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Manufacturing Lead-Time Reduction and Knowledge Sharing in the Manufacturing Sector

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Abstract: At this time, companies' need to improve their manufacturing competitiveness in terms of better, faster and cheaper products has led to a range of approaches including 'just in time'; lead-time reduction; lean manufacture; using social networks; and knowledge sharing, in order to be first to get products and services to customers faster. Companies seek to reduce manufacturing lead-time (MLT) in order to reduce the cost of production; short lead-times are a major source of potential competitive advantage. This paper proposes a study on reducing MLT in factories in the Kurdistan region of Iraq, where lead-time has become a major issue for the manufacturing industry. The aim is to provide guidance to industry practitioners and technicians on how to reduce MLT. The paper will present a conceptual framework of the causes and will use knowledge-sharing sources such as social media to survey the factors that have significant impact on lead-time. It will also describe the relationship between setup time, operation time, and non-operation time in order to find potential methodologies that can reduce lead-time in the manufacturing process and identify simple strategies for reducing lead-time.
Keywords: lead-time reduction, throughput time reduction, manufacturing management, manufacturing knowledge sharing.

1. Introduction

Most modern manufacturing companies are driven by rapid technological advancements; shorter lead-time is now more pressing than ever. Any unexpected obstacle or glitch in the manufacturing process can create longer lead-time, which will prevent the product from promptly reaching the customer—something necessary to increase the reliability and safety of manufacturing setups and systems. Lead-time has several definitions. It can be regarded as the time between when a customer makes an order and when that customer receives the finished product. However, others claim it is the time that elapses between the placement of an order and receipt of that order into an inventory [2, 3]. In purchasing systems, lead-time is the time between the recognition of the need for an order and its receipt; whereas in production systems, lead-time is the ordering, waiting, moving, queuing, setup and run times for each component [1]. Therefore, MLT is important for further study because it is the sum of setup time, processing time, and non-operation time [9].

Although MLT reduction can be a daunting task due to the many factors that influence it and their complex relationships [7], there are basic principles that, if applied correctly, can be used to reduce MLT. This paper proposes a study on the reduction of lead-time in the manufacturing industry and provides guidance to industry practitioners on how to reduce manufacturing throughput. The factors that can reduce manufacturing throughput time are not always clearly identified and understood [4]. Specific research has been conducted on the formulation of MLT, which could be used as guidance for achieving a shorter MLT. This research paper identifies certain key factors that should be considered in MLT reduction studies. The research objectives are to identify simple strategies for performance excellence and reducing MLT as well as to determine assessment tools to find defects, resolve a problem and recommend opportunities for working towards reducing MLT. The first step is the surveying procedure, which is the best strategy for reducing defects and lead-times in the manufacturing process. Knowledge-sharing platforms such as Weblog and other social media networks were used to market the survey questionnaire, which was used for both data collection and data analysis in this research study. The survey questionnaire was administered in Northern Iraq in order to evaluate and assess the performance of manufacturing systems in that region and to identify ways in which to approach lead-time reduction. Future work will come in the form of case studies, which will be designed and developed based on two published case studies by Johnson (2003) that focus on throughput time/lead-time reduction efforts in four plants [7].This dual theoretical and technical approach (analysis and case studies) to manufacturing management will enable recommendations to be made to reduce lead-time (see Figure 1).

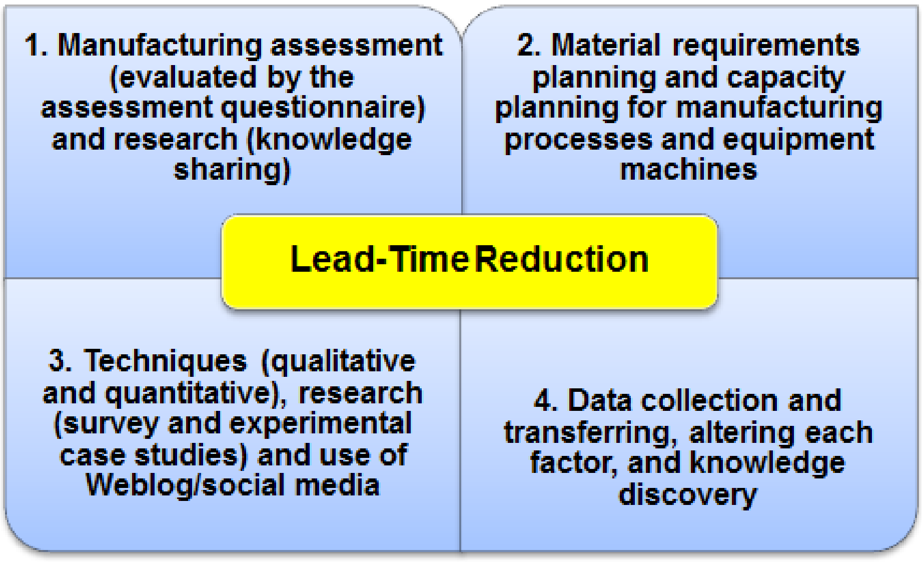

Figure 1: Research strategies for lead-time reduction in the manufacturing sector

2. Literature Review: Lead-Time

For the purpose of this research, an exhaustive search has been made of the literature related to lead-time reduction. Firms cannot ignore demands for improved customer service, greater diversity in terms of product lines, better quality, quicker response and a much shortened time-to-market for newly introduced products. These, therefore, are key to analysing how lead-time can be reduced. Lead-time reduction is comprised of various components—process time, moving, waiting/queuing, setup, lot size, and rework time—and most of them should be treated as controllable variables in our study, but the most important thing to bear in mind is that no organisation can excel in all these factors simultaneously. If a firm competes in terms of quality and lead-time, then it should be judged in terms of its ability to deliver quality products in a timely manner. For instance, early research assumed that lead-time is random and analysed the problem of investing in reducing lead-time randomness (see [10] and, for similar models, see [11, 12]). Newer research stated that "the impact of customer order and lead-time are of crucial importance on the firm's ability to earn money" [13, 14]. Lead-time reduction strategies are responses to numerous logistical chain problems such as procurement, manufacturing, and distribution problems [19]. Quick Response Manufacturing (QRM) achieves lead-time reductions by focusing on management principles, manufacturing methods, analysis techniques, and tools that use basic concepts of system dynamics to reduce lead-time [4, 17]. Currently most manufacturing companies are trying to reduce their lead-times. Suri (2003) demonstrated that while companies are trying to reduce their lead-times, most managers still support policies that will increase their company's lead-time [16, 17].

2.1 Manufacturing Lead-Time (MLT) Formulation

Why should MLT be studied? Production consists of different processing and assembly operations. Aside from these operations, there are tasks relating to material handling, inspections, and other non-productive activities. According to Hoope and Spearman (2001) and Groover (2008), MLT is the sum of setup time, processing time, and non-operation time [8, 9]. Production lead-time (PLT) is the sum of design time, manufacturing planning time, manufacturing control time, and MLT [6, 9]. The total time of each phase is the amount of time each function spends completing its part of the job for a given product; this can be expressed by Equation 2, where (Q) refers to the batch size and (**n**) is the number of processes needed to manufacture a product [6, 9]:

$MLT = n \cdot (T\ sui + Q \cdot T\ oi + T\mathbf{n}oi)$ ………… (1) [6].

$PLT = TPD + TMP + TMC + MLT$ …………. (2) [9].

(The company produce three similar products throughout the year) so assuming all operation times, setup times, and non-operation times are equal for each manufacturing process, MLT will take up 94% of PLT's duration (refer to Equation 2 and see Figure 2) [20]. This has been proven by several authors, as a major portion of the time is non-operational time because it depends on an average batch size, which is in parts. Thus, previous researchers have stated that "this is particularly important since 90–95% of the time spent in a factory is spent waiting (wait-time)" [8, 9]. As MLT constitutes 94% of the duration of PLT, it is the greatest indicator of production time and is a crucial subject to be studied. This research deals with the key methods for reducing lead-time for those components of MLT that can lead to reduced lead-time in the manufacturing industry.

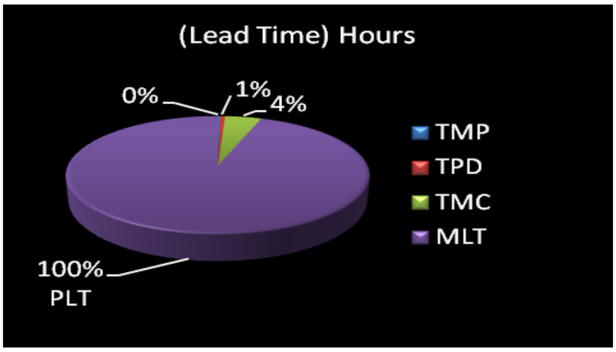

Figure 2: Approximate contribution of MLT through the PLT elements

3. The Role of Knowledge Sharing and Social Media in the Manufacturing Sector

Knowledge sharing (KS) and social media are needed to support process improvements in manufacturing companies. They are methods and tools with which to effectively solve specific and fundamental problems related to MLT reduction practice in the manufacturing industry. This is especially true for survey procedures such as assessment questionnaires and data collection. Technical data exchanges and data analysis were carried out in this research study so as to meet most of the challenges presented, because KS and use of social networks work best as a two-way conversation. Collecting information is important because it comes from a clear request to provide more methods and tools that specifically contribute to a firm's success and competitive advantage, and also for MLT reduction. Sharing information using advanced social media is becoming rapidly more common in modern manufacturing [21]. On the other hand, it is well known that KS within both large enterprises and networked small companies is still related to a number of specific and fundamental problems depending on to what extent the technology and methods available are appropriate, especially in regard to social media and multimedia [22]. Information sharing is a key ingredient for any supply chain management system [23]. Advantageously, by taking the data available and sharing it with other parties within the supply chain, an organisation in the manufacturing industry can speed up the information flow, improve the efficiency and effectiveness of reducing lead-time, and respond to customers' changing needs more quickly. Therefore, information sharing will bring an organisation a bigger competitive advantage in the long run, as will using social media as a listening tool.

3.1 Survey Questionnaire and Knowledge Sharing/Social Media

Online surveys originated in market research and are now widely used in academic research. This research study used Google Forms, which is basically a way of conducting a survey, with participants' responses added automatically to a spreadsheet. Google Forms is one of the best online survey tools and is absolutely free. This research made use of Google Forms because in comparison to SurveyMonkey, Zoomerang and SurveyGizmo it is much better in three ways: researchers can customise their brand image, allow for more than 200,000 responses and export their survey questionnaires and results to PDF or a Word document [24]. Furthermore, the survey themes are robust; e-mail or web-embedding is easy; and there are a number of ways to visualise your data. The study also employed social media tools in order to revitalise research methodologies through setting up a YouTube channel for training and using Facebook and LinkedIn for brand promotion, joining groups and gaining insight into hundreds of companies' corporate structures. Social media was used to ask questions and share knowledge in order to solve problems faster once all questions had been designed on Google Forms. In preparing for gathering data via surveys and for sharing information, researchers should take to account these four features before sending out requests for responses:

1. Showing a link to submit another response by selecting the appropriate box will allow users to submit as many form responses as they would like.
2. Publishing and showing a link to the results of the form by selecting the appropriate box will give respondents access to the form's summary of responses. Allowing respondents to edit responses after submitting their answers will allow respondents to change their answers to the live form.
3. Pre-populate form answers: respondents can be presented with a form with some fields already filled in; Google Forms makes this easy. Pre-populate forms answer fields by, while working on the form, clicking the 'Responses' menu, then selecting 'Get pre-filled URL'.
4. Share form with collaborators: share a form with a collaborator by clicking 'File' and then 'Share'. Choose whether to share the form for editing by mangers, supervisors, practitioners or engineers.

4. Lead-time Reduction Methodologies

The first stage of the procedure is survey-based research, carried out so as to identify the factors that have had the greatest impact on reducing lead-time. The survey constitutes one of the pieces of equipment needed for the research. The objective of the questionnaire was to gain insight into MLT, to identify the defects in the manufacturing industry (caused by an increased lead-time), and to identify improvement opportunities for reducing lead-time. The second stage of the procedure is using tactics and technical tools in order to control lot sizing, monitoring defects, and lead-times. Using both Overall Equipment Effectiveness (OEE) and social media tools helps systematically improve the manufacturing process as it truly reduces complex production problems into simple, intuitively presented information. One example is using capacity planning as a tactic for minimising the impact of changed lead-time by splitting an order ('lot splitting'), in order to improve utilization. The third stage is using experimental case studies in order to understand the relationship between the factors and determine which factors create a longer lead-time and reduce throughput time. The case studies should also be used as sources of knowledge discovery for diagnosis and prognosis to help achieve the research target. Analysis of the results obtained from survey questionnaires will provide a framework in the form of a simple hypothetical manufacturing system, which will illustrate the basic factors, i.e. the main components of MLT (see Figure 3).

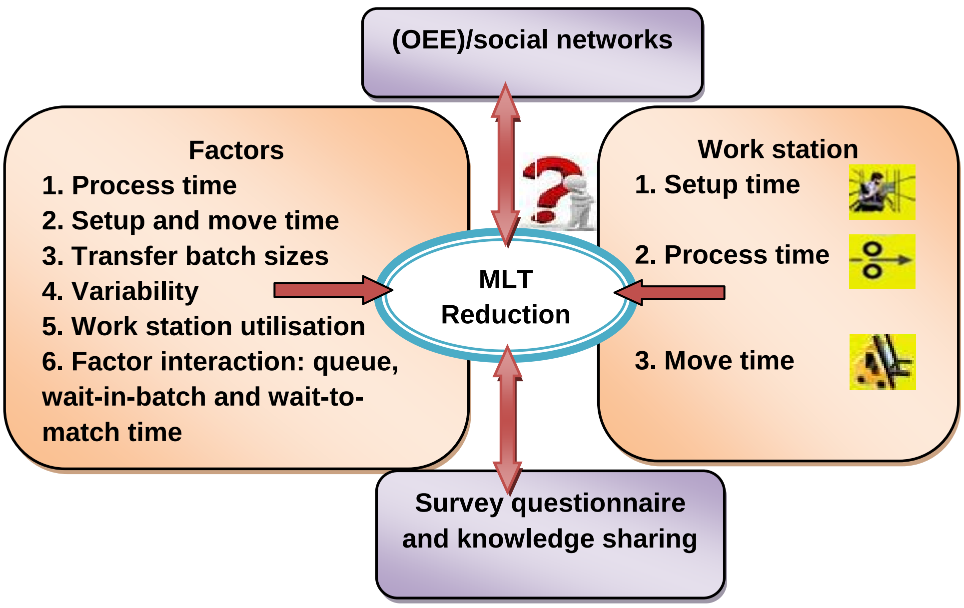

Figure 3: Road map of the research area

4.1 Survey Procedure

The sample was selected appropriately and there were 17 questions prepared, which ensured answers were in-depth and accurate. Questionnaires were used to achieve the objective of this study. Interviews were also used, in the form of a face-to-face meeting. A survey of the manufacturing industry in Northern Iraq was conducted to evaluate and assess the performance of manufacturing systems; 160 respondents were selected from plant staff, based on their professional roles. The respondents were located across eight factories. The answers from the assessment questionnaire will help to identify those areas of the manufacturing process that may need attention, identify those areas for capital, defects, and time investment, also identify the causes of delays—highlighting some of the non-technical parts and defects that have a great impact on lead-time reduction. This research uses knowledge sharing and social media in order to revitalise research methodologies in terms of data collection and data analysis procedures (see Figure 3). Therefore, a survey questionnaire covers the general functional requirements (see the brief summary of results of the manufacturing assessment, garnered via survey questionnaire, in Figure (4, 5 and 6).

4.2 Experimental Case Studies

A multiple-case design is a hybrid exploratory–explanatory approach, which this research study will apply. The objective of the case study design is to gain insight into MLT and to identify improvement opportunities for reducing lead-time. For example, one case study examined in this paper is plastic pipe manufacturer Bamok factory's use of order or lot splitting as a tactic so that the production planner is able to utilise factory capacity more effectively and minimise the impact of changed lead-time. The rest of future work will come in the form of experimental case studies, examined in order to find potential methods for reducing lead-time as well as identifying simple strategies for reducing lead-time. The case studies are based on the questionnaire survey results and depend on a simple hypothetical manufacturing system, used to illustrate the basic factors that determine MLT and throughput time. These case studies offer valid survey results, which can be applied to case studies related to the six factors in order to provide guidance for industry practitioners on how to reduce MLT (see Figure 3).

5. Results and Discussion

MLT is the greatest indicator of production time—as shown in Figure 2—and so is a crucial subject to be studied. Converting manufacturing assessment to the survey questionnaire is one of the most important steps. The stage of survey questionnaire will help further validate the argument of the research and also can help achieve towards MLT reduction. A survey questionnaire covers the general functional requirements of MLT reduction. 160 responses to each question comprised staff members' opinions and suggestions on how to improve lead-time reduction. Figure 4 shows that the respondents noted that most of the eight factories have not used enough documents and procedures for: lead-time analysis; work in process/on-hand inventory; or master production scheduling). The survey asked whether respondents had received clear explanations of equipment idle-time and down-time from their supervisors; as shown on the Pareto chart, they said they had not received clear explanations for those defects and problems. This means no instructions or feedback had been given to employees. Furthermore, most of the factories had not been using enough quality control tools such as Statistical Process Control (SPC) in their company procedures. The Pareto chart shows that 20% of all problems, those three categories will present 80% of all lack of using documents, procedures and explanations. Therefore, these categories provide the opportunities for reducing defects and lead-time at each step of the manufacturing process. The areas of management practice, human resourcing and operation management have been identified as needing attention, and they should be improved before starting to reduce lead-time.

Figure 5 shows the respondents' answers regarding the factors that have a significant impact on MLT reduction and that they consider should be targeted by their companies. The average rating of 4.7 indicates that the general sentiment among respondents is that process time has a major impact on lead-time reduction; the standard deviation is 0.30. This means that the largest average ranking indicates the top answer. Move time has an average rating of 4.4, indicating that improved system performance needs a strategy for process and product layout. Meanwhile, batch size, setup time, waiting time and time utilisation received average ratings (3.8, 3.4, 3.4 and 3.3, respectively). Therefore, these factors can be viewed as having a major strategic role in reducing lead-time. They should be considered as guidance for future experimental case studies and should be evaluated in terms of their ability to deliver high-quality products in a timely fashion.

Figure 6 shows that most of the eight factories have not provided enough professional training and feedback to employees and that most of them do not have enough Quality Assurance, Quality Control and Traceability in place in their company procedures. Only 13% of the participants mention fully supporting company procedures. Therefore, these statements provide the major direction for reducing defects in each step, measures which should be taken before the next step. 72% of the responses mentioned that the company maintained stock production. This affects decisions about batch size for products because 90% of respondents noted in the survey that the company informs their customers when orders are expected to be late. The researcher also asked respondents to rate their companies on job organization. 52% of respondents referred to an average situation and none of the 160 respondents mentioned an excellent situation. Therefore, these areas of management practice, human resources and operation management have been identified as needing some attention and they should be improved before starting to reduce lead-time

Figure 7 shows that the case study aims to provide a logical tactic for smoothing the load and minimising the impact of changed lead-time. One such tactic includes order or lot splitting at Bamok—a factory that produces plastic pipes. Bamok's production planners have insufficient time to complete their production orders in the allotted seven days. Pipes should be ready for shipping so as to be delivered on time, but a problem occurs four times during the year. The pipes take 15 minutes each but only 480 minutes of production time is available in the factory each day, and employees only work five days a week. Figure 7 shows that the capacity was exceeded in the (A) period on day two and day five because the required capacities were 510 minutes for day two and 525 minutes for day five. As they have only 480 minutes available in the work centre each day, they assigned two units from day two to day one's work, and two units from day five to day four's work and one unit to day three (or requested overtime). As shown for the (B) period, the average available capacity is adequate, at 480 minutes, and has become equal to the required capacity. Therefore by splitting the order, the production planner is able to utilise the factory's capacity more effectively and still meet order requirements. This tactic will lead to controlling and reducing lead-time.

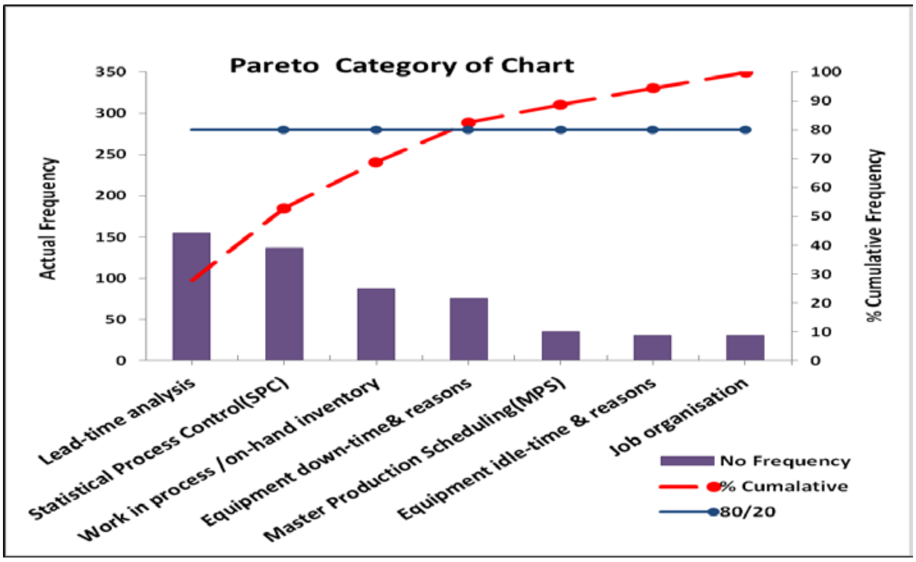

Figure 4: Categories for the lack of using proper documents, procedures and explanations

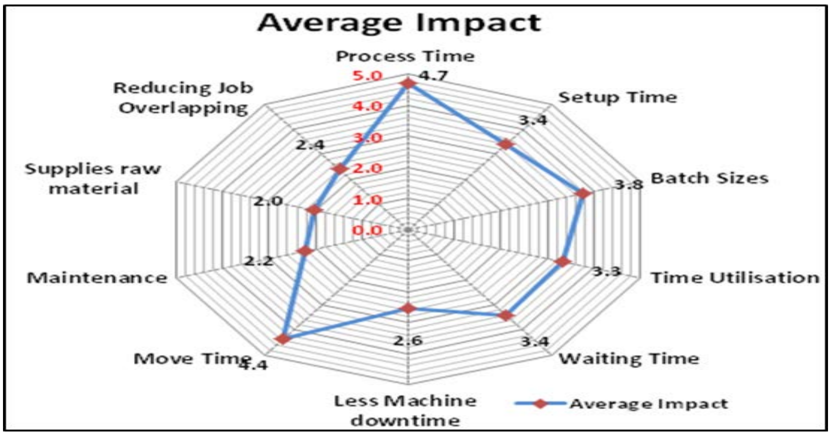

Figure 5: Average rating of factors that have a significant impact on MLT reduction

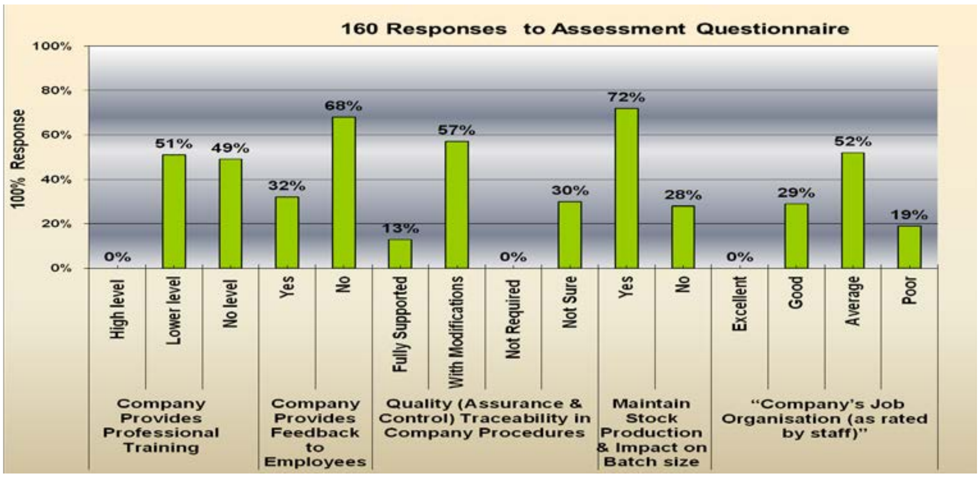

Figure 6: Responses to management practices and human resources assessment

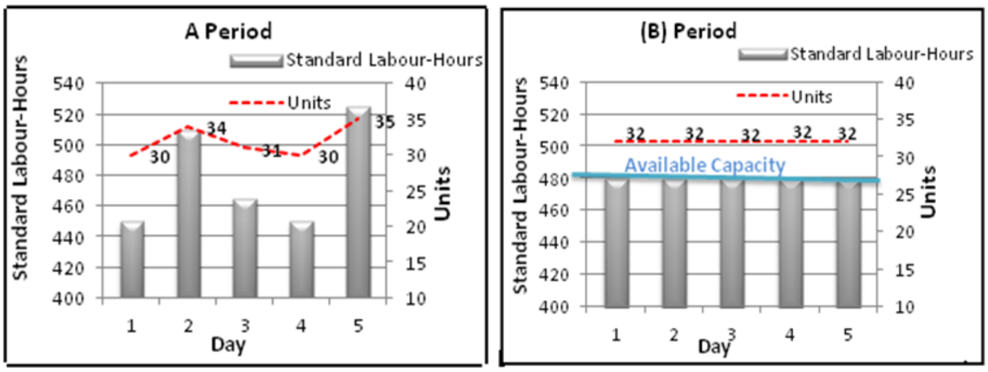

Figure 7: (A) period resource requirements (B) period smoothed resource requirements for Bamok Plastic Pipes

6. Conclusion and Future Work

The inductive approach of this research relies on the interpretive method. More specifically, the techniques applied in this work include a survey conducted in order to find the best opportunities for reducing lead-time. Nowadays, most companies attempt to improve management by reducing the opportunities for work to be damaged and shortening the time between manufacturing and defect detection. The researchers have identified the key methods for reducing lead-time. MLT is an indicator of PLT; as such, it should be considered a research area worth investigating. The Manufacturing Survey Questionnaire is one of the key tools for this purpose and is an effective assessment tool for helping to understand the problems of and opportunities for reducing MLT. Therefore, most of the statements indicated that the factories have not competes on quality, which means that defects and long lead-time could be expected during the process time. Knowledge sharing and social networking, in terms of using the OEE tool, allows for solving specific tasks better and faster and it is truly reduces complex production problems into simple, intuitive presentation of information. It helps us systematically improve our process with easy-to-obtain measurements. Splitting orders should be considered a logical technique for smoothing the load and minimising the impact of changed lead-time. Future experimental case studies should consider six factors for road map of the research area. Each of these factors must be addressed and the studies will be designed in order to provide guidance to industry practitioners on how to reduce lead-time.

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