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JIT Manufacturing Systems in Indian Industries: A Review

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Abstract

Most of people understand JIT as a system of reducing inventory and quality control but they do not realize that it is a system of highlighting the problems, and forcing the organization to find quick solutions. It creates a problem solving organization. However, there is no standard to implement the 'JIT' other than continuous progress towards the ultimate objective of delivery as wanted with a smoothly synchronized continuous flow keyed to final demand, with perfect quality of incoming goods. Therefore, its successful implementation is a serious issue. JIT imposes a different set of requirements on typical work culture. Therefore, work culture of a society plays critical role in successful implementation of this approach. Researchers and managers of different countries think in different way according to their social and cultural principles. Its implementation in India may differ from the western countries. Therefore, it is important to focus on that JIT attributes which have high degree of importance in Indian context. This study investigates JIT implementation practices and performance in manufacturing organizations in the India. For this, literature related to JIT usage and performance is reviewed. A literature classification scheme is suggested in this paper for surveyed literature considering thirty-seven JIT attributes. To aid this classification, thirty-seven identified attributes of JIT production system are classified into five main categories. The frequency of citation of an attribute in the literature is assumed to be measure of its importance. Thus, relative importance of such attributes is also highlighted.

Keywords: Just-in-Time (JIT), Quality control, Production control, Inventory control.

Introduction

JIT is a set of management technologies, and when globally implemented has a large number of cultural aspects imbedded in its development. The JIT manufacturing system is a pull system, which means that the production system responds to customer demand regardless of the level of demand. This is in contrast with the traditional push system, where production schedules are determined before demand is precisely known. JIT manufacturing utilizes production methods that emphasize reductions in raw material, in work in progress (WIP), and in finished goods inventories. A JIT manufacturing facility is clean, work areas are very well organized, and a typical JIT plant has numerous visible instruction signs posted for workers. In addition, JIT requires different work culture. The JIT system comes from a culture that emphasizes speed and efficiency, has a concern for space because of its very dense population, and has a very high literacy rate. Therefore, its implementation in India may differ from the developed countries. The study of this approach in Indian context may be helpful for those industries, which are still struggling with problems of unreliable and long lead-time, inferior quality, low productivity, high rate of scrap and defects, shortage of raw material, and under utilization of workers and equipments [1]. JIT system works on some unique principles. JIT motivates the workers to think quality first and production rate second. JIT operations insist all workers to do their jobs right the first time. To ensure strict compliance with quality standards, quality audits are performed every so often. In addition, management allows time for the identification and solution of the quality control problems by scheduling production rate at lower than full capacity. The responsibility is given to each person in the organisation to perform quality control functions. Product inspection and quality control functions are performed by workers, which were previously performed by quality control inspectors. They are made responsible for checking the quality of materials from a vendor. A worker may also be asked to perform product quality checks on another worker's value added efforts. This new concept places greater

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job responsibility on labour and, enlarge the worker's job. In the JIT environment, workers with the responsibility to perform quality control activities are often motivated by the added responsibility to offer suggestions for improving quality of product or process. This process helps the managers to solve quality problems [2].

In the past, managers were held responsible for product quality. They therefore made and maintained records of process control charts themselves. But, in the JIT environment, the workers are trained along with managers in preparation and interpretation of the process control charts. The control charts have motivational effects. Workers can see immediate increase or decrease in their efforts to change the quality of the products they are producing. Quality control charts are placed on the walls or machines of work centres where everybody can see and observe quality control efforts. Thus, high level of quality control visibility motivates the workers to change towards improving the production quality [3]. In addition, the worker and automated system are given authority to bring a production line, cell, department or entire plant to halt, if quality control problems are uncovered. Thus, the quality responsibility is not only given to everybody but also matched with authority to share in control of product quality. When identified problems are coupled with authority to stop production, workers motivate management to address and solve quality control problems quickly. Solving quality control problems helps to improve the flow by eliminating future line stoppage [4,6]. This concept also helps to solve quality related problems quickly, and saves rework and scrap cost.

The flexibility of workers is also an influential part of JIT system. Flexibility gives workers the opportunity to accept more job responsibility, increase their feeling of values to the company. Since cellular layout is essential element of JIT system, each worker is able to do all the necessary tasks within a cell. The workers therefore control volume and quality. Extensive cross training of personnel is designed to provide job assignment flexibility. The workers are trained to perform a variety of different jobs. This permits management flexibility in making job assignments when production requirement shifts. It also helps to assure workers they will be retained during the period of change [5]. Thus, Japanese Just-in-Time (JIT) system achieves goals of high quality and productivity. Conceptually, this approach combines apparently conflicting the objectives of high quality, manufacturing flexibility, reasonable cost and delivery dependability. It stimulates new directions of planning and performing activities in a manufacturing. Its effects are significant in improving the overall performance of the whole organization.

JIT can be summarized as an approach to eliminate waste and achieve manufacturing excellence. Much has been written about its positive strategic influence on the Japanese manufacturing sector. It is, therefore, essential to review the literature to identify the various dimensions of JIT. The global status of this approach can be studied through surveys, case studies, empirical studies, and modelling work. Fortunately, the literature related to this approach is rich with these types of studies. This paper reviews the JIT literature in Indian context with following objectives:

- To identify the various dimensions of JIT production system.
- To classify literature on JIT in Indian context.

JIT Concepts in Indian Context

The manufacturing firms in India have been adopting innovative management practices to improve performance, particularly in the energizing competitive market environment. However, JIT approach has not yet been considered and implemented in its full operational form by Indian organization owing to several reasons. Many studies have shown that some Indian industries have benefited significantly from implementation of JIT practices. This section reviews the literature to highlight the status of JIT practices in Indian context.

Conceptual Articles

JIT quality control and inventory control methods and work culture are very different to tradition quality and inventory control methods. Many authors discussed these concepts in their research papers. Ajit singh [11] illustrated the relationship between Just-in-Time (JIT) practices and Total quality control (TQC). Both techniques offer the complementary means of reaching quality objective. JIT removes the buffer of inventory accrued by traditional stocking methods and expose the quality problem at earlier stages. TQC detects the pattern and exact locations of quality problems. However, operators must be trained to trace and remove the defects. They should also be trained to perform the preventive maintenance activities so that preventive or corrective action can be taken instantaneously in case of machine failure. Neat and clean workplace is another common requirement of both techniques. Clean and orderly workplace provides the visibility for earlier detection of problems, and enhances the work discipline needed for continuous quality improvement. Padukone and Subba [8] suggested that JIT should be implemented in two stages. In first stage, the elements

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such as set-up time reduction, lot size reduction, total quality control, layout improvement, buffer stock reduction and flexible workforce may be implemented. These elements are essential for JIT to work since they focus on simplicity, flow quality, and fast set-up that can be achieved in short term. In second phase, more difficult elements like kanban, JIT purchasing, buffer stock removal, multifunctional worker, pull scheduling, enforced improvement, and visibility may be implemented. They pointed out that Indian industry may be benefited by JIT implementation if its elements are implemented in a systematic manner. But JIT implementation without understanding the conceptual framework cannot result in long lasting improvements.

According to Garg et al. [9], JIT requires a culture that allows the worker to become a participant in decision making and thus necessitates putting trust and responsibility in the hands of workers and supplier to become same interest group by the way of having long term relationship. In JIT environment, work culture required is marked by trust, locality, responsibility, development, motivation, authority, long-term relationship, and respect for human being. It is critical for a firm to make conscious and deliberate efforts to change the work culture for successful implementation of JIT. These changes in work culture require top management commitment, involvement and leadership, worker participation in decision making and massive education and training to the people concerned. It is also pointed that cultural factors are biased against above said rapid and massive changes because people prefer an existing inequity to known improvement.

Kumar et al. [10] stated that traditional view permits small but allowable amount of poor quality product in outgoing manufacturing goods. On contrary, JIT does not allow poor quality products in any quantity by focusing the special attention on efforts to get high quality products in small lots. The basic principles of JIT such as high level of visibility on quality, strict product quality compliance, participation in control of product quality, self-correction of worker-generated defects, 100% quality inspection of products, routine maintenance and house cleaning duties, continual quality improvement and long-term commitment to quality control efforts have been identified in this study. Finally it has been concluded that consistent with these principles, JIT motivates the workers to achieve product quality perfection.

Kumar et al. [11] explained how JIT and modern electronic systems could work together to achieve the production benefits. With the help of modern electronic systems, workers could immediately see electronically measured impact of their efforts in area of quality. The quick implementation of worker suggestions is important feature of these systems. Electronic systems integrate the different quality control activities, and generate information that are shared by different departments to frame the better plan for quality improvement. Thus, electronic systems enhance the use of automated quality control for making quality efforts more visible as JIT requires. The study concluded that modern electronics systems are changing the ways to conduct the businesses. Electronic funds transfer; global positioning system, robots, e-mails and e-manufacturing obsolete the traditional systems. Therefore, Indian industries should make serious efforts to integrate their company's activities with these new technologies through the effective use of R & D.

Survey/Review Articles

To find out the applicability of JIT concepts in Indian context, some authors have conducted surveys of Indian industries and reviewed the literature. This subsection presents the results of these surveys. Garg et al. [12] administered a questionnaire to eighty different Indian industries. The questions were on the company's profile, JIT implementation, and JIT purchasing in their respective companies. Twenty-eight responses to this questionnaire were obtained. Thirteen companies have indicated that middle management level persons look after the purchasing functions while eight companies did not respond. It has been found that numbers of companies are implementing manufacturing systems such as material requirement planning (MRP-I), material resource planning (MRP II), data base management system (DBMS), production planning systems and preventive maintenance. They are also giving good weightage to multi-skilled workers, stock to dock delivery, standard container, and buyer control over delivery schedule. The companies select, develop, and evaluate their suppliers on the basis of their past performance, quality, delivery time, cost-financial health, and service level. Most of companies were using ABC system for their inventory control. However, they were not using any method to estimate ordering cost. The study also indicated that the professionals are not very optimistic about scope of JIT implementation in India. However, they generally agree that companies will be benefited, if elements of JIT purchasing are fully implemented.

Garg and Deshmukh [13] reviewed and classified the literature on JIT purchasing. Two classification schemes have been suggested in this

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study to categorize the available literature into: a) conceptual articles, survey and reviews, case studies, and empirical/modelling work; and b) buyer action, supplier action, joint buyer-supplier action, and outcome attributes. The importance of attributes in JIT purchasing has also been identified based on its frequency of citation in the surveyed literature and in an Indian context. It has been found that conceptual, survey/review and empirical/modelling articles in the surveyed literature have ignored the supplier-action attributes, however, in case study articles, they have been given some weightage. The attributes, e.g. reliable deliveries, small shipment size, reduced delivery lead times, and fair processes have often been discussed in the surveyed literature. However, attributes e.g. small shipment size, elimination of receiving inspection, reduced paper work, and exact quantity seem to have been ignored in the surveyed literature. This study suggested that attention must be focused on the identified important attributes in an Indian industrial environment so that maximum benefits can be obtained by JIT implementation.

Kumar et. al. [14] pointed out that Indian industries are still using the traditional manufacturing practice while they are pushing to uncertain and competitive global maker environment by opening the economy. The price for adoptions of these practices are paid in form of long work-in-process, huge inventories, lost orders, and poor quality. In addition, mass production strategy is not suitable in present competitive environment because product life cycles are becoming shorter due to continuous improvement in design of product, technological advancement, and change in customer behaviour. The most effective and economical solution of these problems is adoption of stockless production. They have also surveyed the twenty-two Indian industries to study the applicability of JIT in Indian context. The study concluded that perfect implementation of JIT may not feasible in most of Indian industries due to lack of resources, lack of technology, non availability of multifunctional workers etc. However, some elements such as standardization, statistical quality control, work centred quality control, long-term contract, layout improvement, smooth flow of material etc. are easy to implement. Therefore, maximum weightage must be given to these elements to reap maximum benefits.

Kumar et al. [15] classified the JIT/TQM techniques into four categories: management techniques, analytical techniques, idea generation techniques and data collection techniques, and surveyed the forty-six industries on the basis of this classification. Data collected was analysed with help of factor analysis on scale (0-100), and mean scores were put into scatter chart. The result of survey reveals the great importance of these techniques in Indian industries. The techniques such as total preventive maintenance, cause and effect diagram, quality policy deployment, affinity diagram, kaizen, JIT purchasing and matrix diagram require more attention since their efficient implementation may be helpful to improve the present situation of industries in area of quality, cost and flexibility by developing specific time bound improvement action plans. Finally, the study concluded that JIT/TQM techniques seem to generate awareness about quality and associated cost at every level, and in every sector of Indian industries. However, their effectiveness would depend upon the Indian workforce situation, behaviour patterns, personality traits, attitude and values.

Deshmukh [16] classified the JIT literature into four categories: a) JIT definition/objectives and JIT as a philosophy; b) implementation aspects of JIT; c) the mathematical models of JIT; and d) miscellaneous issues in JIT. The author pointed out that under the JIT framework, few models have been reported. Generally, the simulation approach seems to have been followed. This could be due to either inadequate understanding of the JIT holistic approach and putting it into a broad systems model or to the inadequacy of the present modelling techniques and optimisation approaches. Furthermore, the models reported are often restricted to single JIT method or technique and over look the wholeness concept that is implicit in JIT. However, the literature seems to be replete with model on buyer and vendor relation and the joint economic order determination for vendor and buyer.

Mahadevan [17] conducted a survey of 43 Indian organizations. The survey indicated that automobile industry in India has made significant improvements in areas such as multiskilling of work force, total preventive maintenance, and JIT purchasing. These factors constitute the basic requirements for successful JIT implementation in any firm. Most of the firms with some JIT efforts have reported starting their efforts only recently**.** Firms with major JIT programmes have indicated an implementation lead-time of more than three years. Supplier development, employee involvement, and top management commitment are prominently listed as critical success factors. Training, task force formation, re-layout, and pilot study are indicated as among the first five steps taken in JIT implementation. Proximity of suppliers, stable production plan or high volume repetitive manufacturing is never mentioned among the main reasons for JIT implementation. Finally, the study concluded that JIT and TQM are two sides of the

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same coin while JIT provides an organizational framework for the TQM programmes to solve the problems. Hence, it is important to understand that neither JIT nor TQM can stand-alone in the long run.

Garg et al. [18] conducted a survey of thirty Indian industries to analyze the importance of the JIT attributes. Data collected were analyzed with help of factor analysis on a scale (0-100). The scope of JIT implementation was found 70 on scale (0-100), which can be said 'fairy good'. This study has predicted better scope of JIT implementation in India compared to earlier studies. In addition, the results of survey have indicated that Indian industries are giving fairly good importance to JIT purchasing attributes such as high quality, mutual trust and cooperative relationship, reliable (on-time) deliveries, exact quantity, increased customer support to supplier, supplier evaluation, stable production schedule, reliable network of suppliers, reduced delivery lead time, quality circle, long term contract, continuous improvement, fewer suppliers and increased volume to supplier (in decreasing order).

Case Studies

Indian industries have been benefited with wide range of benefits obtained from JIT implementation. But JIT implementation India is slightly difficult due to low literacy level and cultural differences. Many authors highlighted such the difficulties through case studies. Singhvi [27] presented the experience of an Indian automobile company in implementing JIT. Some important changes were made for improvements in quality level, reduction in W.I.P., reduction in space and reduction in material handling. The study has found that 'employee involvement' is a critical element for implementing the JIT. Large investments are not found to be essential, but it is impossible to implement the JIT without employee involvement, and persistent focus on quality. It is also felt that implementation of JIT is not so difficult in India and its implementation could be a great opportunity for Indian industries due to its wide range of benefits.

Kaujalgi and Lingraj [19] provided an overview of changes implemented in a spring manufacturing department over the last three years. These changes were made as part of a continuing implementation of a JIT manufacturing system in an oil seal division of company. The complete implementation process of JIT is described in six phases. In first phase, the MRP II based systems were replaced. The orders for oil seals (product) were placed strictly by customer's requirement date and a pull system was implemented throughout the plant. The replenishment system was developed and kanban cards were delivered with containers of manufactured springs. In second phase, sets up times were reduced, and inventory limits were placed in front of each downstream operation. The replenishment systems for the product lines within plant was replaced by a system of making to customer order during third phase. A system was developed which also schedule jobs for actual customer order as part of forth phase of implementation. The work-in-process was reduced to less than two days during fifth phase of JIT implementation. In sixth phase, kanbans were reduced for further reduction in amount of allowable work-in-process.

Garg et al. [20] conducted a case study of a tractor assembly industry located near Delhi. The company had started implementing JIT in mid 1980s. The key steps of JIT implementation were: extensive training of employees on pull concepts, identification of key performance parameters, assessing current performance on the above parameters, new layout based on U-shaped cells, standardization of operations, a maintenance plan for each machine, housekeeping, visual control, and multi-skilling training. Initially, the company received discouraging results in almost all areas for several years. But management was confident about the ultimate success of their programme. After few years, everything was stream lined and management begun achieving significant results. The findings of study have indicated that significant visible improvements in the cylinder headline, internal line, control housing, hydraulic line, transmission line and final tractor assembly line are observed through JIT implementation. Also, significant benefits are achieved by reductions in inventory, material movement, space, manpower, work-in-process and lead-time; increases in productivity, linearity, and quality.

Deshmukh [21] presented the effects of JIT implementation in Sona Steering, Gurgoan. Sona's production system is 'lean' rather than 'mass'. The machines are set in 'cell formation' and one operator is in-charge of multiple jobs. Machines are closely put together without in-process stock and only the stock of raw material and finished product is maintained at every cell. Production workers are empowered to stop the line moment a defect occurs. The fool proofing devices and various other aids are provided on the production line help the workers take such decisions. The entire logistic within the company and key suppliers are managed with use of kanban cards. Supplies to major customer Maruti Udyog, located a few kilometres away are made on the just-in-time basis: there are roughly sixteen deliveries made every

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day, and about one day's requirement is stocked at the customer. The study concluded that Kanban is a simple and effective tool for implementing just-in-time system. It provides an excellent way for promoting improvements because restricting the number of kanbans in circulation highlights problem areas.

Modeling Framework

Some authors have developed JIT models for justification of this system in Indian industries. Vrat et al. [22] conducted a Delphi study to assess the applicability or difficulty of implementing JIT elements in Indian context indicates that quality circles and good communication are not very difficult to implement while other critical elements like multifunctional workers, long term relationship with vendor, support from labour union and top management attitude have high rating, which indicates that JIT implementation in India is difficult, but not impossible. The study suggested that attention must be focused on poka-yoke, reduced set up time, Kanban system and quality of incoming material.

Chander and Kodali [23] developed a multi-attribute decision model using analytical hierarchy process (AHP) for justification of JIT manufacturing system in Indian industries. The selection of important JIT attributes and sub-attributes was determined through literature survey. All JIT attributes and sub-attributes were then used in AHP to achieve the related benefits. The results of study have quantified the JIT benefits in descending order: increased profit margin, improved competitive position, quality improvement and reduction in inventory. Also, the study has pointed out that electronic data interchanges can be used connotating the JIT techniques to lessen inventories. A forecast could be generated based on the previous day's sales, and the demand signal could be sent electronically to all concerned suppliers. However, this technique is not fully developed in India.

Garg et al. [24] have parametrically analysed a JIT-PQD model using PC-based spreadsheet. A numeric example has been considered to illustrate the results. The average annual relevant cost has been found relatively insensitive to ordering, inventory holding and shipment costs. It is also pointed out that the parameters are liable to vary in a wide range in actual cases but the automated spreadsheet is capable of processing these in practically no time. An optimal decision could be made with help of spreadsheet in case of several suppliers and or different operating parameters; both order quantity and number of deliveries can also be optimised. The study concluded that large order size with more number of deliveries is expected to encourage the supplier to create JIT-PQD scenario and consequently lead to stronger buyer supplier relationship.

Kumar et al. [25] carried out parametric analysis of price quantity discount model under just-in-time purchasing agreement considering 'reliability' as an important factor in JIT supply system. Only single source of supplying the material with an alternate supplier has been considered in this model. The results of this study have been shown that average annual relevant cost increases marginally with increase in holding and ordering costs. When shipment cost and unit cost are increased to great extent, average annual relevant cost marginally increases, but net effect of reliability factor on annual relevant cost is decreased. Finally, the study concluded that reliability of JIT supply system can be increased to great extent at optimal and considerable cost.

According to Mahapatra [26], the popular Japanese JIT approach has not yet been considered and implemented its full operational form by Indian organizations owing to several reasons. The author forecasted the year when JIT will be implemented as a whole and its various constituting sub-approaches in Indian manufacturing organizations. A technique of Max.-Min Fuzzy Delphi Method (MMFDM) is used for this long range forecasting. Based on a survey by the MMFDM involving one hundred ten managers with about sixty-five percent response data, it is forecasted that Indian manufacturing organizations will start realizing benefits of JIT around 2015 AD.

Suggested Classification Analysis

In the literature, JIT practices have continuously drawn the attention from researchers and practitioners. This is reflected in number of conceptual articles, survey and case studies, and empirical/modelling work. The possible classification scheme shown in table 1 is suggested based on extensive review of the literature. To aid this classification, thirty-seven identified attributes of JIT production system are classified into five main categories. The frequency of citation of an attribute in the literature is assumed to be measure of its importance. Thus, relative importance of such attributes is also highlighted. It may be observed that the 'Quality Control' attributes are being given enough attention. In addition, production control attributes have also been received good response in the literature. Summary of attribute frequency count by article type is given in table 2. Table 2 show that some research papers have discussed few attributes indicating the beginning of specialized research interest in JIT practices by academician and industries.

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Quality Control Attributes

Continual improvement (kaizen), Error prevention (poke-yoke), High QC visibility, Line stop strategy, Long term QC commitment, QC authority to worker, QC training to workers & suppliers, Quality circles, Regular quality auditing, Process control, Statistical quality control, Total quality control, Zero defect and 100% quality inspection are key quality control attributes of JIT production system. As evident from table 1, the attributes continual improvement (kaizen); quality circles; total quality control; and QC training to workers/suppliers have received good response. However, line stop strategy; regular quality auditing and long-term QC commitment could not attract the attention of researchers; hence they may be assumed to be of little significance. Table 2 indicates the continual improvement; quality circles and total quality control are discussed in all types of studies. High QC visibility and zero defects seem to have been less importance in the literature. Similarly, Process control; and statistical quality control are ignored in modelling/empirical literature.

Work Culture Attributes

Product inspection and quality control functions are performed by workers, which were previously performed by quality control inspectors. They are made responsible for checking the quality of materials from a vendor. Employee empowerment, Group incentive scheme, Job enlargement, Multifunctional worker Self-correction of defects and team work are key attributes of JIT work culture. Among 'work culture' attributes, multifunctional worker and teamwork had been discussed frequently in the surveyed literature while job enlargement; group incentive scheme; and employee empowerment have been touched to small extent.

Inventory Control Attributes

Buffer stock removal, Kanban, Short lead time, Small lot size and Standard containers are key attributes of JIT inventory control. The 'buffer stock removal' has also been highlighted in the literature to some extent as is obvious from Table 2. The attribute 'standard container' is also touched to small extent. However, good weightage is given to short lead-time, Kanban and small lot size.

Purchasing Attributes

Frequent and reliable delivery, Long-term contract/employment, Quality certification of supplier, Strong buyer-supplier relationship and Vendor rating are key purchasing attributes. 'Frequent and reliable' delivery has been discussed many times in literature. In addition, 'Long-term contract/employment' and 'Vendor rating' have also received good attention by the researchers. Less weightage is given to attribute 'Quality certification of supplier' as compared to other attributes.

Production Control Attributes

Effective communication, Total preventive maintenance, Set up time reduction, Standardization, U-cells/ layout improvement, Scheduling flexibility and Zero deviation schedules are some production control attributes of JIT production system. Although set up time has been discussed in all type of work yet this attribute is not discussed in detail. The attributes e.g. effective communication, scheduling flexibility; standardization and U-cells/ layout improvement have been discussed frequently in the literature while the attribute such as 'zero deviation schedule' and 'total preventive maintenance' have not been get much attention from the researchers.

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Table 1: JIT attributes in Indian context

	Authors	JIT attributes																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Conceptual	A		*								*				*		*		
	B	*		*	*				*		*				*				
	C	*	*	*	*	*		*		*		*			*		*	*	
	D	*	*		*	*			*	*			*	*			*		*
	E			*	*	*	*		*					*	*				*
Survey/Literatur	F			*	*		*						*						
	G		*	*		*		*	*	*	*			*	*	*	*		*
	H					*		*	*		*				*	*	*		
	I		*	*			*	*		*					*				*
	J		*				*								*			*	
	K		*								*		*		*	*			
	L		*	*			*						*					*	*
Case	M			*	*					*					*	*			
	N	*	*								*								
	O			*			*		*				*		*			*	
	P	*	*	*							*								
Modeling work	Q	*	*	*		*					*				*	*		*	
	R		*				*				*					*			
	S	*					*								*				
	T		*	*	*		*				*		*					*	
	U		*	*			*						*		*			*	
	Frequency	7	14	13	7	6	10	4	6	5	10	1	7	3	14	6	5	7	5

Table 1: JIT attributes in Indian context (Contd.)

	Authors	JIT attributes																		
		19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Conceptual	A	*				*			*				*					*		*
	B				*		*							*	*		*			
	C	*		*									*		*		*			
	D	*	*	*						*	*		*			*		*	*	*
	E	*	*	*				*	*		*							*		*
Survey/Literatur	F	*			*		*			*							*	*		
	G			*	*	*			*		*		*		*	*		*	*	*
	H	*			*			*		*	*			*	*	*		*		*
	I		*		*	*	*	*	*			*	*							
	J	*			*		*					*		*	*		*			
	K	*			*		*	*				*	*	*	*			*		
	L	*	*		*	*			*	*		*	*			*	*	*	*	*
Case	M	*			*	*	*		*				*	*			*			
	N				*	*	*		*				*							
	O	*			*	*		*				*		*	*	*	*			

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	P				*	*									*				*	
Modeling work	**Q**	*			*	*	*				*	*	*	*	*	*	*			
	R				*			*						*	*		*			
	S				*	*	*							*		*				
	T	*					*	*				*	*				*			
	U	*			*		*		*	*		*		*	*	*	*			
	Frequency	14	4	4	16	10	11	7	8	5	5	8	11	10	11	8	11	8	4	6

JIT attributes :1) *Buffer stock removal;* ***2)*** *Continual improvement (kaizen);* ***3)*** *Effective communication;* ***4)*** *Employee empowerment;* ***5)*** *Error prevention (poke-yoke);* ***6)*** *Frequent and reliable delivery;* ***7)*** *Group incentive scheme;* ***8)*** *High QC visibility;* ***9)*** *Job enlargement;* ***10)*** *Kanban;* ***11)*** *Line stop strategy;* ***12)*** *Long-term contract/employment;* ***13)*** *Long term QC commitment;* ***14)*** *Multifunctional worker;* ***15)*** *Total preventive maintenance;* ***16)*** *QC authority to worker;* ***17)*** *QC training to workers & suppliers;* ***18)*** *Quality certification of supplier;* ***19)*** *Quality circles;* ***20)*** *Regular quality auditing;* ***21)*** *Self-correction of defects;* ***22)*** *Set up time reduction;* ***23)*** *Short lead time;* ***24)*** *Small lot size;* ***25)*** *Standard containers;* ***26)*** *Standardization;* ***27)*** *process control;* ***28)****Statistical quality control;****29)*** *Strong buyer-supplier relationship;* ***30)*** *Team work;* ***31)*** *Total quality control;* ***32)****U-cells/ layout improvement;* ***33)*** *Vendor rating;* ***34)*** *Scheduling flexibility;* ***35)*** *Zero defect;* ***36)*** *Zero deviation schedules;* ***37)****100% quality inspection.*

Authors : A) *Ajit Singh [7];* ***B)*** *Padukone and Subba [8];* ***C)*** *Garg et al.[9];* ***D)*** *Kumar V et al. [10];* ***E)*** *Kumar V. et al. [11];* ***F)*** *Garg and Deshmukh [13];* ***G)*** *Kumar V. et al. [14];* ***H)*** *Kumar V. et al. [15];* ***I)*** *Garg et al. [12];* ***J)*** *Deshmukh [16],* ***K)*** *Mahadevan B. [17];* ***L)*** *Garg et al. [18];* ***M)*** *Singhvi [27];* ***N)*** *Kaujalgi & Lingaraj [19];* ***O)*** *Garg et al. [20];* ***P)*** *Deshmukh K. [21];* ***Q)*** *Vrat et al. [22];* ***R)*** *Chandra & Kodali [23];* ***S)*** *Garg et al. [24];* ***T)*** *Kumar V. et al. [25];* ***U)*** *Mahapatra [26].*

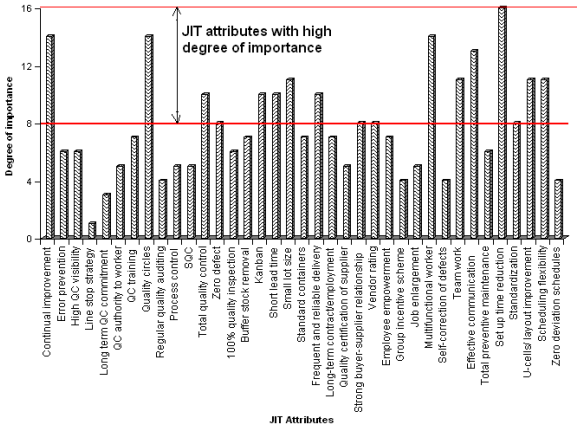

Figure 1: Degree of importance of JIT attributes in literature

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Table 2: Summary of attribute frequency count by article type

Attributes	Attribute no.	JIT Attributes	No. of article reviewed				Frequency	Total
			5	7	5	4		
			Conceptual articles	Survey/Review articles	Case studies	Modeling/ Empirical work		
Quality control attributes	2	Continual improvement (kaizen)	3	5	2	4	14	**94**
	5	Error prevention (poke-yoke)	3	2	0	1	6	
	8	High QC visibility	3	2	1	0	6	
	11	Line stop strategy	1	0	0	0	1	
	13	Long term QC commitment	2	1	0	0	3	
	16	QC authority to worker	3	2	0	0	5	
	17	QC training to workers & suppliers	1	2	1	3	7	
	19	Quality circles	4	5	2	3	14	
	20	Regular quality auditing	2	2	0	0	4	
	27	Process control	1	3	0	1	5	
	28	Statistical quality control	2	2	0	1	5	
	31	Total quality control	1	3	2	4	10	
	35	Zero defect	3	5	0	0	8	
	37	100% quality inspection	3	3	0	0	6	
Inventory control attributes	1	Buffer stock removal	3	0	2	2	7	**45**
	10	Kanban	2	3	2	3	10	
	23	Short lead time	1	3	4	2	10	
	24	Small lot size	1	4	2	4	11	
	25	Standard containers	1	3	1	2	7	
Purchasing attributes	6	Frequent and reliable delivery	1	4	1	4	10	**38**
	12	Long-term contract/employment	1	3	1	2	7	
	18	Quality certification of supplier	2	3	0	0	5	
	29	Strong buyer-supplier relationship	0	4	1	3	8	
	33	Vendor rating	1	3	1	3	8	

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Table 2: Summary of attribute frequency count by article type (Contd.)

Attributes	Attribute no.	JIT Attributes	Conceptual articles	Survey/Review articles	Case studies	Modeling/ Empirical work	Frequency	Total
Work culture attributes	4	Employee empowerment	4	1	1	1	7	**45**
	7	Group incentive scheme	1	3	0	0	4	
	9	Job enlargement	2	2	1	0	5	
	14	Multifunctional worker	4	5	2	3	14	
	21	Self-correction of defects	3	1	0	0	4	
	30	Team work	3	4	2	2	11	
Production control attributes	3	Effective communication	3	4	3	3	13	**69**
	15	Total preventive maintenance	0	3	1	2	6	
	22	Set up time reduction	1	7	4	4	16	
	26	Standardization	2	3	2	1	8	
	32	U-cells/ layout improvement	2	4	2	3	11	
	34	Scheduling flexibility	2	3	2	4	11	
	36	Zero deviation schedules	1	2	1	0	4	

Figure 1 shows that Continual improvement (kaizen), Statistical quality control, Kanban, Short lead time, Small lot size, Frequent and reliable delivery, Multifunctional worker, Team work, Effective communication, Set up time reduction, Scheduling flexibility and U-cells/ layout improvement have high degree of importance in Indian context because these attributes have received good attention from the researhers. Figure 2 show that 'Quality Control' attributes are being receiving enough attention. In addition, Production control attributes have also been received good response in the literature, while 'work culture attributes' and 'inventory control attributes' are getting equal weightage.

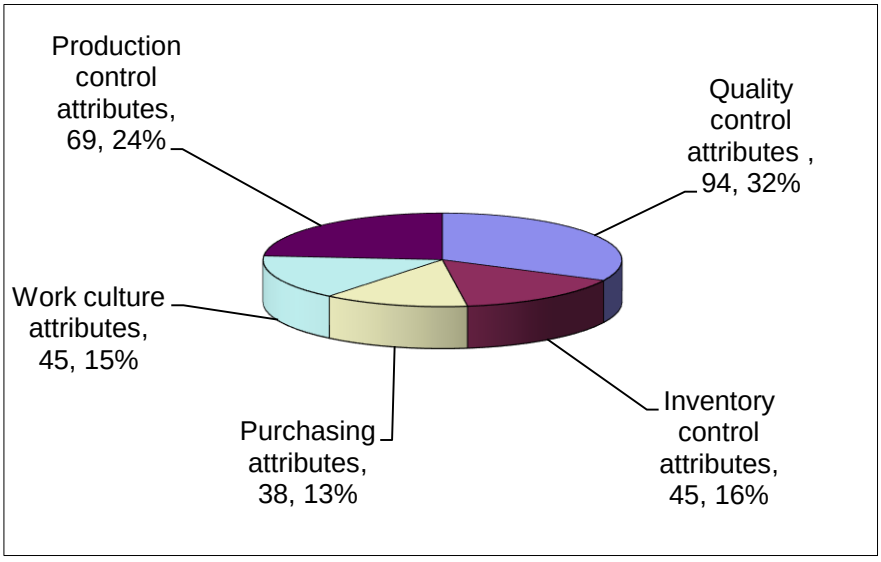

Figure 2: JIT attributes and their importance in Indian context

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Important Observations

From literature cited, the following observations can be made:

- The literature survey has made clear that Indian firms focus more on attributes such as worker flexibility, WIP reduction, strong buyer-supplier relationship, total quality control, and standard container than line stop strategy, plant layout improvement, and kanban system, which are heavily emphasized in Japanese firms.
- The literature on JIT practices is replete with a number of case studies. The high-volume repetitive manufacturing firms are prime JIT adopters.
- In literature survey, few models have been reported under JIT framework. Generally, Analytical Hierarchy Process (AHP) and simulation approach have been used to develop these models. The inadequate understanding of JIT approach or inadequacy of the present modeling techniques and optimization approaches perhaps is responsible for this. The literature survey shows that the developed models are restricted to limited JIT methods. The modeling work on buyer-vendor relations and joint economic order determination for vendor and buyer seem have been frequently discussed in the literature.
- The literature includes many success stories of JIT approach, but it seems that JIT success depends upon several factors such as size of company, turnover and work culture. It also appears that quality and worker motivation are key elements in implementation of JIT practices in developing countries.
- Quality control attributes play important role in JIT success as shown in figure 2. From the review of literature, it seems that many companies in India are trying to implement quality control attributes in systemic manner.
- Strong buyer-supplier relationship has been well acknowledgement in the literature. Many researchers have discussed importance of co-ordination between buyer and supplier, and related benefits.
- The need of set-up time reduction has been found an important issue in the literature. It has taken greater importance for those industries, which are trying to operate in JIT environment. However, in JIT literature, this has not been discussed in detail.
- In literature, degree of success of JIT implementation has been linked to work culture. The work culture attributes such as multifunctional workers and teamwork have received good attention from the researchers.
- Surprisingly, the attributes such as 'line stop strategy' and 'regular quality auditing' seem to have been ignored in the surveyed literature while these are foundation elements of JIT quality improvement programme.

Conclusion

This paper attempts to review and classify the literature related to JIT production system. The literature survey cover twenty one studies carried out India. Two simple classification schemes have been suggested here, categorized the available literature in two ways: (i) conceptual articles, survey and reviews, case studies, and empirical/modelling work; and (ii) quality control, inventory control, purchasing, work culture, and production control attributes. The literature related to JIT and its growing adoption in developing countries indicates the interest shown in this area by researchers and practitioners. The importance of various attributes has also been identified based upon its frequency of citation in the surveyed literature. Since full implementation of JIT may not be feasible in many situations, the identified important attributes need to be paid close attention during practice in industries.

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