Abstract—This article reviewed the elements of Just-In-Time (JIT) implementation in automotive industry. JIT is considered as one of the most effective management system in manufacturing since it has been introduced. By implementing JIT, Toyota has become world best manufacturer. Based on Toyota Production System (TPS), there are three elements should be considered in order to implement JIT. But, as many companies all over the world are trying to implement JIT, the implementation elements have been varies. This paper discuss in details of elements that are important in implementing JIT. The article ended by concluding the top crucial elements that being frequently mentioned in literature as it is important to implement JIT in a desired company.

Keywords—Just-In-Time implementation, elements in Just-In-Time, automotive manufacturing system, pull system.

I. INTRODUCTION

TOYOTA Production System (TPS) is one of a well-known successful manufacturing system all over the world. TPS is developed by Japanese and being adapted in either manufacturing or in management world since it brings enormous benefits to Toyota, the first implemented company.

The basic goal and objective of TPS is to reduce their lead time [1],[3]. Lead time can be described as a moment when a customer place an order to the point where they receive the order and manufacturer collect the cash [1]. To reduce lead time, Toyota aimed to reduce non-value added waste.

According to the founder of Toyota Motor Company (TMC), the best way to survive in automobile manufacturing is having all the parts for assembly at the side of their line just in time for their use [1]. As automotive industry is viewed as one of the toughest industries existed in the world, a good management system is highly important to ensure the continuity of the business.

The idea of having all parts for assembly ready at their line only when they are needed leads to the invention of a remarkable system called Just-In-Time (JIT). Because of its efficiency, the system is then classified as one of the pillars of TPS.

Companies that implement JIT are able to reduce inventory level and approach zero inventory conditions [1]. The famous TPS is build up with two important pillars [1]. As one of the pillars is JIT, the other pillar is called Jidoka. These two pillars are considered important and lead to the successfulness of TPS. Further understanding of TPS can be illustrated in a house diagram [2].

Referring to Fig. 1, the successfulness of the great TPS is driven by a lot of supporting factors. Stability of a company in term of material, process, man power as well as machine play major role as it is considered as a basic fundamental of TPS house. Heijunka, means leveling the production amount, standardized work where all process and action were recorded and established in a fix step-by-step instruction, and Kaizen, meaning that continuous improvement practiced are also considered as the fundamental of TPS house [1],[2].

Toyota goal as been stated in TPS house is to produce highest quality product with lowest cost with a shorter lead time. Achieving this goal, two pillars needed despite of the fundamental elements that have been described earlier. These two pillars are JIT and Jidoka. JIT can be considered as manufacturing techniques that produce and deliver part or product in just amount needed. To achieve JIT conditions, three elements listed. These elements are continuous flow, takt time production, and pull system. Another pillar of TPS is Jidoka. Jidoka means automation with human touch. According to this pillar, machines should be able to stop and notify abnormalities. Human work and machine work also should be separated.

Fig. 1 Toyota Production System (TPS) House [2].

The concept of JIT in Toyota works in a reverse direction where the final assembly line is taken as a starting point [1],[3]. The final process withdraws the required quantities of production from the preceding process at a certain time [1]. This procedure is repeated in reverse order up through all the
earlier processes.

Visualizing the concept of JIT, a good flow of process coordination required. Hence, a signal card called Kanban being introduced [1]. Kanban able to ensure all movements in plants could be unified and systematic [3]. Kanban carries three categories of information. Those information are pick up information, production information, and transfer information.

As Kanban only send signal to production on what should only be produced, the usage of Kanban helps Toyota to eliminate waste of overproduction as well as waste of inventory. A company that has more inventory, will have the less likely what they need [3]. Reducing inventory helps company to save cost. For example, reducing inventory can eliminate the need of warehouse and its manager. Having a high inventories also makes problems are explicitly hard to detect [1]. Kanban helps Toyota achieve their objective by reducing waste, smoothen the production flow as well as satisfying their customer by having on time delivery. Achieving JIT environment, Kanban is considered a powerful tool that able to visualize the situation [1].

II. THE DEFINITION OF JIT

TPS was being implemented across nation after the oil crisis in fall of 1973 [1]. This mean, JIT was also adopted by other automotive manufacturers as well as electronic manufactures in Japan [4]. Moreover, Japanese manufacturing firm is to be told having the best globally manufacturers reputation for superior quality and growth in productivity by implementing JIT system [5]. As JIT approach are simple and able to control inventories, US industries were pleased to use and implement JIT method in order to catching up with Japanese fast rising industries [4]. Since then, JIT is being implemented globally [6].

According to TPS, JIT means that; in a flow process, the right parts needed in assembly reach the assembly line at the time they are needed and the amount needed [1]. But, as JIT has been spread globally, the word JIT have been interpreted in various definitions as it being introduce outside Japan. Some claimed JIT as a manufacturing philosophy that utilize all value added sources and activities as well as seeks and eliminate waste efficiently [4]. JIT also is defined with the emphasizing of continuous improvement in adapting organization [7].

Most importantly, JIT is a pull system [1], where, successful companies that implement JIT will strikes two major objectives, which are, improving in quality of product produced with the ability of controlling production time and delivery to customer [8]. Above all, the definition of JIT can be simplified for better understanding. JIT can be defines as a manufacturing philosophy that makes and delivers just what is needed, just when is needed, and just amount needed.

III. VARIOUS JIT ELEMENTS IMPLEMENTATION

JIT is viewed as more of a philosophy than a series of manufacturing techniques [9]. It also is viewed as a set of management technologies in global world [10]. Because of that, JIT has been famous to the world. United States has become the earliest country that implements JIT in year 1982 [4]. However, implementing JIT is not easy. Since JIT being introduces, a lot of studies conducted assessing the best implementation method. But, until today, there is no specific guideline and best method outlined in any studies related to the best implementation practices.

JIT requires a complex changes in organization [11]. As JIT viewed as organizational philosophy, an organization needs to modify its operating procedures, production system and its organizational culture [12]. Besides that, in order JIT to be effective, JIT has to be viewed as organization wide [8], [11], [13]–[16].

Many researchers argue that culture is the most critical element to the successful implementation by Japanese. Moreover, the effectiveness and success of TPS is claimed derived from the Japanese culture amongst themselves [10]. So, to enjoy the fruit of JIT, it requires an organizational to change their organizational culture [12]. Many organizations failed adopting and implementing JIT because of difficulties to adopt new methods due to present culture they have in organization [17]. This present work culture that organization has is a way different than strong Japanese work ethic [10].

A lot of phases, methods and elements implementing JIT suggested by researchers appeared in literature. But, these methods or phases are different from each other. Based on TPS, three elements should be considered in implementing and ensuring JIT success [1]. First element is takt time production. Takt time production indicates time required to produce a product to meet customer demand. As the production follows takt time, there will be no over production or shortage in production. Second element is smooth flow production. Smooth flow production will ensure the continuous flow of material in a production line. Last element is pull production. Pull system withdraws subsequent part from preceding process and works in reverse direction. Pull system works in reverse direction in a process flow with the aid of Kanban card.

Creativity and consideration of many aspects are needed in implementing JIT outside Japan due to the differences of work culture. Hence, various implementation elements appeared in literature nowadays. These days, various numbers of crucial elements recorded in research. Some researches suggest only three crucial elements in implementing JIT [17]. But, these elements are different from JIT pillar of TPS [1]. Some study suggest four elements [19],[23], eight elements [20]–[22], fourteen elements [18], sixteen elements [24] or as many as twenty elements [25] that is considered in JIT implementation.

Simplifying the discussion of implementation problems, a classification of effort towards JIT is then classified into four different levels [26]. Another study also found that implementation of JIT should be involving only three phases with detail building block [27]. This building block consist of waste elimination, total employee involvement and workplace organizations. A company must do justification of awareness development and strategy formulation as the first step [27]. Next phase should be with the organization, where setting up steering committee, recruiting JIT champion, selecting project teams and developing project leaders should
be done in the phase [27]. JIT champion is a person who initiates JIT implementation and usually will be responsible for and takes a leadership role in entire implementation process [28]. In contrast, another study had listed only ten elements that should be considered in implementing JIT [29].

Some research used alternate model to conduct a study on elements of JIT implementation [30]. The model consists of three elements to ensure successful of JIT implementation. Organizational support that leads to JIT implementation will produce performance improvement [30]. Different from another study conducted, factors includes employee, managers, and suppliers are identified as the most critical elements in order to ensure firms that implement JIT gains benefits [31]. Employee involvement also has been considered a major factor of JIT implementation elements [13]. To support employee involvement, quality circle and total quality controls are being practiced [32]. To make short, a review and analysis been conducted in order to detect the most important and crucial elements needed to implement JIT at a company that can ensure JIT success.

IV. JIT MOST FREQUENT IMPLEMENTATION ELEMENTS

Since there have been a lot of arguments in defining critical elements of JIT implementation, an analysis of case studies, journals and books from available resources for the past 33 years are summarized. Each critical element identified and recorded. The frequencies of critical elements mentioned noted. The result summarized as in Table I.

Referring to Table I, there are 29 most frequent elements appeared in literature and being mentioned by researcher in past studies. Data were taken from available written resources from year 1977 until 2010. Thirteen studies recorded on JIT implementation elements from year 1977 to 1987 [6], [20], [35], [34], [43]-[45], [48], [56], [63], [65], [67], [68]. Another thirty-two studies were analyzed from year 1988 to 1998 [9], [11], [12], [16], [15], [19], [24]-[26], [28], [29], [31], [32], [35], [37], [39], [41], [42], [46], [47], [49], [51], [57], [58], [59], [61], [62], [66], [69]-[72]. From year 1998 to 2010, seven studies taken to be reviewed and analyze [13], [14], [17], [18], [30], [40], [50].

V. CRITICAL ELEMENTS IN JIT IMPLEMENTATION

Previously, Table I show that there are twenty-nine elements that always appeared in literature and considered important in JIT implementation. Those elements are various and contradict to each other research. From Table I, further analysis is being conducted to indicate which elements are actually important in implementing JIT. These elements are considered critical elements because of the repetitive frequencies appeared in research conducted.

As been mentioned by researchers at least ten times or more, these fourteen elements are considered important in JIT implementation at a company or organization. As shown in TABLE II, we clearly indicate that there are fourteen elements that being mentioned at least ten times or more. These elements are considered crucial in order to implement JIT and the existence of these elements able to ensure the successful implementation of JIT at a company or organization.

Setup time reduction is the most critical elements in implementing JIT at organization [13],[20],[24],[33],[34]. Reducing set-up time can enhance JIT production strategy towards better implementation of JIT [25]. Reduction of machine set-up time is required to accomplish the ideal lot sizes of one unit [28]. The set-up and die changeover refers to the time lost between the productions of the last item until the production of the new item of comparable quality is made [23]. Evidence of setup time reduction can be shown through several activities. For example, changeovers are done in...
minutes rather than hours [35], changeover eliminated completely [36]; and establishing special setup reduction team and projects [24]. Adding to that, reducing set-up time can eliminate waste [17]. Waste is defined as any activity which does not advance the firm towards its stated objectives [16]. Similar to Toyota objective, reducing waste can enables a company to achieve JIT environment.

Total Quality Control (TQC) or Quality Circle (QC) of an organization have been second leading elements appeared in literature for the past thirty-three years. TQC is defined by program that establishes quality as the top priority of the organization’s business objectives; involving supplier and all function of employees. On the other hand, QC is defined by employee participation program where involve employee in problem solving and decision making [13]. QC can guarantee continuous quality improvement and quality control of an organization [37]. In simple word, quality is one of the important elements that should be considered in implementing JIT at organization. This is because; the achievement of high quality levels is a prerequisite of successful JIT [9], [30], [37]-[39]. Common use quality programs in support JIT includes zero defects, statistical process control and work team quality control [18]. TQC also consists of supplier quality level, where it is measured by the step to involve supplier in the planning and quality improvement process [24]. As the aim of JIT is to produce product to meet customer demand, with perfect quality of equipment design for flexible floor layout are considered very important to create a congenial environment among co-worker [36]. Some evidence listed are employees take initiative to solve specific problems, employees willing to do extra job without reward, there are substantial number of group problem solving team, and team members’ opinion are sought and considered. Employees should perform activities such as participate in improvement activities and problem solving, participate in decision making, assume responsibility for quality, and develop new skills as in effort to continuously eliminate wastes to achieve benefits of implementing JIT [31].

Decrease lot size is another element that is considered crucial in implementing JIT success [37], [39], [43], [47]-[48]. Since both production and waiting time are directly proportional to lot sizes, the most effective way to shorten lead time is to reduce lot sizes [27]. Moreover, study found that reduce setup time is crucial to decrease lot sizes [34]. Being able to produce smaller lot sizes enables JIT systems to operate effectively. Following benefits such as less work-in-process inventories, less space required, and increase flexibility in scheduling can be achieved [28]. As reducing lot sizes, both the quality and timeliness of process feedback increases, leading to reduction in process variance [46]. Decrease lot sizes involve the evaluation of product mixes, reduction of set-up times, and leveling of production load. Suggestions from employees are also instrumental to the success of decrease lot size [27]. The performance measurement of an organization of having small lot sizes is evaluate through the level of activities the plant is taking to lower the lot sizes [24].

Another studies conducted found that education and training is another important elements in implementing JIT [6], [9], [20], [26], [44], [49]-[51]. In one study conducted, it is found that on of the most common implementation JIT problems in Egyptian manufacturing plant is lack of formal training or education for either management or worker [52]. Another researcher once stated that the biggest mistakes a company can make when implementing JIT is to ignore interpersonal skills, education and training [53]. Furthermore, without clear understanding of JIT, the conversion from old to new concept will be very difficult or perhaps even impossible [27]. Another study conducted found that training should concentrate on basic understanding of the technical aspects of JIT and the impact that JIT will have on the operating environment [28]. Some programs suggested to be include in JIT education and training of an organizations are ongoing training and education rather than ad hoc programs, training is aimed at all employees not just salaried employees, training is aimed at more than purely technical skills, cross training for multiple skills, and extensive training upon hiring [36]. Cross training for all workers is a must to develop multiple skills so that workers can do different jobs in the factory [54]. With proper training and education, it will help workers to understand the philosophy, concept and techniques of JIT.

Employee involvement comes to sixth element that is most frequently appeared in literature [13], [15], [26], [39], [45]. All members in the factory, from upper management down to the shop-floor workers, must work as a team [27]. It also is a very important to create a congenial environment among co-worker [28]. Plus, to make JIT implementation successful and to minimize the chances of creating conflicts, it is important to maintain support from all people involved in production [17]. Some evidence listed of employee involvement factor [36]. Some evidence listed are employees take initiative to resolve specific problems, employees willing to do extra job without reward, there are substantial number of group problem solving team, and team members’ opinion are sought and considered. Employees should perform activities such as participate in improvement activities and problem solving, participate in decision making, assume responsibility for quality, and develop new skills as in effort to continuously eliminate wastes to achieve benefits of implementing JIT [31].

The following important element is total preventive maintenance [13]. Management of existing physical resources, including preventive maintenance is agreed to be viewed as important to JIT success [6], [19], [25], [30], [40],...
Because of JIT allows very little work-in-process inventory, machine breakdown can be seriously disruptive. Besides that, preventive maintenance is needed to provide smooth flow production [28]. This involves by getting the machine operator actively participating in minor maintenance functions [13]. Moreover, down-time can caused by poor maintenance and workers should be encouraged to fix problems before they start [27]. Total preventive maintenance can be measured by the steps plant management has taken to introduce preventive maintenance practices to workers daily routines, reserved a part of the shift for preventive maintenance and incorporated productive maintenance into manufacturing strategy [24].

The next element is process and workers flexibility. Process flexibility is considered as one of the most flexible elements in implementing JIT [28][30][33][40][43][57][58]. Flexibility might be considered as the ability of a manufacturing system to produce variety of products [28]. It also means being able to respond quickly to customers’ needs. Flexible workforce on the other hand refers to cross training, alternate work schedule, minimal non-process steps for operator together with usage of a system that is user friendly, adaptable and expandable [23]. Cross training is considered a must in order to produce flexible and multifunction workers [13]. A firm that moving towards JIT need their work-force to be more flexible and the union should be supportive on job flexibility. This is because higher skills requirements may keep some companies from moving towards JIT [11]. With a higher skill of workers and process flexibility, a firm or an organization can save a lot of costs in hiring new workers for different skills, and machines to do different process.

Another frequent elements that always appeared in literature as one of the important elements in implementing JIT is uniform workload. Uniform workload is defined by program that attempt to stabilize and smooth the production workload by level schedule [13]. The product mix each day would be the same. Variations to the demand would be handled through varying frequency of product mix. Uniform workload able to minimize variations workload that then handled through varying frequency of product mix. Uniform workload is defined by literature as one of the important elements in implementing different process.

A JIT production requires high quality, small lot sizes, and frequent delivery of raw materials [28]. A good relationship with suppliers is crucial to achieve this requirement [12][15][28][44][51][59]. Because of this, vendor should be provided with clear information on specifications and delivery requirements as well as feedback and quality control problems [27]. Quality and delivery should be stressed to vendors as a long term commitment to the plant. On the other hand, a study conducted claimed that long-term partnership relationship is essential to the implementation of JIT [15]. Having suppliers located within close proximity will help to reduce lead-time for delivery [11]. To measure the performances of JIT implementation via vendor or supplier relationship, vendors are measures by integrating vendors into production in term of using Kanban containers, making frequent or JIT delivery and quantity certification [14].

Above all, some study did argue this element in ensuring the successfulness of JIT implementation [9]. For the successful implementation of JIT, it is necessary to stabilize their own internal environment before extending the JIT philosophy to their supplier bases [13]. JIT purchasing (between suppliers and vendors) also should be introduced toward the end of the JIT implementation process to support continuous development of cumulative capabilities.

Surprisingly, Kanban appeared as the eleventh element that is considered important in implementing JIT [14][16][17][46][57][58]. Some benefits of using Kanban instead of computerized systems include the reduction of cost processing information, rapid and precise acquisition of facts, and able to limits surplus capacity of preceding shops [35]. Kanban attempts to eliminate the push system of material flows and develop a pull system which is dependent upon the operators at the downstream workstations to initiate material movement and control the pace of material flow for upstream work stations versus traditional management control of the initiation of material movements [13]. Even Kanban is a powerful tool to achieve JIT environment, some study conducted found that Kanban should be introduced toward the end of the JIT implementation process to support continuous development of cumulative capabilities [13].

Top management commitment is one of the essential ingredients for successful implementation of any new philosophy or technology, especially JIT system [11]. Top management involves action and support for planning, implementation and follow-up of any major technological change [16][19][28][37][61][63]. Implementation of JIT cannot be successful without top management commitment [28]. Management must be willing to devote the resources which are necessary to support an implementation such as JIT education and training. Besides that, management should be able to initiate and provide education training to workers while implementing JIT [60]. Top management are urged to have formal means for listening and always investigate suggestions suggested by employees [25]. They also have to participate and keep track of quality circle in organization. Management commitment also is viewed as crucial to keep the process of JIT implementation to reach the level desired. This is because, even employee involvement plays central role in JIT implementation, management initiatives are beyond that [36]. Strong support from four major management initiatives which are promotion of employees’ responsibility, provision of training, promotion of teamwork and demonstration of visible commitment are each necessary condition for each of employee involvement, JIT flow, and JIT quality. Thus, managers planning to implement JIT should ensure that these four initiatives are undertaken.

JIT is claimed as a pull system [1][64]. Another element that is considered important in JIT implementation is pull system [33][39][43][58][65]. Pull system is defined as a production responds to customer orders immediately after an order is received [23]. It is different from push process which tries to move as much product as possible through the system, whether there are confirmed orders for the product. Some research has outlined the evidence of an organization if they used pull system [36]. The characteristic of organization that applied pull system can clearly be seen by the usage of Kanban or similar signals that used to authorized workstation,
the schedule or production rated are issued to final assembly operations only, a fixed number of standard containers are used for movement and storage of goods, and there is strict control of work-in-process inventory levels. The first requirement of just-in-time production is to enable all processes to quickly gain accurate knowledge of timing and quantity required [35]. Because of that, Toyota adopted a reverse method of where the following process withdrawing the parts from the preceding process instead of the preceding process supplying the parts to the following process. The usage of pull system in successful JIT implementation is measured by the integration of plant has introduced supporting pull systems, such as stopping for quality problems, efficient floor layout, and workers directed production [24]. 

Lastly, the elements that frequently mentioned by researchers in their study and research is eliminating waste [6], [27], [31], [37], [38], [43], [50], [66]. All workers should be installed the concept of continuous improvement to eliminate waste [27]. Waste is considered any non-value added activities that requires cost but did not add any value to product produce. Waste has been classified into seven types of categories [1]. The types are, waste of transportation, waste of overproduction, waste of over process, waste of motions, waste of defects, waste of inventory and waste of waiting. To reduce waste, lean method such as the usage of Value Stream Mapping and SS, look for and eliminate easy problems can be practiced [64]. Reduction of lot sizes, reduction of lead time and automation are included in elimination of waste [37]. JIT teams should be always aimed to eliminate waste and workers should always been reminded on continuous improvement by eliminating waste in order to obtain the successful conditions of JIT implementation at an organization.

VI. CONCLUSION

Analysis result on crucial JIT implementations elements that need to be considered based on previous studies is quite surprising. It is found that setup time reduction, total quality control or quality circle, and smooth flow production are the top three important elements that been mentioned in literature for the past thirty-three years. This is different from the elements suggested by Toyota, which is continuous flow, takt time production, and pull system.

In a literature, takt time production is not considered as one of important elements in implementing JIT. Following the top three frequent elements that appeared in literature is lot size reduction, education and training, employee involvement, total preventive maintenance, process and workers flexibility, uniform workload, vendor and supplier relationship, Kanban, top management commitment, pull system, and waste elimination. These fourteen elements considered important element that should be tackle in a first place if a company or organization plans to implement JIT.

Regarding to the differences and contradictions of important elements of implementing JIT, it is believe that every implementing company have their own definition and understanding on JIT system. Besides that, implementing JIT at a company requires creativity and consideration of many aspects. Moreover, every company that implements JIT has own target, objective and goal in order to improve their services and satisfying customers. Amongst all, by implementing and adopting JIT philosophy in management or process, it is guaranteed that implementing company is receiving benefits and profits gradually.

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