Computation and Improvement of JIT Performance Index for Better Productivity

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Abstract—Manufacturing organization experiences highly volatile market due to the technological updates, customer needs, environmental issues and competitor’s product. The ultimate objective of the manufacturing industries today is to provide the market with products of the highest quality, at reasonable prices, at the optimal time. Just-in-time (JIT) has been widely implemented in manufacturing industries as a survival strategy against global market competition as it offers various benefits, such as greater throughput, higher productivity and better quality. The aim of the paper is to discuss few strategic issues and some important rules for getting the system off the ground. The procedure for planning and implementation along with global status and pay off has been discussed critically. A designed questionnaire for self-test has also been given along with evaluation criteria to identify the weakness and strength of the company for successful implementation of JIT manufacturing strategy. It also gives a methodology for computation and improvement of performance index using the principle of continuous improvement. This paper focuses on how to enhance the productivity/ performance index while applying systematically, scientifically basic principles of JIT approaches. The design guidelines are applied to a small scale industry as a case example. The ideas presented in the paper will be useful for those who want to implement JIT manufacturing in their organizations.

Index Terms—Survey Instrument Design; Self-Test; Implementation; Pay Off; Strategic Issues; Performance Index.

I. INTRODUCTION

Manufacturing is no longer a local matter. Advances in communication and transportation have greatly reduced the world’s size, and manufacturing should now be considered as a world affair [1]. The consequent variety of choices makes decisions regarding manufacturing strategy very difficult and risky. Today industries face world competition, and manufacturing is at the heart of the problem. To maintain competitive edge, industries engaged in manufacturing face the difficulty of reducing costs and improving their quality level [2]-[4],[7]. One way to accomplish this is to use correct strategy in manufacturing [8]-[10]. It is necessary to develop a commitment to manufacturing earlier in product development phase. It is important to use common senses in studying the different choices and to carry out decisions that will make the manufacturing process effective, fast and burdened with very low overhead [11]-[14].

JIT is a new way of thinking about manufacturing. The challenge of JIT is that it constitutes a complete departure from the old operational systems that have been used for many years in our industries. Most of the JIT concepts have been developed in Japan through many years of hard work and attention in detail [5]. Policy makers will have to give careful consideration to the initiation and expansion of JIT in manufacturing industries [15]-[17].

It is important to recognize that an organization cannot adopt JIT in isolation, but only with the close participation of other involved organizations, particularly suppliers, so that risks of late deliveries of materials and components are minimized [6]. Furthermore, it calls for a high degree of organization within the company so that it can respond rapidly to market demands.

Schonberger [5] describes the JIT system as to: “Produce and deliver finished goods just in time to be sold, sub-assemblies just in time to be assembled into finished goods, and purchased materials just in time to be transformed into fabricated parts”.

II. CHANGING REQUIREMENTS

The modern industries are witnessing an evolution in all stages from design to manufacturing. In the present era of high competitiveness, the industrial winners will be those industries which will fulfill the following demands of market environment:

1) There should be minimum delay between order placement and delivery.
2) Quality and reliability should be high/ consistent.
3) Change in design should be incorporated at a faster rate than the competition- flexibility.
4) Change in lot size and production quantities should be accommodated by the system.
5) The price should be competitive.

Under these circumstances the right form of technique like JIT could prove an invaluable resource. JIT implementation is not an option but a matter of survival.

III. STRATEGIC ISSUES IN JIT MANUFACTURING

Strategic issues in manufacturing fall into two categories. The first addresses those issues that are related to how an industry interacts with customers and competition and second is concerned with top management choices and priorities. From experience five key strategic questions have been identified and are:

1) How will JIT impact on the market place?
2) How suitable is JIT for particular manufacturing environment?
3) Should investment be made in JIT, AMT or both?
4) How should JIT be implemented?
5) What fundamental changes are to be made, to make an industry into a JIT industry?

Developing a strategy is a two stage process. First set of goals are defined and second the means of achieving the goals are defined. A manufacturing strategy must define the factory capacity level of inventors, quality goals, level of automation and operational environment [21]. Every product should be designed to meet criteria of lowest cost and highest standards of quality and produced only according to demand.

IV. GETTING A JIT SYSTEM OFF THE GROUND

Some of the most important rules are (list is not exhaustive and there are other rules that will also be helpful) [18]-[19]:
1) Start working on a JIT system as soon as possible. Don’t wait until the company has a large production volume.
2) Don’t use the excuse of low volume to avoid implementing JIT. The system will work in any environment. Remember, the ideal volume in JIT production is one unit.
3) Use repetitive manufacturing, daily schedules, and daily pull methods. It avoids the complexity of work orders and allows problems to be detected as soon as they occur.
4) Get senior executive/ managers involved immediately. Their support is important for the success of the programme.
5) Start educating middle managers and workers about JIT principles immediately. Their understanding of JIT must be clear, even if they are initially skeptical of results.
6) Have senior managers get involved with key suppliers at the beginning of the programme. This is essential for motivating the suppliers to support JIT. Point out to suppliers that they stand to gain from having a long term relationship with, and being single source suppliers of the company.
7) Don’t start with a global programme. Choose a few key areas in which to implement JIT. Then pick another area.
8) Develop JIT systems and procedures at the beginning, and then provide training before instituting them. As the organization gains experience, review the procedures and look for possible improvements.
9) Develop a set of measurable goals for the JIT programme. Then monitor them and review their status with managers and workers. Allow the goals to be adjusted midstream, if necessary.

V. GLOBAL STATUS AND PAY OFF:

Japan is the home of JIT and basic techniques were developed (and are still being developed) there. In almost all cases the core of JIT consists of three parts- flow, flexibility and developing the chain of supply. These are in turn supported by a range of management tools and techniques. Mostly companies have programmes like:

1) Pay attention to the basics before moving on to complex changes.
2) Build team work as a major enabling factor
3) Build quality and waste reduction into people.
4) Move towards a “Continuous Flow Manufacturing” view of JIT.
5) Leave sophisticated techniques such as Kanban and quality circles until much later.
6) Work hard on good supplier relationships.

Pattern is very different in U.K. industries. Companies in U.K. by and large accepted the need for change in manufacturing techniques and processes because of global competitiveness. They are at the same time highly cautious of rapid or radical change. Due to this fact, commitment to implementation of JIT is far less forthcoming in spite of relatively high awareness. There are many barriers to implementation because of cultural factors and misconceptions about JIT.

U.S. Response of JIT has been very much similar to that of U.K. Considering out put on basis of JIT; the U.S. has been ahead of the U.K. U.K. Companies are predominantly still on the plateau, whereas many of U.S. firms are moving to full application. Companies in U.S.A adopted JIT initially as a defense against Japanese encroachment on their domestic and international markets. In U.S.A much greater attention has been paid to union involvement, training and communication. U.S. firms seemed much more willing to see high tech investment (like FMS, CIM etc) as part of their JIT programme. U.S. companies that adopted JIT, and when compared to U.S.A reveals the following observations:

1) Japanese manufacturing strategy was clearer than Americans. Japanese stressed flexibility, American stressed cost and quality.
2) Japanese understand J.I.T. as a direction and Americans as a set of techniques.
3) In both countries need was to have a strong corporate culture and fluid organization structure in order to improve flexibility by reducing lead times.
4) Japanese had been more successful in promoting flexibility with suppliers. European companies are more resistant to change than their Japanese counterpart.

A global survey has indicated that goals embracing JIT include the following payoff:

1) To reduce:
   i. Setup times
   ii. Lead time
   iii. Job classification
   iv. Number of parts
   v. Lot sizes
   vi. Materials handling
   vii. Paper work
   viii. Move distances
   ix. Number of suppliers

2) To increase:
   i. Process quality
   ii. Product quality
   iii. Process flexibility
   iv. People flexibility
   v. Communication

DOI: http://dx.doi.org/10.24018/ejers.2018.3.10.881
vi. Productivity
vii. Team work
viii. Innovation
ix. Efficiency and responsiveness
x. Integration in manufacturing activities.

VI. SUSTAINABLE FOOD PROCESSING

Many of today’s food production systems compromise the capacity of earth to produce food in the future. Globally, and in many regions including Europe, food production is exceeding environmental limits or is close to doing so. Nitrogen synthesis exceeds the planetary boundary by factor of four and phosphorus use has reached the planetary boundary. Land use change and land degradation, and the dependence on fossil energy contribute about one-fourth of greenhouse Gas emissions. Agriculture, including fisheries, is the single largest driver of biodiversity loss. Regionally, water extracted by irrigation exceeds the replenishment of the resource. Price volatility, access restrictions and the interconnectedness of global commodity markets, as well as the increasing vulnerability of food production systems to climate change and loss of agro-biodiversity, will make food even more inaccessible for the poor in the future.

What exactly do we mean by ‘Sustainable’ Food?

There are many different views as what constitute a ‘sustainable’ food system, and what falls within the scope of the term ‘sustainability’. Strictly speaking sustainability implies the use of resources at rates that do not exceed the capacity of the earth to replace them. For food, a sustainable and productive system might be seen as encompassing a range of issues such as security of the supply of food, health, safety, affordability, quality, a strong food industry in terms of job and growth and, at the same time, environmental sustainability, in terms of issues such as climate change, biodiversity, water and soil quality.

How can we move towards a more resource efficient and sustainable food system? JIT is one of the solutions.

A public consultation was held on this question, where a number of areas for action were presented for discussion:

1) Better technical knowledge on the environmental impact of food
2) Stimulating sustainable food production
3) Promoting sustainable food consumption
4) Reducing food waste and losses
5) Improving food policy coherence

VII. SURVEY INSTRUMENT DESIGN FOR DATA COLLECTION

The concept of improving productivity / sustainability is the main area of interests for different manufacturing units. But in order to do so one has to first determine the status of the concerned manufacturing unit with respect to productivity / sustainability. To do that some kind of audit assessment is mandatory. The audit assessment tools will not only give an idea about the status of manufacturing units, but also will provide the direction to implementation programme. Table I gives the different sub-systems of the survey instruments which are applicable, in general, to a manufacturing industry.

| S. No. | Key Performance area/ Subsystem |
|-------|---------------------------------|
| 1     | Data Integrity                  |
| 2     | Education                       |
| 3     | Material Flow                   |
| 4     | Purchasing                      |
| 5     | Planning                        |
| 6     | Process Changes                 |
| 7     | Quality                         |

Survey instrument has sub-systems and each sub-system will have set of performance objectives / attributes / factors which covers the key performance areas of the industry. The choice of different sub-systems and performance objective attributes / factors depends upon the type of industry. By analyzing the responses of the performance objectives and areas which are low on JIT manufacturing and which need attention are pin pointed. This will give direction to the research work, specifying areas where study should further look into.

| Sr. No. | Data Integrity |
|---------|----------------|
| 1       | Inventory record accuracy is 98+% or better both stockrooms and point of use storage |
| 2       | Bills of material accuracy 99+% or better for costing needs and post deduct inventory |
| 3       | Bills of materials flattened |
| 4       | Routing accuracy defined and maintained by line flow |
| 5       | Defined engineering standards for costing |
| 6       | Manufacturing process adhered to |

| Sr. No. | Education |
|---------|-----------|
| 1       | All operators are trained in just in time practices |
| 2       | Individual operators are cross trained take self initiative to move to point of need, have authority to stop the line |
| 3       | Management support for the thinking worker. |
| 4       | All functional organizations (engineering, purchasing, marketing and manufacturing) are part of the problem resolution teams. |

| Sr. No. | Material flow |
|---------|---------------|
| 1       | Weekly or more frequent delivery of 80% of materials to the plant and to the point of use |

DOI: http://dx.doi.org/10.24018/ejers.2018.3.10.881
Table II relative to your company, its culture, its people, and the processes you believe to be most in need of JIT. Assign each question a score of 1-5 using the following criteria:

1 = The conditions adamantly disagree with this statement; that is response not adequate.
2 = The conditions disagree with this statement; that is response poor.
3 = The conditions neither agree nor disagree with this statement; that is response good.
4 = The conditions generally agree with this statement; that is response very good.
5 = The conditions completely agree with this statement; that is response adequate.

Once you have assigned a score to the individual questions, sum the scores for an overall total assessment. Mathematical Model for JIT Manufacturing Index is given as:

\[ l_{\Omega} = \frac{1}{n} \sum \left( \frac{\sum_{i} (\sum_{k} O_{ik} \times w)}{\sum_{w}} \right) \]  

where:

\( \Omega = \) Whole system (organization)
\( s_{i}, i = 1, 2, ..., n \) be the key performance area/sub-system such that \( \sum_{i} s_{i} = \Omega \).
\( O_{ik} \) be the response of the \( k^{th} \) question asked to the respondent of the \( i^{th} \) key performance area,
\( O_{i} = \frac{\sum_{k} O_{ik}}{\sum_{w}} \) be all the responses from the ‘\( k \)’ questions,
\( l_{i} = \frac{\sum_{w} (O_{i} \times w)}{\sum_{w}} \) be the JIT index for the \( i^{th} \) sub-system, \( i = 1, 2, ..., n \), and \( l_{\Omega} = \frac{\sum_{i} l_{i}}{n} \) be the JIT index of the organization.

By making use of the above mathematical model (equation 1) the JIT manufacturing index of various key

| Sr. No. | Purchasing | 1 | 2 | 3 | 4 | 5 |
|--------|------------|---|---|---|---|---|
| 1 | Key volume vendors are local | | | | | |
| 2 | Delivery lead time for most parts range from one day to week | | | | | |
| 3 | Single source vendors make up greater than 50% of all vendors. | | | | | |
| 4 | Parts are received and issued in small lots in standardized containers. | | | | | |

| Sr. No. | Planning | 1 | 2 | 3 | 4 | 5 |
|--------|----------|---|---|---|---|---|
| 1 | Daily rate and level schedules met on due dates | | | | | |
| 2 | MRP is used for internal planning, customer committing vendor schedules and vendor capacity planning | | | | | |
| 3 | Management participates in the planning and preplanning and commits to a realistic capacity level | | | | | |
| 4 | Marketing promotes the JIT demonstrated benefits to customers. | | | | | |
| 5 | Production rates exactly equal demand rates | | | | | |
| 6 | Customer service delivery rate is 100% as committed | | | | | |

| Sr. No. | Process changes | 1 | 2 | 3 | 4 | 5 |
|--------|-----------------|---|---|---|---|---|
| 1 | Single digit set ups established (less than 10 minutes) for most machines | | | | | |
| 2 | All tooling and fixtures available when set ups and jobs begin | | | | | |
| 3 | Where feasible, work orders eliminated or simplified and priorities controlled by demand pull | | | | | |
| 4 | Scheduled preventive maintenance is considered an integral part of production performance | | | | | |
| 5 | Simplified manufacturing process which provides “sight” management vs. complex control systems | | | | | |
| 6 | Simplified manufacturing process which identifies and exposes problems with immediate solutions | | | | | |
| 7 | Accounting systems are redesigned to work in a JIT environment | | | | | |
| 8 | Manufacturing is actively involved in the design of product and process for reducibility | | | | | |
| 9 | Manufacturing engineering is located in the production area and are immediately available for problem resolution | | | | | |
| 10 | Manufacturing processes and procedures are adhered to and formal change procedures are established | | | | | |
| 11 | Production lines have been reorganized to provide mixed model runs with minimum material handling | | | | | |
| 12 | Compensation and rewards for employees is measured on team contribution basis. | | | | | |

| Sr. No. | Quality | 1 | 2 | 3 | 4 | 5 |
|--------|---------|---|---|---|---|---|
| 1 | All inspection sequences have been eliminated and quality is part of the individual operator responsibility | | | | | |
| 2 | Quality control departments are replaced with process audit functions | | | | | |
| 3 | Process variability and early warning statistical quality control tools are in place and are used to monitor and control quality points in the process | | | | | |

DOI: http://dx.doi.org/10.24018/ejers.2018.3.10.881
performance areas and the manufacturing unit as a whole under consideration are computed.

VIII. SCORING SYSTEM AND GUIDELINES

The rating of performance objectives can be measured subjectively on 1 to 5 scales, refer Table III. Each performance objective / attribute of a sub-system is designed for the responses from “not adequately addressed” to “adequately addressed”, as per scale from 1 to 5. When the response is at the rating scale from 1 to 3 i.e. not adequately addressed, it means effectiveness of practices is almost absent & these are the potential areas for improvements. When the response is at the rating scale from 4 to 5 i.e. adequately addressed, it means effectiveness of practices are followed so these areas are slightly covered from a study of effectiveness/productivity improvement. Accordingly, the required actions may be suggested for sustainability/productivity enhancement.

It will provide the assessor some kind of factual status regarding the efficiency and effectiveness of the manufacturing unit as far as JIT manufacturing is concerned. The scaling of the key performance area of a sub-system will help to measure the performance of the key performance area, which is one of the requirements for assessing JIT manufacturing index.

| TABLE III: SCORING SYSTEM FOR DIFFERENT ATTRIBUTES |
|--------------------------------------------------|
| Performance areas/sub-systems | Attributes/Performance objectives | Rating |
|--------------------------------|----------------------------------|--------|
|                                 | Response not adequate | Response poor | Response good | Response very good | Response Adequate |
|--------------------------------|---------------------|----------------|----------------|--------------------|------------------|
| 1                               | 2                   | 3              | 4              | 5                  |

IX. COMPUTATION OF JIT / SUSTAINABILITY MANUFACTURING INDEX

For computing the value of JIT/ sustainability manufacturing index, the multi attribute utility function (MAUF) approach has been used. Accordingly, a survey instrument has been designed for collecting data/information pertaining to particular industry.

A typical industrial organization engaged in manufacturing and marketing (from raw material to finished goods) can be considered to operate as a system with different sub-systems and key performance areas.

Depending upon the size and nature of fabrication/manufacturing industry, the number of sub-systems and sub-sequent key performance areas may vary.

X. ACTION PLAN

Transforming a manufacturing enterprise to a JIT and high performing one requires building a nurturing organizational culture that embraces change, seeks to seize market opportunities, executes strategy faster, and tolerates risk taking behavior of this complex phenomenon.

The underlying foundation for building such a culture necessitates the need for transformational leadership that builds and reinforces the required attributes that make an organization JIT organization. The resulting outcome of becoming a JIT organization yields the competitive advantage that sets the organization apart from its competitors on effectiveness and market performance. Planning for a transformation that requires fundamental overhaul of all aspects of manufacturing processes necessitates intentional revamping of the organizational culture. General practices for implementation of JIT manufacturing system are [20]:

- Do not implement on an adhoc basis, have a plan and see each implementation step as a part of that plan.
- Implementation should start in hostile areas and especially where productivity is lagging.
- Involve from the start all levels of management and the labour force. Total commitment by everyone is necessary for success.
- Financial justification in real time economic terms is essential.
- Clear policies and programs are essentials.
- An initial feasibility study is important.
- Provide training and give them tools necessary to do their jobs.
- Do not forget people requirements. Be honest in answering the questions from the workers in the plant.
- Involve project planner and production people in your efforts.

XI. CASE STUDY

A company engaged in processing of food product was selected for implementation of proposed model. The manufacturing and other working data were collected by using designed survey instrument. Table IV depicts the data collected for a particular case under consideration, in column existing situation. By making use of mathematical model the JIT index of various key performance areas as per data/information collected from industry are computed and are shown in Table IV.

| TABLE IV: COMPUTATION OF JIT MANUFACTURING INDEX |
|--------------------------------------------------|
| Sr. No | Sub system and key performance objective | Key Performance Objective | Rating | Existing situation | After implement I mile stone | After implement II mile stone | After implement III mile stone |
|--------|-----------------------------------------|---------------------------|--------|--------------------|-----------------------------|-----------------------------|-----------------------------|
| 1      | Data Integrity                         | *                         | *      | *                  | *                           | *                           | *                           |
Bills of materials flattened
Routing accuracy defined and maintained by line flow
Defined engineering standards for costing
Manufacturing process adhered to

Performance index

0.6 0.6 0.6 0.6

All operators are trained in just in time practices
Individual operators are cross trained to take self-initiative to move to point of need, have authority to stop the line

Performance index

0.7 0.7 0.7 0.7

Weekly or more frequent delivery of 80% of materials to the plant and to the point of use
Vendors are an integral part of the production process
Parts are only produced as required and built in quantities approaching one
Labor is not “kept busy” by building product when not needed at the next operations.

Performance index

0.65 0.65 0.65 0.65

Key volume vendors are local
Delivery lead time for most parts range from one day to week
Single source vendors make up greater than 50% of all vendors.
Parts are received and issued in small lots in standardized containers.

Performance index

0.4 0.7 0.7 0.7

Daily rate and level schedules met on due dates
MRP is used for internal planning, customer committing vendor schedules and vendor capacity planning
Management participates in the planning and preplanning and commits to a realistic capacity level
Marketing promotes the JIT demonstrated benefits to customers.
Production rates exactly equal demand rates
Customer service delivery rate is 100% as committed

Performance index

0.5 0.5 0.7 0.7

Single digit set ups established (less than 10 minutes) for most machines
All tooling and fixtures available when set ups and jobs begin
Where feasible, work orders eliminated or simplified and priorities controlled by demand pull
Scheduled preventive maintenance is considered an integral part of production performance
Simplified manufacturing process which provides “sight” management vs. complex control systems
Simplified manufacturing process which identifies and exposes problems with immediate solutions
Accounting systems are redesigned to work in a JIT environment
Manufacturing is actively involved in the design of product and process for reducability
Manufacturing engineering is located in the production area and are immediately available for problem resolution
Manufacturing processes and procedures are adhered to and formal change procedures are established. Production lines have been reorganized to provide mixed model runs with minimum material handling. Compensation and rewards for employees is measured on team contribution basis.

| Performance index | 0.5 | 0.7 | 0.7 | 0.7 |
|-------------------|-----|-----|-----|-----|
| All inspection sequences have been eliminated and quality is part of the individual operator responsibility. | * | * | * | * |
| Quality control departments are replaced with process audit functions | * | * | * | * |

7 Quality
Process variability and early warning statistical quality control tools are in place and are used to monitor and control quality points in the process.

| Performance index | 0.4 | 0.4 | 0.4 | 0.6 |
|-------------------|-----|-----|-----|-----|

**JIT Manufacturing System Performance Index**

0.5357 0.6071 0.6357 0.6642

To improve the JIT index the availability of technical and financial resources were reviewed and accordingly it was decided that the required improvement in JIT index will be carried out in three stages. These stages are categorized as 1st, 2nd, and 3rd mile stones. Four months were allotted to each mile stone for the implementation of suggested methods/processes for improving key performance area / attribute.

**XII. COMPUTATION OF JIT INDEX AFTER 1ST MILESTONE**

Two key performances areas namely purchasing and process changes are identified & certain attributes are selected for 1st mile stone for implementation and improvement where the response rating is not up to the mark.

A. **Purchasing**

Key volume vendors must be as local as possible to keep the procurement costs and delivery lead times down. Also few shared visits, face-to-face problem solving reduce replacement time. This enables education of many other elements of vendor lead time, such as process handling, non-standard containers, no certification, useful use of acknowledgements and even vendor returns.

Vendor management is no different than production arrangement. Internal JIT movements are made in small lots of standardized containers. The objective is to get the vendors to frequently deliver quality parts in small lot standardized containers.

Single sources are selected; sole sources are forced. Emphasis should be on developing “partnerships” with single source vendors. Masses of multiple vendors are not manageable and are very wasteful. Fewer vendors mean here is less paper, better accountability, more leverage, fewer contracts to manage and more cooperation.

Vendor management is one of the greatest profit contributors to a JIT implementation.

B. **Process Changes**

Set-up reduction is a key element for internal lead time reduction. It requires all tooling and fixtures to be available when set-ups or jobs begin. Set-ups should be focused first on flow inhibitors, not across the board. Set-ups can be reduced first by simply having as much of the required tools and exact quantity of parts in the work center as possible in an organized and timely manner.

Scheduled preventive maintenance should be considered a part of manufacturing management performance. However, PM’S are usually seen as an expense not directly related to product and is often poorly supported.

Signaling systems create “SIGHT” management and lead to simplified control systems and processes which expose problems and makes solutions visible. They are a necessity.

Accounting systems can be a serious inhibitor to JIT. Terms like efficiency, utilization, overhead, burden, inventory, return on assets, operating expense, consumption all take on different meanings in a JIT environment. It is assumed that inventory will be consumed as defined in the bills of materials unless some deviation or usage variance occurs. If this happens, only the exceptions are reported. This eliminates all inventory transactions but the exceptions. Accordingly, the application of labor to product cost is defined by a work center not a work order. Thus labor collection is apportioned by the quantities flowing through a work center instead of collected into a work order bucket. Cost accounting people are not accustomed to these approaches.

Manufacturing and/or industrial engineering must be assigned as support to production process. They need to be immediately available to resolve problems, reorganize flows, orient material handling equipment, minimize handling and train operators.

Cellular orientation is an excellent solution. This is becoming a common approach in JIT implementations. The objective is to remove as much space between the work centers as possible as well as integrating as much of the individual processes into one work center as possible. One of the best solutions was to have the vendors do some assembly work and bring them direct to the final cells. Each cell was designed to perform multiple task.

Compensation and rewards for employees must be based on group performance not on individual performance. This generates differential pride that eventually creates conflict and contention within the group.

Suggestions of 1st milestone have been implemented and the value of JIT index is calculated by using mathematical
model and the improved value of JIT index is shown in Table IV.

XIII. COMPUTATION OF JIT INDEX AFTER 2nd MILESTONE

Key performances area of planning is identified & certain attributes are selected for 2nd milestone for implementation, where the response rating is not up to the mark.

Mainly rates and level schedules met on due dates are few because of the failures have begun due to parts shortages, poor quality, demand and design changes.

Material requirements planning (MRP) as a calculation tool for planning, committing and scheduling vendors is critical for JIT performance. All priorities (i.e. due dates or times) are driven by a stable master production schedule (MPS)

An effective MPS should be the focal point in any company implementing JIT. It plans and controls the time sequences of the overall resource utilization throughout the company. Management must use the MPS to pan or re-plan the factory based on a realistic level of capacity.

Production scheduling for JIT will be scheduled by quantity rather than by work order due date. There are many differences between these two techniques.

The true measure of a good MPS is that the production rates match the demand rates. If this is true, the delivery rate to customers is 100% as committed.

Suggestions of 2nd milestone have been implemented and the value of JIT index is calculated by using mathematical model and the improved value of JIT index is shown in Table IV.

XIV. COMPUTATION OF JIT INDEX AFTER 3rd MILESTONE

Key performances areas of Quality is identified & certain attributes are selected for 3rd milestone for implementation, where the response rating is not up to the mark.

When most inspection sequences are eliminated and the operators are responsible for their own quality, profits, throughput, and lead times all improve. The true role of JIT quality assurance is to audit and train on the operators’ quality performance.

The impact of quality on volume throughput is always a problem to overcome quality failure in low volume JIT flows have a devastating effect. In one case study, each of five major subassembly work flows assumed that their own small 3% failure had little effect on final assembly. But, the cumulative effect of a 3% failure in each channel when multiplied by each other in the above probability statement shows that only 86% of the final product was shippable without rework. Many “Red Tag” quality failures were sent back for rework in upstream work centers – obviously impacting the flow. Vendor quality, test procedures and online checks were instituted to reduce these failures. Inspection however was still in the flow of the product as an official operation. Some inspection steps were at 100% inspection due to inconsistent or variable failure was typically occurs in electronic assembly. At the beginning of the year, the inspection process was reduced to random sampling in some areas, and quality failure dropped to less than 1% overall.

Process variability and early warning statistical quality control tools must be in place and used to monitor and control quality at critical points in the process. A synchronized production flow with only one part moving at a time cannot have even one failure without disrupting throughput, thus the need for immediate notification of quality problems. The Japanese words “poke-yoke”, meaning fool-proof mechanisms, and “and on”, meaning trouble or alarm lights have become known as visible failure warnings. These types of indicators or tools are instantaneous indicators of failure and must be responded to immediately.

Suggestions of 3rd milestone have been implemented and the value of JIT index is calculated by using mathematical model and the improved value of JIT index is shown in Table IV.

Fig. 1 indicates JIT/ sustainability manufacturing indices of various key performance areas obtained after different milestones. Fig. 2 gives the values of JIT / sustainable manufacturing index of the total manufacturing system after different milestones.

Fig. 1. JIT manufacturing indices of various key performance areas

Fig. 2. JIT manufacturing system index after various milestones

XV. SUGGESTED PROCEDURE FOR COMPUTATION AND IMPROVEMENT OF SUSTAINABILITY/JIT MANUFACTURING INDEX

1) Decide about key performance areas / subsystems applicable to a particular organization.
2) Survey instrument design for data collection including key performance areas and scoring systems.
3) Chose performance objectives/ attributes for each performance area with a view of JIT thinking in order to measure and monitor performance.
4) Measure inputs used in the manufacturing systems as per the scoring guidelines.
5) Compute manufacturing sustainability / JIT index in order to evaluate each subsystem/ key performance area.
6) Understand your results
7) Chose opportunities to improve performance and take action to improve productivity index.
8) Decide upon implementations having different milestones after choosing opportunities for improving performance.
9) Create action plan to implement as a continuous innovative process.
10) Revise the process regularly in different milestones to constantly improve your actions for better sustainability index.

XVI. RESEARCH AVENUES
Researcher has to start thinking from a different viewpoint which includes:
1. Reduce resource utilization in the manufacturing process by using less harmful materials
2. Use environment friendly materials and energy systems.
3. Reduce all forms of waste and emissions while planning manufacturing process.
4. Reuse and recycle as much material as possible for self-recovery.
5. Optimize the process by introducing agility and flexibility in the process.
6. Carry out total product life cycle analysis by considering material acquisition, material production, product manufacturing, product use and final disposal.

XVII. FUTURE SCOPE
Depending upon the type of industry involved the weightage factor of sub-systems and attributes maybe incorporated for calculating the JIT Manufacturing Index. It will increase the mathematical complexity but may give more precise result and if required some already available techniques such as ANN, GA, ANT, Fuzzy Logic, ANF etc., may be used as and where applicable.

XVIII. CONCLUSION
JIT is a revolutionary concept. Making the complex simple is the main goal of JIT. This philosophy is emerging as a concept which facilitates significant improvements in manufacturing performance. It is an approach to problem solving the main areas to attack are those identified as wasteful and to eliminate waste. It also allows to reduce lead time to zero or as close as possible to that number. JIT represents a genuine opportunity for industry to regain a competitive posture in the international market place without investing in high capital cost equipment and complex computer systems.

A JIT system will be in constant evaluation. It forces individuals to think practically about analytical matters. It is advisable to record the actual values of every item before implementation begins. During implementation, compare the progress achieved with the goals suggested. A survey instruments has been designed and developed having different key performance areas or sub-systems and each sub subsystems with a different key performance objective for collecting information for an industry under consideration. JIT manufacturing index, which gives an idea of performance of the system, has been computed by using the mathematical model developed and data collected for the industry under consideration. Depending upon the values obtained, the performance index of different subsystems, and the implementation procedure has been decided.

After the implementation, the JIT manufacturing index improved from existing 0.5357 to 0.6071 in the first mile stone and subsequently to 0.6357 and 0.6642 in the second and third mile stones, respectively, for the case under consideration.

The effort does not stop once you have a complete JIT implementation. Like most areas of technology, JIT is constantly evolving and based on the philosophy of continual improvement, JIT is closely a ‘journey without end’. Fortunately, much of the JIT implementation is regarded as a ‘common sense’ by shop floor staff and has the advantage of visible results in the short term.

ACKNOWLEDGEMENT
The authors express heart-felt gratitude to Dr. Mukul Agrawal, CEO, Kogence, California for his expert guidance in the preparation of this paper. The authors also thank Dr. Manoj Agrawal, Associate Professor, Department of Mechanical Engineering, GLA University, Mathura and Dr. Vikas Kumar Sharma, Principal, GLA University Polytechnic, Mathura for their critical reviews and valuable suggestions.

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