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An Experiment Research on SCM of Automotive Engine Assembly

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Abstract: To reduce the logistics cost and integrate all links that constitutes the Supply Chain Management (SCM) of automotive engine assembly, an experiment research in the engine company was carried out and both the Milk-run system and the direct line haul system are used in the case of the engine assembly. By analyzing and comparing both of the features, the applied results of the latest Milk-run mode based on WITNESS simulating are summarized. The results can be got that the method is utilized for reducing costs with transport, warehousing and stocks maintenance activities, maximizing the vehicle utilization and minimizing the time expended. Not only the stocks in all chain links are reduced, but also the establishment lasting relationships of trust between the all chain components is optimized. So that a total supply chain integration with the Milk-run mode in the future was essential that will be structured around regional and national distribution centers for the need to integrate and standardize supply chain processes to flourish in a highly competitive marketplace where maximized efficiency is paramount.

Key words: SCM, engine assembly, WITNESS, milk-run mode

INTRODUCTION

For purpose of achieving the effective integration of supply chain in the automotive industry, it is essential to establish partnership with suppliers for incorporating them in the initial stages of the product development process. By doing this, the suppliers will have more opportunities to participate in the product specification, anticipate future troubles and divide responsibilities in the product development, design, production and distribution.

Supply chain management and continuous optimization are able to bring tremendous benefit for companies (Ellram and Cooper, 2009). Modern enterprises, especially for automobile manufactures, are attached importance to upgrade company's core competitiveness and optimized processes (Patricia *et al*., 2006). The simulation model about SCM can be established by using the WITNESS software (Li, 2008; Zhao *et al*., 2008).

The Milk-run system was first established by the Japanese manufacturers Toyota and Isuzu in the 1990s (Yi *et al*., 2007). The Milk-run system functions for orders are less than a full truckload and it includes supplier pickup Milk-runs, customer delivery Milk-runs and mixed Milk-runs (Zhang *et al*., 2006). In a Milk-run pickup system, the manufacturer acts the parts purchaser, collects components periodically (not necessarily daily) by using its own or a 3PL (Thirty Party Logistics) fleet of trucks, instead of the parts manufacturer's delivery of the parts. A Milk-run pickup system manages the inbound logistics operations between a manufacturing plant and its suppliers by controlling the sequencing, routing, frequency of container pickups and the staging and parts deliveries. This method reduces inventories while speeding the flow of materials between facilities and reaches a higher efficiency for cargo loading and better vehicle utilization. The system is important for a JIT production line that needs to maintain small inventories (Chuah, 2000).

EXPERIMENT FUNDAMENTAL

Except of the cross docking mode for third of the whole parts involving a few KD parts and small quantities from remote places where were beyond twenty kilometers, there are two modes for the milk-run experiment of the SCM, Milk-run system and direct line haul system with two-thirds of the parts. In this situation, the engine plant as the parts' purchaser collected them from the local suppliers, which is just less than twenty kilometers from the engine plant. The parts are then stored in the warehouse of the engine company to feed its assemblies.

SCM of engine assembly: The engine is a complicated electromechanical device and according to the type of product it needs over 800 pieces of 300 kinds of parts to

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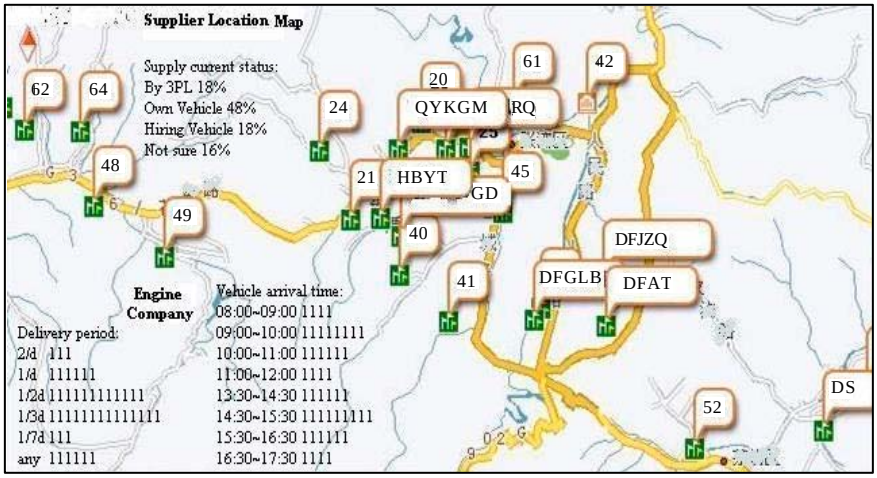

Fig. 1: The local suppliers' site map

Table 1: Pieces and storage pallet of parts

Area in warehouse	Parts and components	Type I	Type II
A	Standard components	332/32	161/16
B+C	Special components	73/172	25/68
D	Subassembly	1/40	1/20
Total	Mix Parts	406/244	187/104

assemble such a unit. Many of the cooperation parts are small components, including general parts and standard components such as bolts and nuts and about 50 key special parts (subassembly, components) are identified by the manufacturer.

After a strict suppliers' selection procedure, the manufacturer has established its supply base. Among them, the order numbers, part numbers, dimensions and supplier site locations of these main parts are listed in Table 1 and Fig. 1.

The planned annual production volume for the factory both type, all will be 10000 units, which amounts to a daily production of 40 units output. The average delivery period is about 0.5 day for C, 2 days for B and 4 days for A and so on. So each purchasing batch will be based on both the delivery period and the daily expected volume. All delivery periods are also shown as in Fig.1.

Local suppliers' distribution: A map illustrating the main suppliers' site locations is plotted in Fig. 1.

The current supply status is also shown as in Fig. 1. Most suppliers' logistics operation by own fleet of trucks and only 18% of the operation by 3PL's. Daily arrival vehicles are over 65 batches. Arrival times are not yet balanced, because the arrival peaks were concentrated on morning from 9:00 am to 10: 00 am and afternoon from 14:30 pm to 15:30 pm. On Average, the hours over 80% are busy on the operations.

Table 2: SCM experiment volunteers

No.	Supplier	Pathway	Deliver Period	Objective
1	Supplier00	Direct line	0.5days	≤1day
2	Supplier01	Pathway 01	1 days	≤1 day
3	Supplier02	Pathway 01	2 days	≤1 day
4	Supplier03	Pathway 01	2 days	≤1 day
5	Supplier04	Pathway 01	3 days	≤1 day
6	Supplier05	Pathway 02	3 days	≤1 day
7	Supplier06	Pathway 02	3 days	≤1 day
8	Supplier07	Pathway 02	4 days	≤1 day
9	Supplier08	Pathway 02	1 days	≤1 day
10	Supplier10	Direct line	3 days	≤1 day

For better service, a 3PL company will intend to invest on its own fleet of vehicles rather than adopt the practice of hiring vehicles on an as-needs-basis.

Partnerships Choosing of SCM: The trial task of the Milk-run mode is to determine the pickup routing of these suppliers and the vehicle assigning is to decide which points on the site network must be visited by each vehicle and the visiting sequence in which they must be done.
The first thing is to choose project participants from agglomerations of suppliers in the same city site and the approximately ten cooperators are summarized as shown in Table 2 and Fig. 2.

Note that the quantity in both sites supplier00 and supplier10 is larger than the vehicle's capacity. Direct lines are needed for them. Others pickup quantities are all less than third of vehicle's capacity. For sites in the north, the supplier01~04, can be assigned as pathway01 of the Milk-run system. For sites in the south, the supplier 05~08 can be assigned as pathway02 of the Milk-run system.

Witness modeling elements: The Milk-run simulation model is as in Fig. 2. This model is a representation of a Milk-run mode simulation where the suppliers' vehicles

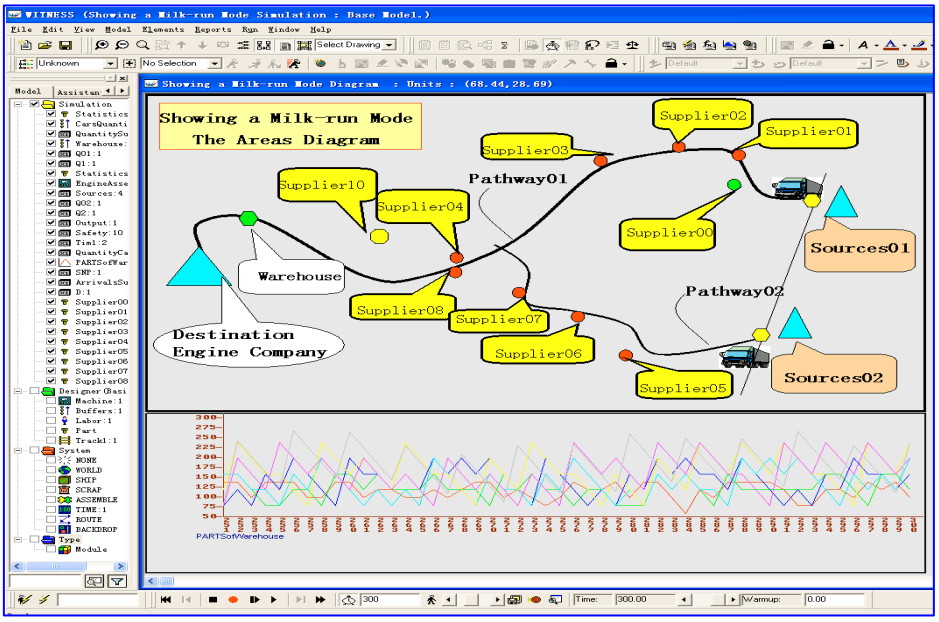

Fig. 2: Milk-run simulation model

arrive to destination, the engine company to deliver a range of components for each.

The pickup routes can be outlined geographically as north lines (Supplier01~04), as the south lines (Supplier05~08) and the two direct lines for both sites supplier00 and supplier10. The 3PL's vehicle routes will provide the service for the four lines which were involved in two pathways of Milk-run system and two direct lines. In the WITNESS model built in Fig. 2, the Part Elements are used to represent ten suppliers participated in the experiment. The production of the engine assembly is represented by the Machine Element which plays selecting parts and components and shipping the finishing assembly products according to the engines' volume. The Buffer Elements are used to separately represent both the engine company's warehouse and the used amount of daily fleet of vehicles. The Time-series Element, a time series showing levels of stock per day displays a rate utilization of the warehouse of the engine company. This model can be used to illustrate the productivity of the engine in determining how inventory and purchase cycle and so on can be improved.

MODEL SIMULATING

The experiment dates for the base case model have all been established and are already put into the model showing as in Fig. 2. The included dates were shown in Table 3.

Table 3: Experiment data

Parameter	value
Product Volume	10000/Year
Safety Inventory	IUNIFORM(1,3,1)
Max Inventory	300~360
Lead Time	UNIFORM(0.5,1.5,5)
Assembly Time	1/40 day
Supply Pathway	4
Deliver Period	According to plan a
Supply Quantity	According to inventory a
Trucks' amount	According to systematic b

The value of the uniform (0.5, 1.5) of the Lead Time means that, on average, one supplier's lead time can vary between 0.5 days to 1.5 days but spread randomly. This random time pattern is represented by the UNIFORM distribution (Zhao *et al*., 2009). And about the value of the IUNIFORM (1, 3) of the Safety Inventory will be considered as below.

Stock level design: The Total inventory is as follow:

$$I = \sum_{i=1}^{n} (Q_i + S_i) \quad (1)$$

$$Q_i = D_i \times O \quad (2)$$

$$S_i = \sum_{j=1}^{7} S_{ij} \times O \quad (3)$$

Here, O equals Daily Output, a constant, I is Total Inventory of all suppliers, D_i is Deliver Period for

each supplier, S_i is Safety Inventory for each supplier, S_{ij} is Total Time required for each part, i = 1, 2, … , 10, j = 1, 2, … , 7.

For any supplier, S_{ij} includes in all time spent to deliver to an assembly line such as verifying; handling; laying; counting; homing; and so on.

There is an assumption about S_{ij} which is given a predicted distribution, UNIFORM (1, 3). That means that, on average, any supplier will spend the time varying between 1 day and 3 days for assembly. This random time pattern is as follow:

$$S_{ij} \approx \text{UNIFORM}(1,3) \quad (4)$$

Direct line and milk-run mode design: For this particular SCM experiment of the engine assembly, the design has been targeted with establishing how mix-products' assembly could be increased. The suppliers' vehicles daily arrived to the warehouse have alternative option of using direct line or Milk-run mode service. If the vehicle is full, it will be direct mode and they will arrive directly to the assembly line. However if the room of the truck is not full and has more capacity for holding other suppliers' parts then the Milk-run mode will be implemented.

RUNNING RESULT ANALYSIS

A suitable run time for this model is three hundred days (about one year). The results of five scenarios including some run options for comparisons with each other are shown in Table 4 and 5. The comparisons show us that considering the Safety Inventory would improve the number of warehouse that can be decreased by 44% at least. The instances show that the dwelling time in an inventory can be decreased by 61% (2.543 instead of 6.597) and the output of engine assembly increased by 14% (volume up to 11959 instead of 10533).

All these results must be balanced with the practicality of the solution and the costs. There are some assumptions about the costs and the calculations of the

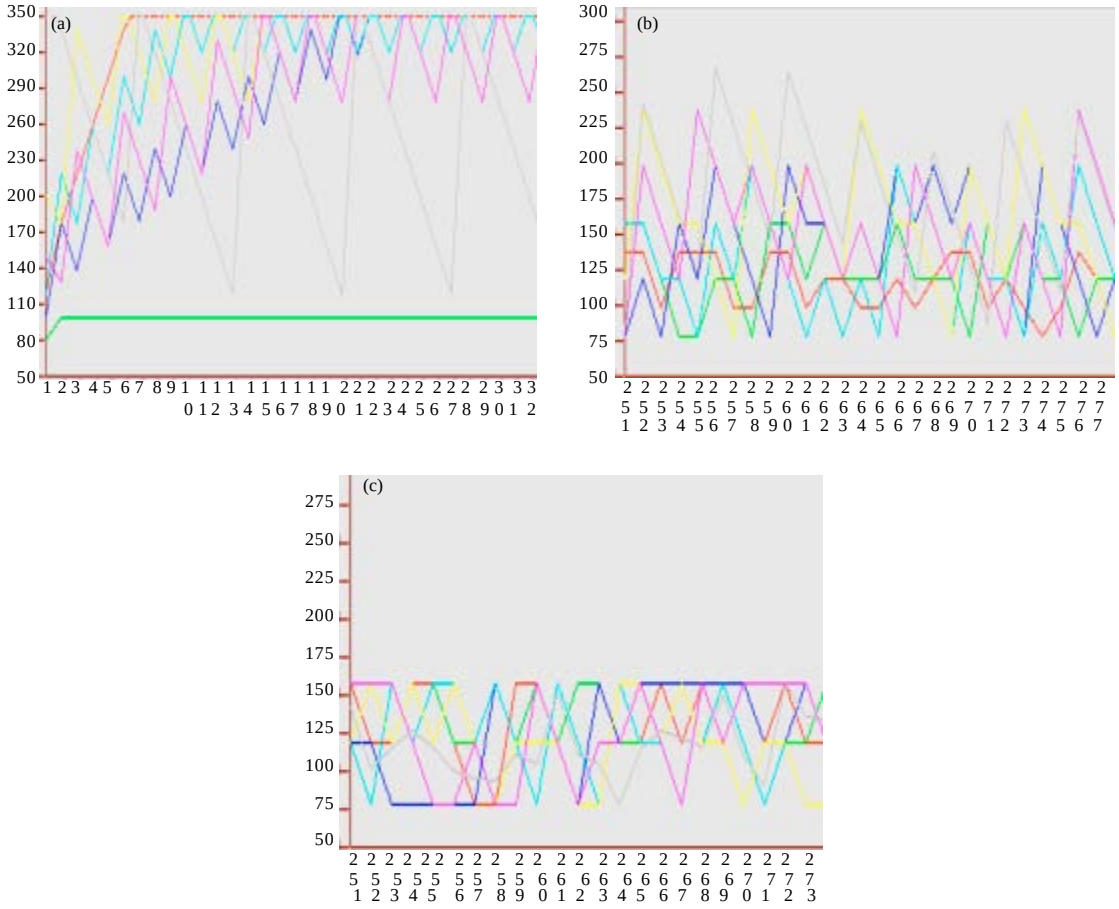

Fig. 3: Stock varying in warehouses (a) Scenario 1 (b) Scenario 2 (c) Scenario 3

Table 4: Options on each scenario

Scenario	Lead time	Interval	capacity	Safety stock control
1	1.5	0.5~7	360	No Control
2	1.5	0.5~4	360	Action
3	0.5	1	300	Action
4	0.5	0.5~4	300	Action
5	0.5~1.5	1	300	Action

Table 5: Result comparison on inventory

Scenario	Output (%)	Direct	Milk-run	Inventory
1	11939 (99.5)	1606(5)	901(3)	6.597
2	10533 (87.78)	1250(4)	740(2)	3.709
3	11959 (99.67)	1786(5)	848(2)	2.543
4	11979 (99.83)	1281(4)	755(2)	3.072
5	10673 (88.95)	1801(5)	870(2)	2.989

Table 6: Result comparison on cost

Scenario	Inventory	Direct	Milk-run	Profits
1	¥6,506,360	¥16,060.00	¥9,010.00	¥-2,678,601
2	¥4,124,816	¥12,500.00	¥7,400.00	¥-97,420.60
3	¥3,956,795	¥17,860.00	¥8,480.00	¥621,113
4	¥4,298,818	¥12,810.00	¥7,550.00	¥284,149
5	¥3,750,102	¥17,620.00	¥8,490.00	¥333,333

examples can be seen in Table 6. The inventory enormous costs caused by transporting of pickup parts have been saved by 53%.

To reduce the "bullwhip" effect, the Fig. 3 shows that it could just be the normal daily checking run, which results in a reliable information that is relatively easy to predict and manage (Fig. 3c). In scenario 3, the process is effective of daily inventory control approach.

In comparison, the time and cost of delivering had been cut down dramatically as well as the production volume are increased tremendously by this testing.

CONCLUSION

On the basis of both the history of the delivery period and the safety inventory controlling, rationalized quantities of re-supply could be made. Due to the using of Milk-run system, additional profits can be achieved by improving daily rolling planning. With the Milk-run mode, the initial 65 batches of the previously status of daily arrival vehicles will be predicted to be reduced to less 30 batches of the current condition, which will improve logistics situations within the factory.

One of the possibilities for future work may involve the package standardization of the supply chain, as well as the optimal design of pallet package for a better loading and unloading for forklifts or trucks to target with reductions in the operation time. In addition, a total supply chain integration will be structured around regional and national distribution centers for the need to integrate and standardize supply chain processes to flourish in a highly competitive marketplace where maximized efficiency is paramount, was essential.

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