.16
4	Frame type semi-trailer transport vehicles 32.5 m Car transporter Fuhua/BPW	68.74	54.99	45.83

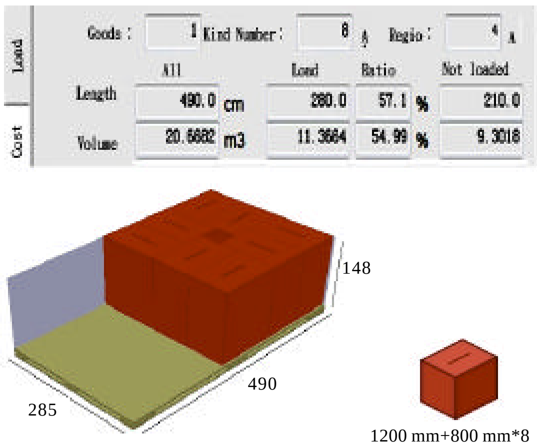

Fig. 13: Frame type semi-trailer transport vehicles 32.5 m car transporter Fuhua/BPW parking the 1200 mm×1000 mm specification's Micro Box simulation diagram

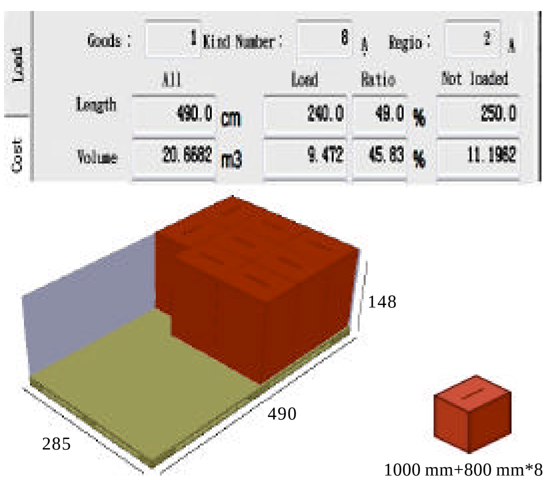

Fig. 14: Frame type semi-trailer transport vehicles 32.5 m car transporter Fuhua/BPW parking the 1200 mm×1000 mm specification's Micro Box simulation diagram

Comparison between micro container and ordinary workbin: The differences between decentralized management mode for workbins and racks with micro container transportation are shown in Table 4.

Loading spare parts with micro containers can be applied in different distribution stages, they are reusable and high efficient (Qian and Liu, 2010).

Less capital investment, high operating efficiency: One vehicle with multi-use is fulfilled by using suitable

Table 3: Strengths of micro container transportation

No.	Strengths
1	Uniform specification with fixed capacity, stackable, easy for stocktaking
2	International standardization, compatible with standard pallet, improve space utilization and loading rate
3	Low recycle costs, substitute of workbins
4	Solid structure, high loading capacity, durable with galvanization on the surface
5	Easy to operation, occupied less space with foldable structure, large range of applications
6	Convenient for loading and unloading with equipment of wheels on the bottom

Table 4: Comparison between micro container and ordinary workbin

Ordinary workbin without RFID chips	Micro container equipped with RFID chips
Hard to achieve large-scale milk run	Recyclable and reused ensure large-scale milk run
Difficult in accurately tracking workbins and racks in the supply chain	With the help of barcode and RFID, it is easy to track and real-time monitor the status
Hard to forecast the demand of workbin and racks, less flexible	Flexible to facilitate efficient management
Difficult in calculating the turnover rate of the bins, rack; unable to improve utilization	Rapid turnover with high turnover capacity
Hard to count damaged, lost bins and racks; unable to put forward effective protective measures due to lack of information	Equipped with RFID chips, easy to get useful information

stowage plan. By doing so, a large amount of money invested for promoting new design conveyances can be saved and the sharing and coordination of logistics resources between truck-load and spare parts transportation can be achieved. Through integrating vehicles of truck-load and spare parts, mixed transportation can be realized to reduce costs, optimize operation processes, improve backhaul utilization and loading rate. Taking full consideration of different requirements for transporting finished goods and components, this design can maximize inner space utilization rate. In summary, the integration transportation mode can be used to transport finished products, spare parts, as well as the combination of those two kinds of cargoes.

DISTANCE ANALYSIS FOR DROP AND PULL TRANSPORT

Suppose a batch of cargoes is scheduled to transport from the starting city GO to other m cities and finally reach the destination -city Gm+1. Prerequisites are that only one vehicle is available during the transportation, besides, the trade volume of different cities is not allowed to exceed the vehicle's total deadweight Q. The vehicle will return to city GO after visiting the m+1 th city and among the passed m cities, certain number of cities will be randomly selected to load spare parts (Song *et al*., 2000). This is to use micro containers to achieve full truck load in backhaul transportation. First, the indexes can be defined as follows:

- f1 : Profit rate without using micro container
- f2 : Return costs of micro container
- Pi : Revenue for the i th cargo
- Di : Cost for the i th cargo
- W : Transportation cost for full truckloads of freight
- K : Return container cost
- a : Loading rate
- T : Return container cycle
- d : Radius for drop and pull transport (transport distance)
- v : Variable coefficients of return container
- a : Fuel consumption per km

Establish the modal:

Profit rate without using micro container:

$$f_1 = \frac{\alpha\sum_{i=1}^{n} D_i}{\alpha\sum_{i=1}^{n} P_i} \quad (1)$$

Total revenue:

$$\alpha\sum_{i=1}^{n} P_i \quad (2)$$

Total cost:

$$\alpha\sum_{i=1}^{n} D_i \quad (3)$$

Transportation costs:

$$W = \sum_{T=1}^{n} ad - vK \quad (4)$$

Return costs of micro container:

$$f_2 = \frac{\alpha\sum_{i=1}^{n} P_i + \alpha\sum_{i=1}^{n} D_i - (\sum_{T=1}^{n} ad - vK)}{\alpha\sum_{i=1}^{n} P_i} \quad (5)$$

Make $f_2 \geq f_1$, through calculation, the radius for drop and pull transport in trunk transport can be obtained: $d \leq 500\alpha$.

Namely, when loading rate is greater than 80%, the radius is 500 km. If the transportation distance is less than 500 km, the increased revenues generated from the high efficiency are more than the incurred return container cost, therefore it is advisable to use drop and pull transport mode with micro container as loading units. If the distance is more than 500 km, ordinary transportation mode will still be used (Zhang and Sui, 2010).

CONCLUSION

The study systematically analyzes current situation of truck-load and spare parts transportation in automobile logistics, then based on the idea, one vehicle with dual use, it proposes the concept of drop and pull transport mode with micro container as loading units. In order to achieve the optimum combination of spare parts and truck-load transportation, it integrates transportation of spare parts. Combining with RFID technology, this transportation mode is aimed at reducing the capital involved as well as decreasing the loss and damage cost of spare parts. In the end, we do hope the ideas in this paper could provide useful guidance for developing the mixed transportation of truck-load and spare parts.

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