International Journal of Engineering & Scientific Research
Vol.09 Issue 03, March 2021,
ISSN: 2347-6532 Impact Factor: 6.660
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

Hybrid material feeding system for a large sized high variety with low volume parts assembly a case study

D. Rajasekar
Department of Management, Research Scholar- Techno India university, Kolkata, West Bengal, India
E-mail: drajasekar99@gmail.com

Dr. Goutam Sengupta
Vice chancellor of Techno India university, Kolkata, West Bengal, India
E-mail: goutamsenguptacbs@gmail.com

Abstract:

In the present scenario of consumer/customer requirements are more customized and fluctuating demand based on various circumstances is highly challenging for the automotive components/automobile assembly industries to choose the right material feeding system to deliver products to the market with highly competitive manufacturing cost and other resources in general. This paper is focused on mainly the large-sized parts feeding to high varieties with a low volume of mixed model automobile assembly line with diverse customer demands.

Keywords: Material feeding system, High variety and low volume, Mixed model assembly, Sequencing, Line stocking

1. Introduction

This paper investigates the importance of choosing the right material feeding system for the high varieties and low volume mixed model automotive large-sized parts assembly, it helps the organization to have better utilization of all the available resources. Many of the cases were single type of feeding method doesn't give better results as a whole and the hybrid approach shall be the better option for specific most constrained assembly shops.

2. Literature Review

The focus of literature review will be general and on comparison between widely practiced methods within the manufacturing industries, which aims to bring down the lead time of feeding the parts to assembly lines and provide more available time for the operations to meet the customer demands.

Different types of material feeding methods followed in general for automotive industries:

- Line stocking
- Downsizing
- Sequencing
- Kitting

Line stocking:

In this method the parts with the container as it is directly moved from supplier, warehouse or internal supermarket to the assembly lines in bulk quantity mostly single variant or very few variants, which will be kept along sides of the continuous moving line [1,2].

Advantages	**Disadvantages**
Suitable for low variety of product and low volumes	Occupies lot of space in assembly line borders
Suitable for small, medium, Large, and extra-large parts	

Downsizing:

In this method bulk containers are unpacked in warehouse or other similar location and transferred to the next level of small lots than received or original pack quantities and feed to the assembly lines in a returnable or non-returnable container [1,2].

Advantages	**Disadvantages**
Suitable for low variety of product and higher volumes	Occupies moderate space in assembly line borders
Suitable for small, medium sized parts	

Sequencing:

In this method the parts sequenced based on daily production plan in a single or very few containers and presented in line borders for the consumption in just in time basis [2].

Advantages	**Disadvantages**
Suitable for high variety of product and higher / lower volumes	Requires some sequencing space at shop floor or warehouse (If it is not outsourced to supplier)
Suitable for medium & large size parts	
Occupies less space in assembly line borders	

Kitting:

In this method the parts are presented to the assembly lines in the form of related group of parts combined and supplied based on bill of materials for the station in one unit, it involves the separate process before final operations happen [1,2].

Advantages	**Disadvantages**
Suitable for high variety of product and low volumes	Requires some kitting space at shop floor or warehouse
Suitable for small, medium & large size parts	
Suitable for bottleneck operation/ station	
Occupies very less space in assembly line borders	

Lean management

With the publication of “The Machine that Changed the World: The Story of Lean Production” [6] the advantages of lean principles have been widely recognized. The term Lean implies a series of tools and techniques to eliminate wastes (Muda), reduce non-value-added operations, improve value added processes and maximize performance [7].

The identification and elimination of waste is a primary philosophy of lean is removing the first, large layer of waste generally yields significant improvements in overall performance. At this point most of the improvements are the individual process level, not at the level of flow connecting processes. Subsequently cycles through the continuous improvement spiral will connect processes and can have even larger impact and reinforce motivation to maintain the stability of individual processes [3].

3. The problem and implementation details

The section 3.1 describes the situation prior to the implementation, identifying the problems that were found. The section 3.2 describes opportunities available to change. The section 3.3 describes the changes and the situation after its completion, besides internal management team and internal customers overall satisfaction regarding the implemented changes was evaluated.

3.1 Status prior to the implementation

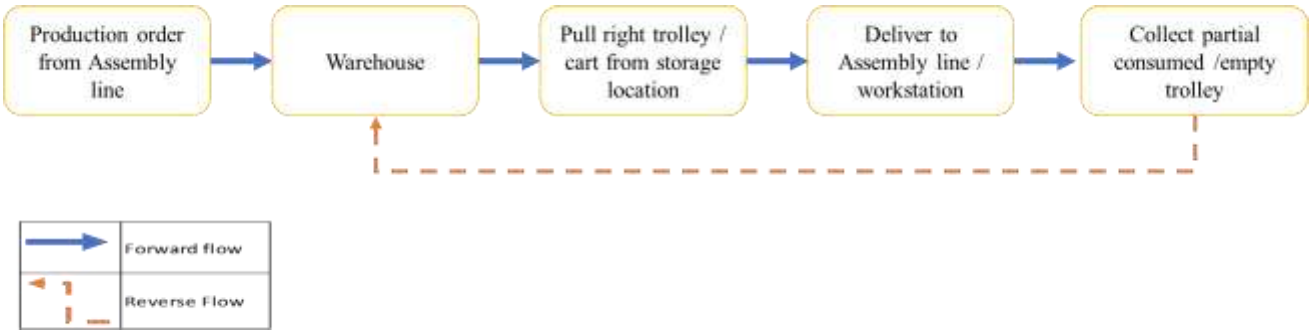
This case study was conducted in one of the manufacturing of an automotive component industry, major components are bought out in nature, not in house manufactured around 2500 varieties of parts, which all put together in the following categories raw material, WIP, finished goods & MRO etc.

The major product group belongs to large size components in high variant and low volume mix with the high fluctuation in customer demand and the case study taken for the part group called " Tie rod" which is used for the commercial vehicles steering tilt system

In present scenario the designed assembly line capacity is not fully achievable due to the constraints faced

3.1.1 Process flow diagram

The process flow shows the activities



3.1.2 Difficulties of the daily transactions

- High varieties of low volume with high mixed model production system ratio of 3:1
- Size of the component is large in nature about 2000 millimeters in length
- Weight of the single component maximum about 15 kilograms per trolley / cart which will hold 28 pieces as standard pack
- Distance between warehouse and the production assembly line is about 100 meters with various floor level and high traffic congestion with two major intercepts along the way
- Assembly line border space occupied with all varieties of components (each model per trolley/cart) is about 12 square meters
- Production operator motion is about 12 meters (To & From) to grab the component for the product assembly on each model change overs

3.2 Opportunity

It encourages the improvement required at various stages in the manufacturing floor and warehouse zones with more organized, systematic way of working, as much as possible figured out in below

- Identify the high mix and low volume components in the part group
- Identify the exact ratio of product mix based on past & future production plan
- Identify the bottlenecks in the flow of activities (Traffic, multiple movement, reverse flows etc.)
- Identify the innovative methods available to reduce the changeover, lead time etc.

3.3 Status after the implementation

The standardized processes and procedures with reference to lean philosophy, started the journey of waste identification with other best practices stated below

- Reduced production operator motion
- Increased productivity of the assembly lines
- Reduced number of material handling and traffic at assembly lines
- Reduced space occupied at assembly line borders
- Reduced inventory levels at assembly lines
- Eliminated partially consumed reverse material flow

4. Research Methodology

Research Approach

Mainly the analysis of this paper is based on primary data collected from the organization and secondary data, online databases, digital libraries, books, journals, conference papers, etc.

4.1 Objectives

The objectives are as below:

- To increase the productivity
- To reduce the space occupied at assembly line
- To reduce the multiple material handling equipment movement/ traffic at assembly lines
- To utilize the maximum space at assembly line for the value addition purposes
- To reduce line operator motion between one model to another model

4.2 Identifying problems & prioritizing

- Major contributor in terms of classification of part group leads to maximum space occupant
- Major contributor in terms of zone/location leads to multiple movements
- Various disorganized activities in the entire process
- Various waste in the process

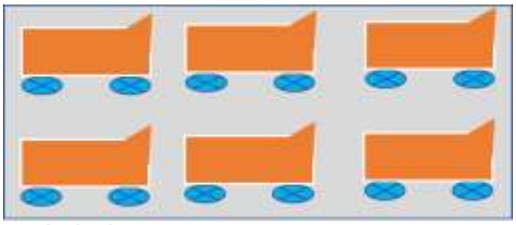
4.3 Important attributes affecting the feeding

(1) Production orders and the product mix

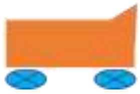
- Rate of production per hour 15 jobs & ratio of product mix is 3 -5 models in an hour
- Fast, Medium & slow-moving finished product wise list past 3 years (2018 to 2020) and future forecast for 1 year (2021)
- Individual components/ part groups total 10 varieties of parts (list of Item code, description etc.)

(2) Layout and feeding method

- At any given point in time 6 Trolleys / carts parked in line borders for consumption
- Line stocking method is followed



Line border space L 6000 x W 6000 mm



Tie rod on trolley / cart
Dimension- L 2080 x W 870 x H 1220mm

(3) Material handling constraints

- Forward flow rate averages every 1.8 hours one trolley /cart moved
- Reverse flow rate averages every 1 hour one trolley / cart moved (Partial & empty)
- Traffic congestion at two junctions 1 occurrence per hour (8 per day in a single shift pattern)
- Multiple handling points at storage and line borders for model change over

(4) Multiple varieties of components/parts and distances

- Size & weight of the components/parts
- Individual components/ part groups (list of Item code, description etc.)

Research Tools

The following tools used as follows, Flow chart, Bar chart, Pareto chart [5], Case study, 5 Why analysis, 5S, Seven types of deadly waste, JIT [4], FSN analysis [8].

5. Case study and analysis

Results of research explained in this section. Accordingly, the entire model of all parts put together comes around 101 finished products made by which using 10 components/parts (Tie rod)

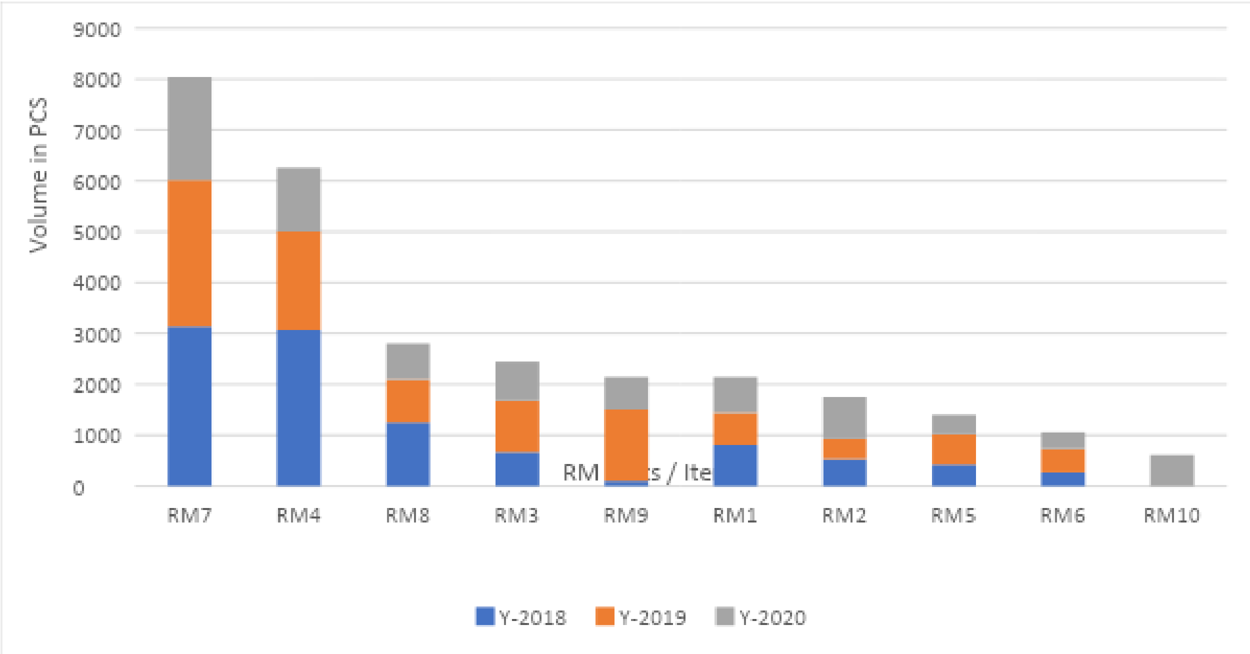
Tie rod on trolley / cart
Dimension- 2080 x 870 x 1220mm

RM- Raw material / Bought out items or parts or component, **FG-**Finished goods is axle

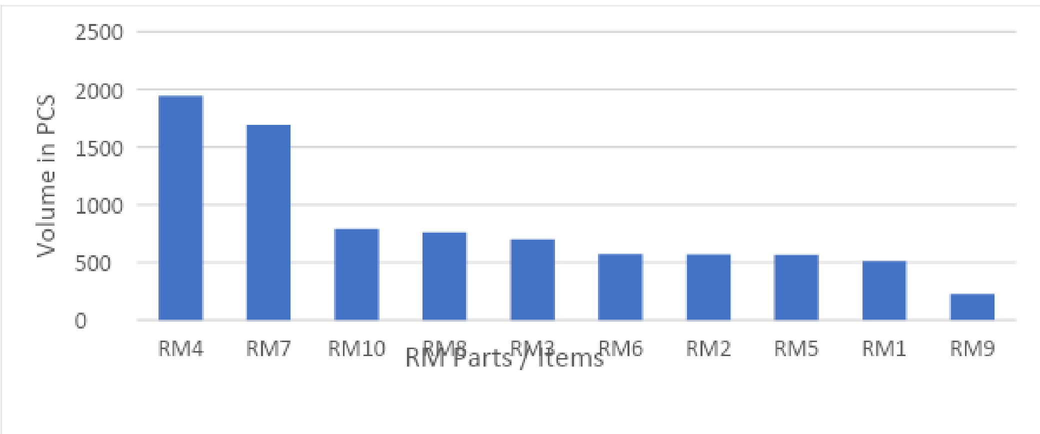
Step: 1 Basic data collection

- History of the parts information in terms of volume and other necessary details (part #, description, weight, number of pieces / packages, dimensions, storage location, classification etc.
- Production trend past 3 years and future 1-year forecast with all varieties based on the finished products drilled down into the individual bought out component/part level (daily, monthly yearly average usage, # of movements per day, ratio of product mix etc.)
- Inventory levels at all the locations, method of current feeding, routes, and other historical information

Past 3 years consumption pattern all varieties inclusive (10 parts)

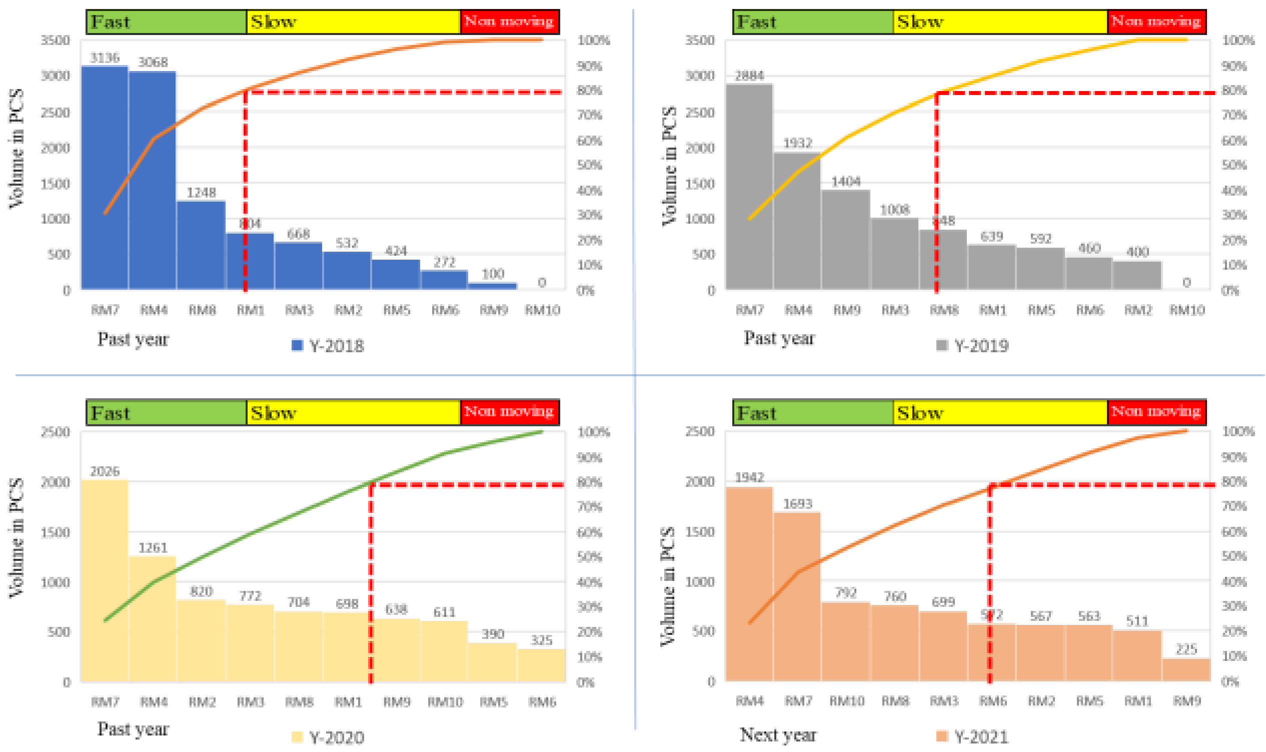


Next 1-year forecast all varieties inclusive



The past 3 years consumption (2018,2019,2020) shows the most used model is RM4 & RM7 part group and others are less consumption compare to those 2 models at all the time in a day production

FSN Analysis with combination of pareto analysis:



The above charts show the only 2-part group out of 10 is the most used model about 80% of time in a day and other 8 items are contributing only 20% of usage in a day

Vital few 80% of volume is the part group consists of only 2 item code as follows RM7 & RM4 interchangeably for the past 3 years and next 1-year forecast

Trivial many 20% of volume is the part group consists of remaining 8-part group which volume is as low compared to vital few group items

F-Fast moving- RM7 & RM4

S- Slow moving- RM1, RM2, RM3, RM5, RM6, RM8 & RM9

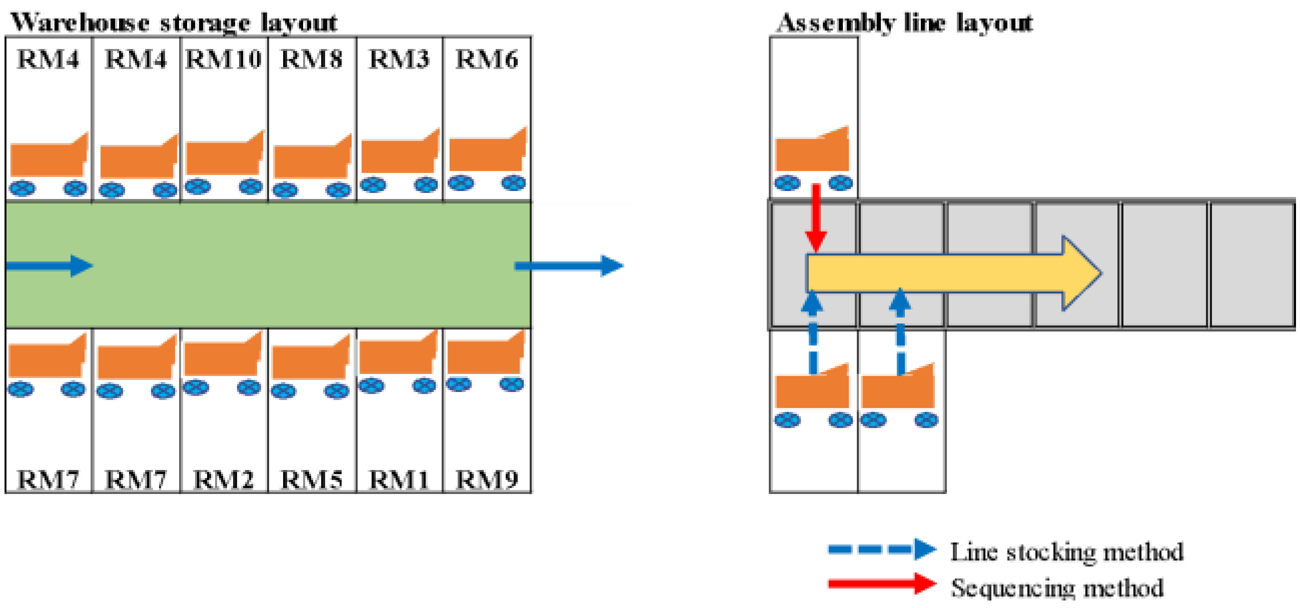
N-Nonmoving- RM10 (only for the year of 2018 & 2019)

Step: 2 Developing the feasible material handling method

Based on the FSN analysis, it is found two type of major category of parts are as follows “Runner and stranger”

Category	Feasibility of feeding method	Forecast ranking	Model wise parts / Item	Number of trolley / carts	Number of quantity / trolley / carts
Runner	Line stocking	1	RM4	1	28
		2	RM7	1	28
Stranger	Sequencing	3	RM10	1	28
		4	RM8		
		5	RM3		
		6	RM6		
		7	RM2		
		8	RM5		
		9	RM1		
		10	RM9		
Total				**3**	**84**

Step: 3 Design of layout at warehouse and assembly line borders



Step: 4 Trial and validation of proposed method

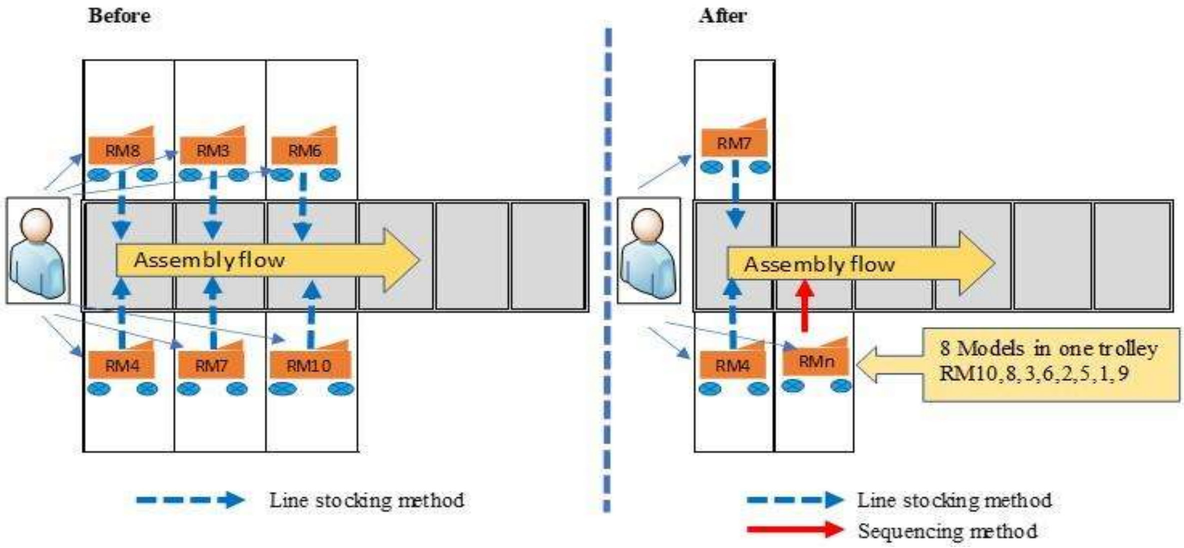
In the this phase various pros & cons validated based on the new layout at the warehouse and line borders, the warehouse operator feed the parts RM4 & RM7 in batch as it is received from supplier trolley/ cart in full quantity, other parts sequenced based on the daily production orders in reverse sequence in a one trolly/cart and moved to the line borders

In this approach it was observed the line border has the advantage of space saving about 50% compare to the previous feeding method, also the line operator movement is reduced drastically with other benefits

6. Conclusion and results

In this paper, the case study main focus was to increase the productivity and reduction of space occupied by the parts in the line border, moreover it depends on the feeding method followed before presenting the parts to the production orders in a line stocking and in future line stocking used for majorly consumed parts remining less consumption parts follows the sequencing method.

6.1 Production operator movement & time reduction trend



After changing the method of feeding at line border the movement of operator (Start- Go- Pick- Return) cycle is reduced from 2304 secs to 1600 secs per shift, it is about 704 secs reduction (31%) compared to the previous feeding method (Line stocking).

The below table of comparison shows the distance walked by operator

Before							After							Saving
Model	Demand per shift	Mix Ratio per shift	Minimum 4 meters	Maximum 12 meters	Total # of movement per shift	Secs / move per shift	Model	Demand per shift	Mix Ratio per shift	Minimum 4 meters	Maximum 8 meters	Total # of movements per shift	Secs / move per shift	Reduction of time in Secs
RM4	19	3	6	0	6	101	RM4	19	3	6	0	6	101	0
RM7	17	3	6	0	6	91	RM7	17	3	6	0	6	91	0
RM10	8	1		8	8	384	RM10	8	1		8	8	256	128
RM8	8	1		8	8	384	RM8	8	1		8	8	256	128
RM3	7	1		7	7	336	RM3	7	1		7	7	224	112
RM6	5	1		5	5	240	RM6	5	1		5	5	160	80
RM2	5	1		5	5	240	RM2	5	1		5	5	160	80
RM5	5	1		5	5	240	RM5	5	1		5	5	160	80
RM1	4	1		4	4	192	RM1	4	1		4	4	128	64
RM9	2	1		2	2	96	RM9	2	1		2	2	64	32
Total	**80**				**56**	**2304**	**Total**	**80**				**56**	**1600**	**704**

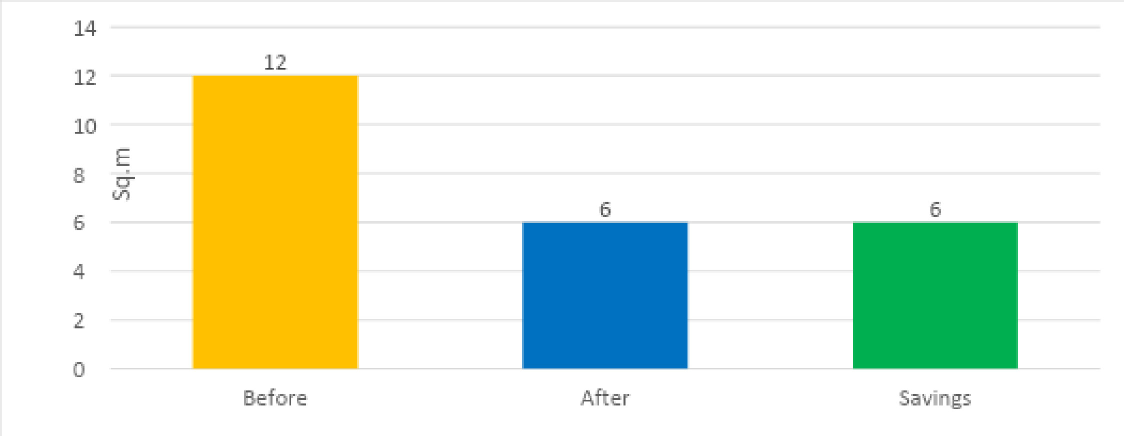
* Time taken for 1 meter distance (Start -Go- Pick-Return) 4 Secs

6.2 Productivity improvement trend

Before		After		
Description	**Calculation**	**Description**	**Calculation**	**Improved / Reduction**
Total shift time (8 hrs x 60 Mins)	480	Total shift time (8 hrs x 60 Mins)	480	0.0
Lunch & Break time (Mins)	50	Lunch & Break time (Mins)	50	0.0
Gross available time (Mins)	430	Gross available time (Mins)	430	0.0
Assumed 10% down time (Mins)	43.0	Assumed 7% down time (Mins)	31.3	-11.7
Net available time (Mins) @ Uptime 90%	387	Net available time (Mins) @ Uptime 90%	399	11.7
Desired cycle time / Production order (Mins)	4.886	Desired cycle time / Production order (Mins)	4.886	0.0
Designed capacity (# of product in Pieces) / As per gross avl time	88	Designed capacity (# of product in Pieces) / As per gross avl time	88	0.0
Actual capacity (# of product in Pieces) / As per net avl time	79.2	Actual capacity (# of product in Pieces) / As per net avl time	81.6	2.4
Total time taken for the TIE ROD movement (secs) / shift	2304	Total time taken for the TIE ROD movement (secs) / shift	1600	-704.0
Total time taken for the TIE ROD movement (mins) / shift	38.4	Total time taken for the TIE ROD movement (mins) / shift	26.7	-11.7

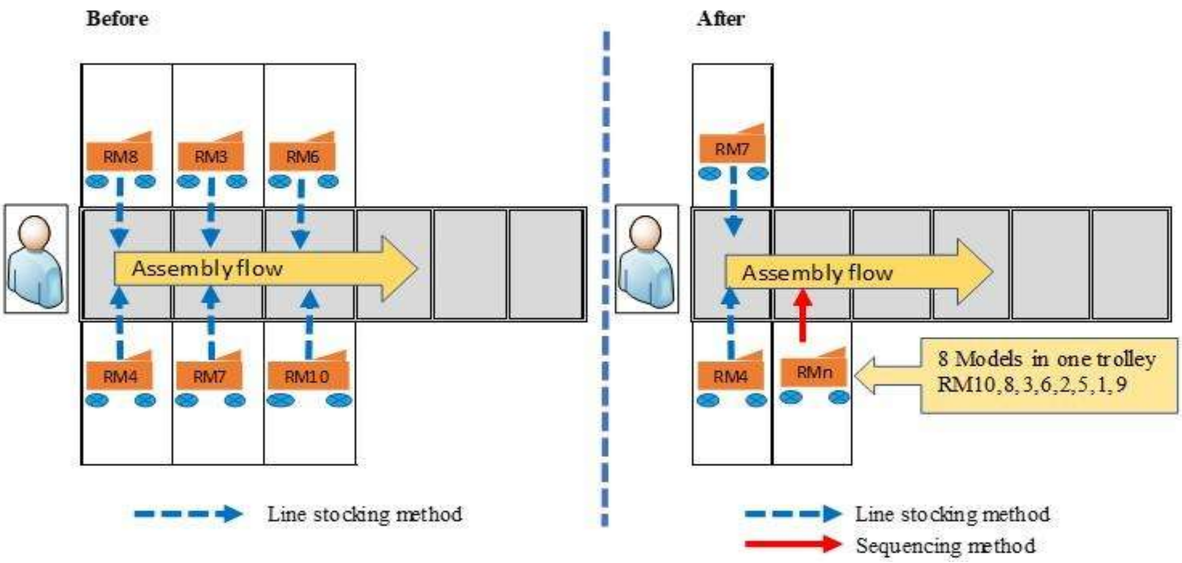
Productivity improved from 79.2 to 81.6 is about 2.4 parts increased per shift

6.3 Reduction of space occupied by parts storage in line border



Previously the assembly line border occupied with 6 trolleys which was occupied 12 Sq.m of space and after implementation of new hybrid feeding method, it has been reduced to 6 Sq.m

Assembly line layout:



Previous condition was the individual model parts per trolley in full kept near by the line borders, proposed condition only two trolleys of majorly runner parts kept in line border in full and other models new production orders were kept in a single trolly on sequence flow method

6.4 Reduction of transportation between warehouse and assembly line

Before:

Model	Per shift demand	# of Trolley required /shift	Min frequency of movement/shift
RM4	19	0.7	1
RM7	17	0.6	1
RM10	8	0.3	1
RM8	8	0.3	1
RM3	7	0.2	1
RM6	5	0.2	1
RM2	5	0.2	1
RM5	5	0.2	1
RM1	4	0.2	1
RM9	2	0.1	1
Total trolley req		**3.0**	**10**

*Volume considered per shift average 80 finished products & single shift a day production demand of forecast

After:

<table>
<tr><th>Model</th><th>Per shift demand</th><th># of Trolley required /shift</th><th>Min frequency of movement/shift</th></tr>
<tr><td>RM4</td><td>19</td><td>0.7</td><td>1</td></tr>
<tr><td>RM7</td><td>17</td><td>0.6</td><td>1</td></tr>
<tr><td>RM10</td><td>8</td><td>0.3</td><td rowspan="9">2 (Inclusive of 8 models together in sequence on one / two trolley)
4</td></tr>
<tr><td>RM8</td><td>8</td><td>0.3</td></tr>
<tr><td>RM3</td><td>7</td><td>0.2</td></tr>
<tr><td>RM6</td><td>5</td><td>0.2</td></tr>
<tr><td>RM2</td><td>5</td><td>0.2</td></tr>
<tr><td>RM5</td><td>5</td><td>0.2</td></tr>
<tr><td>RM1</td><td>4</td><td>0.2</td></tr>
<tr><td>RM9</td><td>2</td><td>0.1</td></tr>
<tr><td colspan="2">Total trolley req</td><td>3.0</td></tr>
</table>

Transportation reduced from 10 to 4 trips per shift, it is about 60% reduction and traffic avoidance

6.5 Reduction of model changeover time at assembly line

<table>
<tr><th colspan="4">Before</th><th colspan="4">After</th><th>Saving</th></tr>
<tr><th>Model</th><th>Demand per shift</th><th>Mix Ratio per shift</th><th># of change overs</th><th>Model</th><th>Demand per shift</th><th>Mix Ratio per shift</th><th># of change overs</th><th># of change over reduction</th></tr>
<tr><td>RM4</td><td>19</td><td>3</td><td>6</td><td>RM4</td><td>19</td><td>3</td><td>6</td><td>0</td></tr>
<tr><td>RM7</td><td>17</td><td>3</td><td>6</td><td>RM7</td><td>17</td><td>3</td><td>6</td><td>0</td></tr>
<tr><td>RM10</td><td>8</td><td>1</td><td>8</td><td>RM10</td><td>8</td><td>1</td><td rowspan="4">1</td><td rowspan="4">27</td></tr>
<tr><td>RM8</td><td>8</td><td>1</td><td>8</td><td>RM8</td><td>8</td><td>1</td></tr>
<tr><td>RM3</td><td>7</td><td>1</td><td>7</td><td>RM3</td><td>7</td><td>1</td></tr>
<tr><td>RM6</td><td>5</td><td>1</td><td>5</td><td>RM6</td><td>5</td><td>1</td></tr>
<tr><td>RM2</td><td>5</td><td>1</td><td>5</td><td>RM2</td><td>5</td><td>1</td><td rowspan="4">1</td><td rowspan="4">15</td></tr>
<tr><td>RM5</td><td>5</td><td>1</td><td>5</td><td>RM5</td><td>5</td><td>1</td></tr>
<tr><td>RM1</td><td>4</td><td>1</td><td>4</td><td>RM1</td><td>4</td><td>1</td></tr>
<tr><td>RM9</td><td>2</td><td>1</td><td>2</td><td>RM9</td><td>2</td><td>1</td></tr>
<tr><td>Total</td><td>80</td><td>14</td><td>56</td><td>Total</td><td>80</td><td>14</td><td>14</td><td>42</td></tr>
</table>

Number of change overs one model to another model frequency reduced from 56 to 14 time per shift, it is about 75% reduction.

References

1. Antonio C. Caputo, Pacifico M. Pelagagge & Paolo Salini(2016). Selection of assembly lines feeding policies based on parts features, International Federation of Automatic Controls, IFAC papers online 49-12(2016) 185-190.
2. Andreas Karlsson & Markus Svanstrom (2016). Parts feeding of low-volume parts to assembly lines in the automotive industry. Chalmers university of technology, Division of logistics and transportation, Goteborg, Sweden.
3. Jeffrey K. Liker, The Toyota way “14 Management principles” (2004). Mc Graw Hill.
4. Taiichi Ohno (1988) Toyota production system: beyond large scale production, CRC Press.
5. Tony Wild (2018) Best Practice in Inventory Management (2nd Ed., p. 40), Taylor & Francis group.
6. James P. Womack, Daniel T.Jones, and Daniel Roos, “The Machine that Changed the World” the story of Lean production (2007). Mc Graw Hill
7. Womack, J. P., & Jones, D. T. (1996). Lean thinking. New York: The Free Press.
8. https://mywestford.com/blog/fsn-analysis-in-inventory-management

****