DEVELOPING INTERPRETIVE STRUCTURAL MODEL (ISM) TO IDENTIFY BARRIERS IN LEAN MANUFACTURING

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1. INTRODUCTION

1.1 Lean Manufacturing

Lean production was developed by Toyota production executive named Taiichi Ohno, in response to a number of problems that Japanese Industry was facing during his time. Lean manufacturing has risen as an approach that coordinates distinctive apparatuses, with a specific end goal to concentrate on the disposal of the waste and manufacture product / generate services that meet customers' requirements. Lean is philosophy of elimination all non-value adding activities /wastes from manufacturing and all other support functions (Caine, 2005). Lean production has a philosophy of product life cycle. It sticks on the continuous improvement, inventory reduction, quality improvement and so on.

Lean production is a conceptual framework popularized in many Western Industrial companies since early 1990s (SaAnchez and PeArez, 2001). Lean production was studied in other industries also later on (Womack et al., 1996, Moore & Gibbons, 2001). Some scholars have suggested that rapidly changing industries have adopted lean production versus mass production as a growth paradigm.

James Moore and Gibbon (2001) defined the key area of focus, each with associated principle, with in the lean manufacturing approach – adaptability, squander end, improvement, process control and the general population usage. Womack and Jones (1996) utilized the term lean intuition to revolt the reasoning procedure of Taiichi Ohno and an arrangement of technique portrayed by the Toyota Production System. Area of the focus that derive lean manufacturing/ production are

- Quality
- Safety
- Delivery
- Moral

The main elements of the lean production are shown in Fig.1.1. A key plume is that less assets input are required by the assembling framework like less material, less parts, shorter creation operation,

less useless time required for setups and so forth. (Karlsson and Ahlstrom, 1996). Side by side higher output performances have to be achieved like better quality, higher technical specifications and high product verities. This may result in grater customer satisfaction, which in term provides the lean company to gain a market share larger than those of its competitors (Karlsson and Ahlstrom, 1996).

Pressure for higher performance

Fewer resources

Fig.1.1- Elements of Lean Manufacturing (Karlsson and Ahlstrom, 1996)

1.2 Objectives of Lean Manufacturing

The main objective of lean manufacturing is to eliminate the wasteful or non-value adding activities or service to product (Womack and Jones, 1996). Amid the most recent couple of years a developing number of concerns have started to rise with respect to the pattern of the Japanese assembling and the use of lean generation procedure and innovation (Karlsson and Ahlstrom, 1996).

There are some activities which are value-added meaning that customer is willing to pay for those activities. So such type of activities should be added in the system while there are also some activities that are non-value added must be eliminated.

Nyman (1992) has identified the following as main aim of introducing lean manufacturing:

1. On time delivery.
2. Improved response.
3. Reduced inventory.
4. Improved quality.
5. Improved workflow.
6. Achievement of flexibility.
7. Cultural change.
8. Delegation of accountability.
9. Better utilization of plant.
10. Better use of skilled labor.
11. Job satisfaction.
12. Smooth information flow.

The pressure to adopt lean production method may be developed from a number of different sources. Among these sources, the domestic and international market put a pressure for product to be universally competitive. Fear of competition from the suppliers put a pressure to manufacture a variety of products and improvement in the technology improving the quality and cost reduction. According to Sohal and Adrian (1994) the other factors, which are forcing companies to adopt lean production are as follow:

1. Desire to employ world best practice (result of Benchmarking).
2. The need for survival from internal constraints (mainly financial).
3. A vision of increasing exports market.
4. Through drive focus to on customer.
5. The development of key performance indicators.
6. The reduction in overhead levels.
7. Need to increase flexibility
8. Poor problem resolution
9. Deduction in tariffs

1.3 Benefits of Lean Manufacturing

An effective implementation and mastering of lean production system would achieve the following benefits (Moore and Gibbons, 1997):

1. Cycle time reduction by 90%.
2. Productivity increase by 50%.
3. Work in process (WIP) is reduced by 80%.
4. Quality enhanced by 80%.
5. Space utilization is reduced by 75%.
6. Labor reduction by 50%.
7. Increasing the capacity of the plant by optimum utilization of the facility.
8. Reduction in the order processing errors.
9. Reduction of paper works.
10. Reduce staff demand.
11. Reduction of employee turnover and attribution cost.

Besides the above benefits, the additional benefits as suggested by Nyman (1992) are as follows:

1. Simplified scheduling
2. Less transaction
3. Less variation “more” predictability.
4. Forecasting became more accurate.

5. Quicker market response.
6. Problems are visible.
7. Product team organization- eliminates department conflict.
8. Facilities cross training.
9. Facilitates alternate pay for scheme (pay for skills).

The undertaking work utilizes the ISM technique to comprehend the shared impacts among the hindrances so driving boundaries which impact alternate obstructions and reliance obstructions, which are affected by the other, are distinguished. By analyzing the barriers using this model, we may be able to extract those barriers that are crucial to implementation of lean manufacturing.

2.1 Introduction

One of the big mistakes one makes in the life is to accept the known and resist the unknown. Kawasaki (1996) has pointed out that one should do in fact exactly the opposite. The flip side of high success potential is high project risk. Thus the success of execution of lean manufacturing is largely depending upon the knowledgeable management. Some of this concern may be related to external environment of companies while other related to the internal production environment. The main internal environment factors affecting the implementation of lean production are related to work force. (Karlsson and Ahlstrom, 1996)

Sometime top management becomes the barriers to any project due to their less responsive or less supportive nature towards such project. For implementing any new concept or philosophy, there always exists a risk. On the basis of their nature, they can be divided into the five categories (Clemons et al., 1995):

1. Financial risks
2. Technical risks.
3. General risks.
4. Functional Risks.
5. Political risks.

Project risk categories	Definitions
Financial risk	The project may not have a payback value as envisioned
Technical risk	Business process orientation information technology solution that is non feasible and non existent.

General project risk	The organization is searching for workable solutions outside its own ambit or the responsible team is not executing the work.
Functional risk	The association isn't gone up against with a redesign design, which isn't appropriate to the sort of business the organization is in.
Political risk	Individuals stand up to the undertaking (protection), or the task bit by bit loses responsibility by upper administration.

Table 2.1 Project risk category (Clemons et al., 1995)

These risks lead to creation of barriers to any new project/philosophy. Barrier are sever, unexpected and not planned for the problems e.g. increment center administration protection against the target of the presenting self coordinating group is such boundary which is surprising and spontaneous prior. Barriers hinder the implementation efforts. There are other problems also which may not be considered as the obstructions, in light of the fact that their effect on the undertaking isn't significantly e.g. illness of the project member, malfunctioning of the computer equipments etc. These types of problem can be solved on the day-to-day basis.

So obstruction must be wiped out in light of the fact that they take truly necessary vitality from the include group/individuals. As the vitality for and against the boundaries may not consider at the underlying advance and in this way influence the yield. In this way it is profoundly prescribed not to pitch achievement factor hard against obstructions but instead to keep the improvement of boundaries ideal from the earliest starting point of the venture.

The barriers to successful implementation of lean manufacturing can be divided into the two groups- hard and soft barriers. Hard obstructions are those, which have finished with things and directions e.g. data innovation issue, asset issue and lawful hindrance. These can be considered as enabler but when not suited to the system, they can be evolved as barrier. Asset issue is missing space for work group to get together all the time. Legal obstacle can be turnout to be severe barrier as many companies are not able to grow as much as they can.

Soft barriers are the people’s problems. Individuals oppose hierarchical changes. Protection from the general population can be additionally isolated into the inner individual protection, inside gathering protection and outer protection. Internal individual resistance describes people behaviors in the organization not accepting the change. This may take coverts or overt forms. It is a common practice that management avoided such resistance with destructive personality explanation, instead of checking or analyzing the reasons for resisting behavior.

Inner gathering protection portrays gatherings' conduct inside the association e.g. a gathering of electronic expert may oppose the arrangement of being part up into work group where they need to work with mechanical faculty one next to the other. These gatherings are formally or casually sorted out.

Outer protection is being performed outside the association. Clients, providers, merchant and sellers may create impressive protection against plans which meddle with their advantage e.g. on the off chance that an organization intends to supplant benefit work force with teller machines, this may cause serious protection by the clients.

2.2 Areas Generating Barriers to Implementation of Lean Manufacturing

All of the barriers to lean manufacturing success are the results of underlying root cause. Sometime these root causes are not self-evident. This is only the reason, why barriers are being attacked head-on, only to find out later that the underlying problem has not been detected and barriers keep on building up. Therefore it is seemed to study the area of potential root cause of barriers to lean manufacturing implementation successfully.

The accompanying zones are suspicious of creating hindrances to lean assembling execution:

2.2.1 Lean venture related range

Lean undertaking setup may prompt obstructions, which must be managed venture substance and task administration are the two main barriers in the lean project area. Lean project content are related to project objective, selected implementation process and introduction of the new technology. The project content may lead to consider resistance e.g. did employee of the production department support the implementation of functional oriented software package in the shop floor. The lean task content is especially, the wellspring of numerous obstructions when they have not been legitimately and naturally characterized.

Lean venture administration can be a wellspring of extreme boundaries, if the streets to go by, stay indistinct to individuals influenced. On the off chance that perplexity makes, question and at some point fear create. Uncertainty and dread prompt falling flat task in light of the fact that the general population, whom have uncertainty of dread, don't make a move towards achieving the undertaking objective. No getting the general population issues in the task administration may prompts extend disappointment.

For the implementation of lean manufacture external consultant are being involved. They often have different attitude, values and use different method. These differences may create considerable

resistance. On the opposite, if a consultant tries to adapt intimately to the client culture and be the part of the system, he may cause resistance, because he may not take much innovative action or action will take a long time to act.

2.2.2 People related area

Individuals influenced by the hierarchical change are the fundamental wellspring of the potential obstructions. This is valid for the all the level in an association. Supervisor may oppose a change, which chances their activity if there should be an occurrence of disappointment laborers may fear joblessness by being supplanted through programmed machine and so forth. Individuals conduct depends on their identity and standards of the gatherings they have a place with.

2.3 Identification of Barriers

After the study of a number of research papers it has been found that execution of lean manufacturing is not a simple task, different kind of problems are encountered during the process. Rigid hierarchy of industries and rudimentary skill of many workers and managers pose big hurdles in implementation of lean technology (Woetzel, 2006). Implementing lean technology in India presents challenge that can easily trip even the companies that are well versed in their discipline. Implementation of lean technology not only requires critical skill in problem solving but also requires industry specific expertise that is needed to diagnose complex technical problem accurately and develop effective solutions rapidly (Woetzel et. al., 2006). Be that as it may, there is much opportunity to get better, many organizations, neglected to tie the change measurements because of budgetary explanation (Kilparick, 2003). At the end of the day the organizations just report the percent change and don't change over this into a fiscal measure. It takes a very long time to completely comprehend and execute all through in an extensive association much of the time longer than the future (i.e. turnover cycle) of manager and decision makers (Kilparick, 2003). Kilparick (2003) also identified poor communication as the barriers to implementation of lean manufacturing. Due to poor language low end workforce are not able to communicate in the same language as management. High turnover under cut the continuity i.e. central to use of lean technology, as investment budget are huge in implementation of lean technology organization (Woetzel et. al., 2006). So huge investment budget becomes hurdle to the implementation of the lean manufacturing execution.

There are many building blocks of lean manufacture like JIT, Kaizen, Cellular manufacturing, 5-S, pull system (Kanban) (Bob et. al., 2004; Kilparick, 2003; Caine, 2005; Maleyeff, 2006). The selection and implementation of these building blocks becomes barrier to successful implementation of lean manufacturing (Kilparick, 2003). For instance clumps are decreased preceding lessening changeover time; changeover time for long hardware use will drop. Lean isn't

troublesome however can be confounded in light of the considerable number of factors and intricacies included, so picking a troublesome or low effect venture at first is an issue in usage of lean assembling (Kilparick, 2003).

Woetzel (2006) has identified the lack of standard procedures, inflexibility, poor training and poor information system as the barriers to implementation of lean manufacturing. Cross-functional communication could results in lengthy service duration, inaccurate information, poor scheduling and inadequate support. Maleyeff (2006) considered the poor communication as a barrier to the execution of lean manufacturing. Poor communication results in non-standard procedure, poorly defined system and inadequate training; which also become barriers. Some barriers are a direct result of the wasteful activities like delays could result in customer believing that the service duration was excessive (Maleyeff, 2006).

The lean manufacturing emphasizes on eliminating manufacturing wastes and increasing manufacturing flexibility. So inflexibility becomes the barrier in implementation of lean manufacturing (Cumbo et al., 2004). The factors, which lead to inflexibility, may be the misalignment between the organization goal and performance measurement, misallocation of function with respect to people and technology (Cumbo et al., 2004). Cumbo et al. (2004) also identified longer changeover time, inability to control production wastes and variability of demands as the barriers to implementation of lean manufacturing. The ideas of rearranging the process architecture into cell represent a serious challenge in implementation of lean manufacturing (Nolon, 2006). It is due to high product mix and may be many of which were produced in low volume.

Uncertain demand, more complex variation in the product mix and growing variability in customer ordering patterns are also become hurdle in the way of implementation of lean manufacturing (Bumgardner, 2006). Implementation of lean manufacturing has its different culture and environment. Caine Peter, 2005 identified difficulty in change of organization culture as the barriers to lean manufacturing implementation. Lack of awareness about lean manufacturing leads resistance to its implementation (Sohal and Adrian, 1994).

Caine (2005) identified the lack of motivational schemes and lack of multi-functional team as the barriers to lean manufacturing. Accurate data and good information system required for the successful execution of lean manufacturing. Moleyeff (2006) noticed the inaccurate data and poor information system as the barriers in implementation of lean manufacturing. Implementation of any new technology put a high risk of its functionality and suitability to organization. Woetzel et al. (2006) found fear of loss of reputation as the barrier in implementation of lean manufacturing.

Besides above mentioned barriers, there are some other barriers also which have been identified by various research scholars, which are as follows:

1. Belief that "our company is different "and the lean does not really apply to our company
2. Inability of personnel to get it.
3. Lack of infrastructure
4. Lack of clear link to the business strategy goals
5. Firms take a piece –meal approach to implements the principles of lean. Partial effort often fails.
6. Lack of employees education
7. Lack of involvement of majority of employees
8. Lack of long term serious management commitment
9. Choosing difficult or low impact opportunity as the first step.
10. Overlooking administrative area.
11. Spending too much time on training and not on doing.
12. Difficult to change in organizational culture.
13. It takes a very long time to completely comprehend and actualize lean all through a substantial association.

In light of the above writing overview and discourse with the specialists, 18 hindrances are distinguished. These boundaries are displayed in the Table 2.2. Suppositions of the specialists are likewise used to recognize the effect of various obstructions on adjustment of lean assembling in the Indian business setting. Last the connection grid of hindrances is utilized as a part of characterizing the common relationship. This relationship lattice is utilized for building up an ISM based model.

Sr.No.	Barriers	References
1	Resistance to lean transformation	Sohal and Adrian (1994)
2	Poor training	Woetzel (2006), Caine (2005), Maleyeff (2006)
3	Poor top management commitment	Caine (2005)
4	Lack of motivational Scheme	Caine (2005)
5	Lack of performance measuring techniques	Bob et al.(2004), Bumgardner (2006)
6	Difficulties in changing organizational culture	Kilpatrick (2003)
7	Poor infrastructure	Sohal and Adrian (1994)
8	Poor information system	Maleyeff (2006)

9	Poor selection of process sequence	Kilpatrick (2003)
10	Employee instability	Woetzel(2006)
11	Lack of multifunctional team	Woetzel(2006)
12	Long period of implementation of lean project	Kilpatrick(2003), Maleyeff (2006)
13	Large variability of demand	Cumbo et. al. (2004)
14	Fear of loss of reputation	Woetzel (2006)
15	Lack of fund	Woetzel (2006), Caine (2005)
16	Poor communication	Woetzel(2006)
17	Lack of standard procedure	Maleyeff (2006)
18	Inflexibility	Cumbo et. al. (2004), Bob et al.(2004)

Table 2.2 List of Barriers on the basis of literature survey

The description of the above suggested barriers are as follows: -

2.3.1 Resistance to lean transformation

Lean manufacturing is all about the elimination of waste not only from the manufacturing unit but also from the other supportive unit (Caine, 2005). Since the way of doing work under the lean manufacturing is somewhat different, it has some tools and techniques that are to be implemented one by one in a predefined sequence. So it requires a drastic change in the organization, which may result in resistance to the implementation of lean manufacturing. Further, people are not much aware about the execution of lean manufacturing, which moves them to resistance to adopt this concept in the organization. Due to embedded culture in the organization, it is very difficult to transform the traditional unit into the lean unit. The resistance to lean transform may a result of poor training and lack of education of the employees. There are also resistances by middle managers (49%) and senior managers (31%) as well as shop floor personnel (Sohal and Adrian, 1994).

2.3.2 Lack of performance measuring technique

The main aim of implementing lean production in a manufacturing unit is to increase productivity, improve quality, reduce lead time, reduce cost etc. (Caine, 2005). The performance of lean production system can be indicated by these factors. The determinant of lean production is the actions taken, the principles implemented and change made to the organization to achieve the desired performance (Karlsson and Ahlstrom, 1996).

Manufacturing companies succeed because they adopted relevant practice in their business and implemented them to ensure their performance improvement (BSL, 1993). Oliver et al. (1993) provides evidence for 18 auto component plants manufacturing different products type, five of which display high performance on measure of both productivity and quality. These five world-class plants are all located in Japan and show consistence superior performance on a number measure giving support for their lean production system.

Measurement of the performance of man, machine requires some measuring techniques. Whatever is being done in the organization can be known by using some performance measuring techniques. We could not come to know the improvement aspect, as it is very difficult to measure the output either in term of physical volume or in terms of money value. If measure in the physical volume, the problem will arise when physical unit are of different shape, size and color etc. It is also very difficult to measure the man-hours in the exact figure. Sometime workers do not put full effort in doing the work but waste time on machine. Adopting suitable performance measuring technique like good data collection system, good data analyzing system etc, can only eliminate the above said difficulties (Bob et al., 2004). In the wake of gathering and breaking down information, the accompanying technique is embraced to quantify the execution of the center business process included are:

1. Collect data for which the measuring performances are to be calculated.
2. Collect data from another similar organization to compare the performance current procedure.
3. Root cause of poor performance is determined.
4. Suitable techniques are developed to eliminate the root cause of poor performance.

2.3.3 Difficulties in changing the organization culture

Each organization has its own embedded culture. Changing inserted culture can bring about a considerable measure of protection in execution of lean assembling in the association (Kilpatrick, 2003). It was the thing of resistor that the change will bring something loose value to them. Changes are welcomed with anxiety. But it was the thought of the people the change is always taken with resistance. Peoples are afraid of technological unemployment. Primary reason for organization not adopting a lean business culture was the misconception that it was too expensive to implement in its start up phase or it was not required for organization to function successfully (Sohal and Adrian, 1994).

Due to introduction of new technology, they have fear of being thrown away from doing important jobs to less important or dead one, which require no or less skill to execute it.

Thus changing the mindset of the employee and with strong leadership can change organizational culture. Best way of tackling the resistance to change is through improvement in communication, motivation and education of employee.

2.3.7 Poor infrastructure

Some organization infrastructure have inbuilt mechanisms that make it poorer. It will lead to inflexibility towards any drastic change in the organization. The things, which make an infrastructure poor, are ineffective use of man, material and machines. Lack of space or poorly designing of the organization infrastructure are the cause of ineffective use of man, material and machines. 74% of the companies said that structural change had occurred in their organization as a result of implementation of lean production method, with change being centered on the flattening of the management structural as distinct from a flattening due to the inception of a TQM regime (Sohal and Adrian, 1994).

Hence when lean is implemented in such organization, a lot of difficulties are come in the way due to poor infrastructure like insufficient use of manpower and machine in such organization. Whereas lean emphasis on optimum utilization of the resource. Poor infrastructure becomes barrier in lean manufacturing's execution in such organization.

2.3.8 Poor information system

Information is important in order to perform according to the goal of the company for the multifunctional team (Karlsson and Ahlstrom, 1996). The information should be provided to the employee in a proper mode and channel so that they could easily understand the meaning of information. Information should be provided timely and continuously in the production flow. Information should be provided more regularly and routinely. The information would also be provided orally, since oral information might create the opportunity for comments and clarification.

Reaching of the right information to concern person played an important role in the building up of the any organization. The information should be reached at right time, at right place and to right person. Delay in getting the information would adversely affect the execution of the lean manufacturing in the organization (Maleyeff, 2006). These also depend upon the effectiveness of the information system. The reason for poor information system may be some managers who were reluctant to share their information with the team. They are afraid of making their position reluctant (Karlsson and Ahlstrom, 1996). Other reason may be that it does not suit to the process for which it is installed. So some suitable, quick and fast responded system should be installed in the organization. The sharing of factual or some other data is an essential element of the lean generation approach, paying little respect to who the provider is whether an independent company or a member

of the group of companies. The latter case should provide further motivation or active exchange of information. (Sohal and Adrian, 1994)

2.3.9 Poor selection of building block

The lean implementation has some building block like JIT, Kaizen, and TPM etc. It is very important to choose the right building block at first and then the other. If the building blocks are choose at wrong sequence, the implementation of lean manufacturing becomes very difficult (Kilpatrick, 2003). The building blocks like 5-S implementation, standardization and TPM should be chose at first. After that proper implementation of these building blocks, other building blocks may choose for implement. These building blocks should be selected according to adaptation in the organization. Expert suggestion are taken, pre-exist organization are analyze and then proper building blocks should be chose to implement. This will helps in implementation of lean manufacturing in the organization in more convenient manner.

2.3.10 Employee instability

The implementation of the lean manufacturing required good training program. The employees are providing a high-class training as per their requirement. Sometime employees do not take interest in the training, which result in the poor training, and when he works on field, it makes him frustrate that result in resign. Some time employees are interested in getting the training about the lean manufacturing. But later on quitting the organization and shift to the other organization for getting a higher opportunity. Unsatisfied with low salary, uncertainty of timing and bad working environment, these all are the reason of instability of employees in the organization. Due to employee instability in the organization, it would be very difficult to implement the lean manufacturing in the organization (Woetzel, 2006).

2.3.11 Lack of multifunctional team

The multifunctional group went for uniting the learning and abilities of the general population from different work zone to recognize and take care of common issue. The most quiet component of the work association in lean generation is broad utilization of multifunctional groups (Woetzel, 2006). A multifunctional team is a group of employee who are able to perform different task (Karlsson and Ahlstrom, 1996).

The multifunctional team is consisting of the members from several specialist or functions and deals with problems that cut across departmental and functional line to achieve their goal. The lack of multifunctional team is due to reason that the specialist of different department may not want to

work together e.g. a electrical specialist may not want to work with mechanical expert as they want to remain in their group.

2.3.12 Long period of lean project implementation

It takes years to fully comprehend the various concepts of lean manufacturing that make its implementation period long (Kilpatrick, 2003; Maleyeff, 2006). Implementation process of lean is very slow and takes years to transform the organization fully lean oriented. There is danger that companies associated lean with quick win and loss the long term benefits (Anne Harris, 2004).

Among the lean production organization, 81% organization said that they had adopted lean production method within the past 5 years, with 12% have been adopted these within the last years. 19% told that they had been practicing lean production for 5 to 10 years. The remaining 7% said that they have been practicing lean production for more than ten years. The majorities of these were large companies and had been trading throughout the world for many years (Sohal and Adrian, 1994).

Unskilled worker and poor training about the lean manufacturing make its implementation period long. Even though there are skilled worker in the organization, due to less interest in the lean project they waste a lot of time in the useless or untidy tasks. Poor co-ordination and poor communication are also the cause of long period of implementation of lean manufacturing in the organization.

2.3.13 Large variability of demand

Due to high product verities and mix, the variability in the demand is also very high (Bumgardner, 2006). The demand of the product in the seasonal companies such as sugar mills, soabin oil refineries RAC companies etc. are very high in the season as compared to off-season. So in such companies, the products are either manufactured in large lot size or small lot size. The variation in the products demand becomes the barrier in the implementation of lean manufacturing. Lean manufacturing aimed at reducing the batch size to the optimum so it very difficult to reduce batch size in such companies. In this way large variety of product demand becomes the hurdles in the way of lean manufacturing implementation.

2.4 Survey Results

The questionnaire made on five –point Likert scale. This questionnaire contained the 18 barriers, which was identified by the literature survey. In this survey, respondents were solicited to show the level from these hindrances. In the questionnaire levels are decided as:

1- Very low
2- Low
3- Moderate
4- High
5- Very high

Questionnaire started with covering letter, followed by two sections. One section consisted of questions related to organizational profile while other section had some questions related to lean manufacturing. And the questionnaire ended with the respondent profile. The questionnaires were floated to various Indian manufacturing companies who have adopted lean manufacturing or at the first stage of its implementation. Around 150 questionnaires were floated by means of mail and individual meeting to concern person in the company. By floating questionnaire in this way, 35 responses were received out of which 3 had incomplete information, which were discarded for the purpose of further analysis.

For the purpose of this project, only relevant part of this questionnaire survey i.e. related to the barriers to implementation of lean manufacturing have been taken. The rank given to the various barriers to lean manufacturing is shown in the Table 2.3. In this table obstructions are appeared in the diminishing request of their noteworthiness.

Sr.No.	Barriers to the implementation of lean manufacturing	Mean score	Rank
1	Resistance to lean transformation	4.09	1
2	Poor training	4.05	2
3	Poor top management commitment	4.03	3
4	Lack of motivational Scheme	3.96	4
5	Lack of performance measuring techniques	3.86	5
6	Difficulties in changing organizational culture	3.83	6
7	Poor infrastructure	3.76	7
8	Poor information system	3.72	8
9	Poor selection of process sequence	3.70	9
10	Employee instability	3.64	10
11	Lack of multifunctional team	3.54	11
12	Long period of implementation of lean project	3.34	12

13	Large variability of demand	2.96	13
14	Fear of loss of reputation	2.76	14
15	Lack of funds	2.64	15
16	Poor communication	2.54	16
17	Lack of standard procedure	2.52	17
18	Inflexibility	2.43	18

Table 2.3 Barriers ranking on the basis of questionnaire survey

3. INTERPRETIVE STRUCTURAL MODELING (ISM) APPROACH

3.1 Introduction

Interpretive Structural Modeling (ISM), developed by Warfield in the 1973 is a technique to help individuals and groups to understand and communicate effectively about complex systems. Essentially, the method involves taking set of system elements, comparing those elements in a defined binary relation, Constructing a reach ability matrix from the comparisons, and deriving hierarchical digraphs (Ohuchi & Kaji, 1989) interpretive structural modeling"

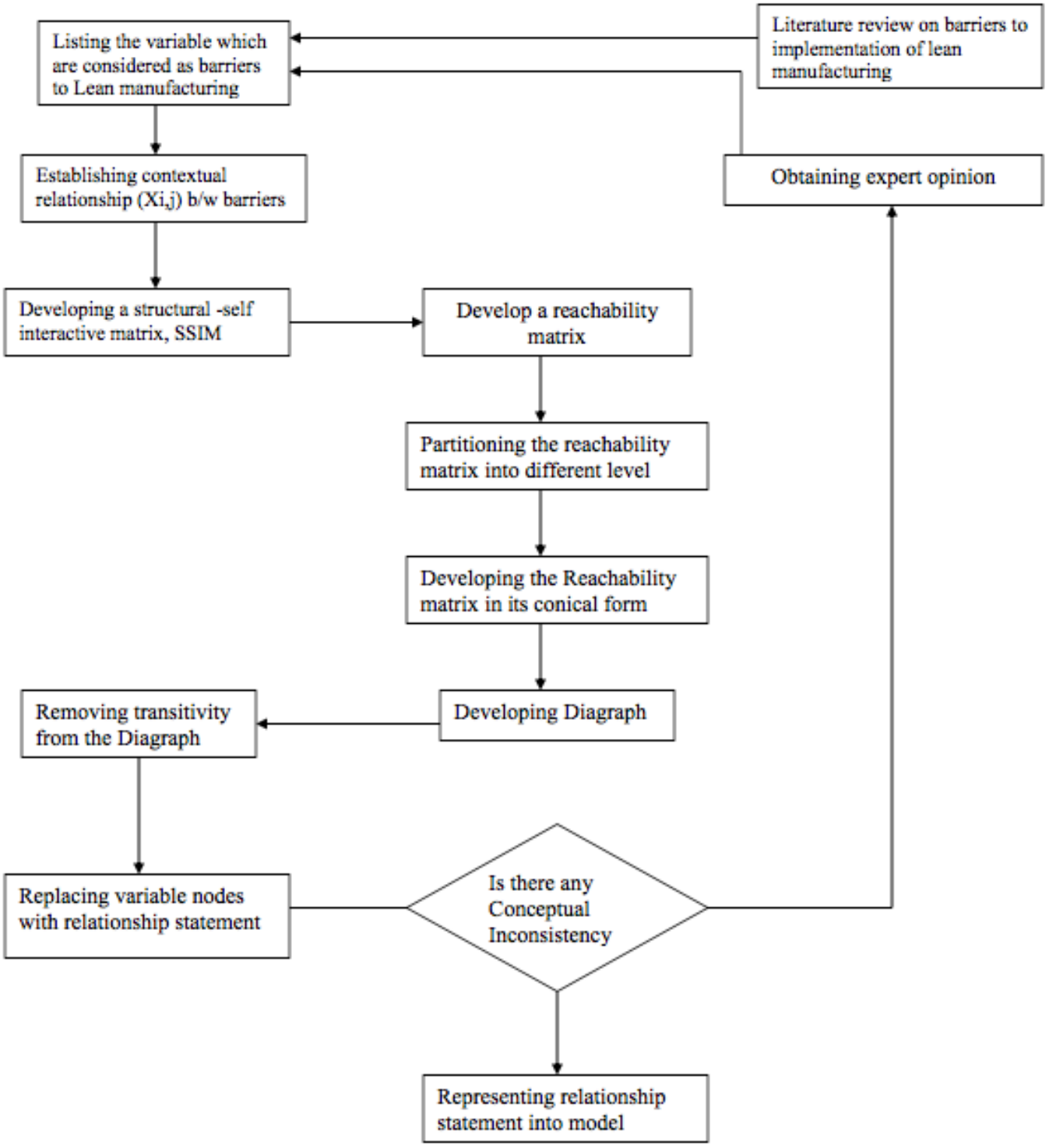

Fig.3.1 Flow Chart for preparing ISM model (Agarwal et al., 2007)

The process of ISM is based upon the one-to-one correspondence between a binary matrix and a

graphical representation of a directed network (Malone, 1975). The fundamental concepts of the process are an "element set" and a "contextual relation." The component set is recognized inside some situational setting, and the relevant connection is chosen as a conceivable proclamation of relationship among the components in a way that logically noteworthy for the motivations behind the enquiry. The elements correspond to the nodes on a network model, and the presence of the relation between any two elements is denoted by a directed line (or link) connecting those two elements (nodes).

3.2.1. Structural self-interaction matrix (SSIM)

Reachability matrix M of a digraph is defined as a binary matrix in which the entries m_{ij} are 1 if element S_j is reachable from element s_i; otherwise $m_{ij} = 0$ (Malone, 1975).

It can be demonstrated that the reachability matrix can be gotten operationally from the contiguousness grid by including the personality network and after that raising the subsequent lattice to progressive forces until the point when no new sections are acquired. That is:

$$M = (A + I)^n$$

Where *n* is determined such that

$$(A + I)^{n-1} < (A + I)'' = (A + I)^{n+1}$$

A reachability matrix is a square, reflexive, transitive, binary matrix M. Such a matrix M satisfies the following two conditions (Ohuchi et al., 1986):

$$M+I=M \quad (1)$$

$$M^2 = M. \quad (2)$$

It is the first step in ISM to obtain the SSIM. The components are contrasted on a couple shrewd premise and regard to the connection R. After examination, one must be ascertaining some relation between them i.e. whether p_i R p_j, or p_j R p_i or both or neither. The relation so formed can be indicated by the symbols V, A, O and X. The symbols descriptions are as follows:

V= Barrier i creates the barriers j.
A= Barrier j creates the barriers i.
X= Barrier i and j make each other.
O= There is no connection amongst i and j.

The matrix which shows the contextual relation between the various variable/element with V, A, O and X symbols is called Structural-Self Interactive Matrix (SSIM).

Understanding it more clearly let us consider the variables V_1, V_2, V_3, V_4, V_5, V_6 of a problem/method or techniques. Now taking variable V_1 and compare it with the other variables.

Now suppose V_1 and V_2 are unrelated with each other, symbol O will be assigned to cell at the intersection of row of V_1 and column of V_2.

If V_1 helps to achieve V_3, V will be assigned to the cell at intersection of V_1row and V_3 column.

If V_1 is achieved by V_4, A will be assigned to the cell at the intersection of V_1 row and V_4 column.

If V_1 helps in achieving V_6 and V_6 helps in initiating V_1, in this situation Assign X at in the cell at the intersection of V_1 row and V_6 column.

Additionally in view of these relevant connections, the SSIM is created. The SSIM so developed look like as shown below.

Elements/variables	V6	V5	V4	V3	V2
V1	X	-	A	V	O
V2	-	-	-	-	
V3	-	-	-		
V4	-	-			
V5	-				

3.2.2. Initial reachability matrix

The next step in the ISM process is to develop Reachability Matrix. The Reachability Matrix is an apt representation of the transitive relation. Since a path from p_i and p_j is indicated by p_i R p_j where there may be intermediate elements between p_i and p_j (Ferris and Saga, 1974). The set of elements to be structured is P= { p_i }, and P is used as both horizontal and vertical index set for the Reachability Matrix M. As the element are already comparing on the basis of pair wise comparison in SSIM.The SSIM is then changed over into the reachabilty framework by changing over the data in every passage of SSIM into 0s i.e. in the binary form.

The 0s and 1s entry can be done as if p_i reaches p_j, then m_{ij} =0 in the Initial Reachability Matrix. And if p_j reaches the p_i, m_{ji} =1 & m_{ij} =0. Similarly if p_i and p_j related with each other, then m_{ij} =1, and m_{ji} =1. Further if p_i and p_j are unrelated, then entry m_{ij} and m_{ji} would be Zero. It to be noted that m_{ii} =1 as every element reaches itself through a zero path length. So the following rules are following for substituting 0s and 1s:

1. If i and j barriers relation in SSIM are denoted by V, Then put 1 in the (i,j) entry and 0 in the (j,i) in the reachability matrix.
2. If i and j barriers relation in SSIM are denoted by A, Then put 0 in the (i,j) entry and 1 in the (j,i) in the reachability matrix.
3. If i and j barriers relation in SSIM are denoted by O, Then put 0 in the (i,j) entry and 0 in the (j,i) in the reachability matrix.
4. If i and j barriers relation in SSIM are denoted by X, Then put 1 in the (i,j) entry and 1 in the (j,i) in the reachability matrix.

By following the above rule, the Initial Reachability Matrix for the variable suggested earlier is shown as: -

Elements/variables	V1	V2	V3	V4	V5	V6
V1	1	0	1	0	-	1
V2	0	1	-	-	-	-
V3	0	-	1			
V4	1	-	-	1	-	-
V5	-	-	-	-	1	-
V6	1	-	-	-	-	1

3.2.3 Transitivity

Consider a relation R that is known to be transitivity. Fig.3.2 depicts that p_1 is transitive to p_2 and p_2 is transitive to p_3. The transitivity says that p_1 may be transitive to p_3.

Fig. 3.2 Represents transitivity between p_1, p_2 and p_3

Now if modular consider that p_i leads to p_j and p_j leads to p_k. The transitivity says that p_i may lead to p_k. For showing it in the matrix entry, m_{ij} =1, m_{jk} =1, then entry of m_{ik} will be 1. This shows that if modular have made comparison between p_i & p_j and p_j & p_k, then he may not need to make comparison between p_i and p_k as its comparison shown by the transitivity. So the entries due to the

transitivity are marked by differently in the Initial Reachability Matrix. Now Initial Reachability Matrix so formed is called Final Reachability Matrix.

4. CONCLUSION

The primary goal of the undertaking is to distinguish the boundaries that fundamentally influence the usage of lean assembling in the association with the goal that administration may handle these hindrances adequately. It has been seen from the ISM demonstrate that absence of reserve; poor foundation, poor correspondence and absence of standard technique are at the base of the model with more prominent driving force. Therefore, the managers of companies that are indulged with lean project should develop standard procedure in the company. They should also develop good communication system in the company.

The barriers like poor information system, poor selection of process sequence, lack of multi-functional team and large variability of demand have solid driving force and reliance. Therefore these barriers significantly impact on the implementation of lean manufacturing. These barriers lie in the middle level both in terms of ranking base on the questionnaire survey and also based on the ISM model. These barriers influence each other as shown in ISM model. So, the production managers should tackle these barriers more carefully while implementing lean manufacturing in their companies.

Driving force reliance chart gives some significant data about the relative significance and association of these obstructions. This could further help management in overcoming of the barriers. The information, which the mangers would get from the driving power dependence diagram, is as follows:

1. The driver power dependence diagram depicts that there is no autonomous barriers in the implement of lean manufacturing that are taken for the study. The autonomous barriers are weak driver and weak dependence and may not much influence. The absence of autonomous barriers shows that management should give its due attention to such barriers.
2. From the driver power and dependence Fig. 5.1. It has been discovered that protection from lean change and worker shakiness is frail driver however solid subject to alternate obstructions. These two boundaries are at the best level in the ISM chain of command, thusly these hindrances are taken as essential obstructions and administration may be given high need in handling them. The management while tackling these barriers should also considered their dependence on the lower level barriers in the ISM model.
3. The barriers at the middle in the ISM chain of importance namely poor information system, poor selection of process sequence, long period of implementation and large variability of demand and fear of loose of reputation are interdependent and have solid driving force and

additionally dependence. These barriers construct the middle level of the ISM model. So these barriers also influence the obstructions, which are at the highest point of the model. Conference at the regular interval and joint meeting of different personnel concerning to lean project should be taken to overcome these barriers.

4. From the driving power dependence diagram two barriers namely poor infrastructure and lack of fund have solid driver power and are less dependence on the other barriers. Therefore these barriers are strong driver may be constructed at the main driver of the all the barriers. So before implementing lean manufacturer in the organization, top management should have joint meeting of the different department to address about these barriers so that a reasonable solution may be achieved to overcome these barriers. Involving everyone in the work of improvement is often accomplished through quality circle. There should such activities through which operators may gather in groups to put up their suggestion on the possible improvement.