A LEAN REDESIGN FOR A MANUFACTURING PROCESS THROUGH COMPUTER SIMULATION

MOSÈ GALLO, TERESA MURINO, LIBERATINA CARME LA SANTILLO
Department of Materials Engineering and Operations Management
University of Naples “Federico II”
P. le Tecchio 80 – 80125 Naples
ITALY
mose.gallo@unina.it; murino@unina.it; santillo@unina.it

Abstract: - The need to develop new product processes is born from the competitive and economic world in which firms operate. Robust solutions as regards market fluctuations are needed to realize. In a brief period customer satisfactions originate from new product development efficiency, then it is on cost- time minimization necessary to focus. The complexity of production systems and logistic activities and their interactions, sometimes masked among different elements, entail a substantial inadequacy of all those tool that do not take them into account. Today more than ever, the operating environment is turbulent and the time to make decisions is reduced more and more, hence the need for flexible tools, versatile and reliable.

The aim of this paper is the integration between lean manufacturing and simulation tools in order to better industrialize new products more efficiently. The purpose is to optimize a cell redesign under lean manufacturing principles.

Key-Words: - lean implementation, cell design, computer simulation

1 Introduction
Nowadays the lean concepts are very important and used but they don’t prove how the system change has to be validated to achieve the goals; In fact it’s not possible to make a continuous iterative repetition of the processes, since it would be a great waste of time to solve problems and an increasing cost for the constituting lean system.

Ferrin, Muller, and Muthler (2005) state that simulation is the only way to support the achievement of a target company and to find a correct, or at least good solution that can meet the target set before implementation [1].

Adams et al (1999) provide an overview of how simulation can be used as part of the lean strategy [2]:

• to identify problems of production processes;
• to train the workers;
• to classify the various opportunities for process improvement;
• to create a document of the process;
• to forecast the impact of improvements accepted before the implementation.

Ferrin, Muller and Muthler (2005) talk about the describe the benefits of using the simulation as a part of a combined process lean- 6 sigma [1]. The reasons for using simulation to improve lean processes have been identified on the basis of numerous experiments carried out with studies in industrial environments. These reasons are:

• variability;
• the data have to be used to analyze and understand the random nature of the system;
• the interaction between the components of the system must be considered;
• the future state must be validated before being implemented to minimize the period of the test and the control of the errors;
• it must always consider alternatives to the future state.

In general the lean design is deterministic process even if some random variables, in addition, can affect the performance of the future. A critical problem may be represented by the demand variability. It would be necessary the creation of storage, buffer time waste, stocks. But the variability of buffers, stocks, seen as waste and so the capability of reducing it is a key requirement.

Dhandapani, Potter, and Naim (2004) show the use of the value stream map (VSM) in the steel systems design and state the importance of simulation to reduce the variability and to increase the reliability and availability of the machineries., and the availability of material [10]. Maas and Stanbridge (2005) show how the simulation, in a lean context, where the variability consists of elements such as customer requests and the machineries failure, can
help to achieve the service levels with specific programs of production. The authors analyze the shipping data (the pallets shipped everyday) carrying out a discrete model [11].

However the tools, for the application of lean, focus on each individual component of a system of production and are not able to discover the interactions between these components. The production processes are characterized by a complexity logistical and technological. The logistical complexity is due to high transaction volumes, while the technological complexity is due to the intrinsic complexity of the system and the multiple interactions between components. The value stream mapping is a fundamental activity of lean methodology.

2 Literature review
The scope of this paper is to study the potential synergy between the lean and simulation approach.

In the literature there are many references of separate implementations of lean and simulation. The integration approaches are few, in fact in many cases more than true integration approaches are joint applications of the various techniques.

The approach of Hobbs (2004) begins with an evaluation of the deficiencies and proceeds through several kaizen steps, re-evaluate the performance of the system and the cycle repeats. The evaluation of the gap determines the difference between the current yield of the system and the desired performance. The method includes the modeling of the system as an input to the physical design, but does not consider the iterative process that should occur between the modeling of the system and the physical design [5].

Another approach has been proposed by Feld (2001) with a simple roadmap for the Lean manufacturing [6]. This approach identifies four phases in implementing a lean program. This methodology does not consider the modeling and simulation of the future state before considering revaluation of the system after implementation. The lean assessment includes an evaluation of the performance of the system at present, and an assessment of the current market for the product.

Basically, these assessments are more descriptive than analytical, more qualitative than quantitative. It then develops a VSM analysis of the current system and identify root causes for the reason the system performance lower than desired. The design of a future state covers a total plan and a detailed design that allows to achieve the desired performance of the system. This information is included in the map of a future state VSM, where they provide a guide on operational performance, and communication is needed within the company and with suppliers and customers.

Marvel, and Standridge (2006) propose a lean approach based on the method proposed by Feld [7]. The implementation of the future state passes through a validation step which generally can be performed with a computer simulation to discrete elements. The validation should help ensure that the planned future state effectively addresses the gaps of the current state.

3 Methodological approach
The approach proposed in this paper is based on the methods already mentioned: the philosophy of simplicity in the model expressed by Feld, the need for validation of the model of the future state by simulating the model Standridge and Marvel, the need for continuous improvement (as lean philosophy) via a closed-loop algorithm as the model of Hobbs.
product or a saving in terms of resources to be used)

- Mapping the current state (it is necessary to analyze the current state value stream and flow of information reporting detailed information on cycle times, waiting times, buffer sizes, forward mode of the product, customer demand, etc.)
- Verify if the set goals are already achieved by the current state of the system. If it is not, we proceed to the next step of the procedure, while in the case in which the set goals are already achieved then returns back to change the targets.
- Research and implementation of strategies. At this stage it was agreed that the system does not meet the requisite, so you define the level and nature of the problem and search in the literature as similar problems were solved.
- Mapping the future state. At this point, we analyze the likely (probable) future scenarios that can be achieved with the application of the techniques found
- Design of experiments. After identifying the various alternative future states you can analyze what are the factors that may influence the outcome and evaluate what are the possible scenarios to be simulated. (One of the most frequently used techniques is the DOE which allows to decrease the number of experiments by decreasing the time and cost of the same.).
- Simulation of a future state. Once defined the possible scenarios, or constructed logic models of the future state, it passes to the simulation.

Obviously, the simulation includes the development of a series of steps that are omitted here.

4 The case study
It is an Italian Company where 72 people employed, and it is located in Ottaviano, near Naples in Southern Italy. 1113 items are produced and more the 90% of the production is addressed to a big Italian firm. Then, this big and important Italian firm is the main customer, and their relationship is a partnership with frequent occasion of co-design kind of Function Delivery, where our analyzed Company designs a specific big Italian firm component based on its requirements. The collaboration between them is not only related to the product, but invests production processes too, and they are visible and controllable from the big Italian firm, according to a shared growth goal. This implies a trust relationship applied through a “co-location”, then a pulsating production system in the peripheral supply chain zone: as matter of fact, the production plan are composed by weekly orders and six-month forecasts.

The order process starts from the weekly program through a shared platform from customer and firm production and logistics functions, called AS400. This platform is daily monitored since sometimes the customer modifies its orders planning and production and logistics shop have to be informed in real time.

Depending on raw materials mix the output items are very different. Our Company deals with foams, mixing polyol and isocyanate quantities. For more noisy cars, the polyurethane isolation is not sufficient, and then two different solutions are present. The first one is the mix of polyurethane with rubber, called EPDM. The second one is the mix with porous material. These two different processes don’t have in common either raw materials, equipments, and outputs. In Figure 5 the firm production, divided in two big production family is highlighted.

![Figure 5: Idef0 of process production](image)

The layout (Figure 6) shows the production system firm: inside the map it is possible to find different area dedicated to each product family.
August 2011 the big Italian firm presented a new model, available on the market since 2012. To their suppliers the big Italian firm provided the new production the specifications and the components quantities. Then the need of design and to adapt new production processes of Ottaviano plant.

### 4.1 The Current State Map

In anticipation of the launch of this new model, the big Italian firm group has delegated the task to its major suppliers to gear up for new components production.

Our southern Company problem consists in their components industrialization. The project starts from the situation analysis “as is”, and it stops with maximum load production capacity verification. Photographing the cell today (Figure 7), the produced items are four products, since depending on the type of engine, it changes the request of insulating capacity, which in turn depends on the thickness of EPDM to be applied to the foam.

The cell logical model where the informative and physical flow is visible integrating all information coming from different functions is represented in the following Value Stream Map (Figure 8).

The critical point is the conversion of demand in the labor force, since the firm employees are Direct blue collar workers and partly by temporary workforce: it means flexibility and the need to make education too often.

### 4.2 The Future State Map

It has been decided to conduct different kaizen project. Firstly, it has made continuous production flow wherever possible, intervening on labor force, which becomes fully shared by all resources, reducing from four to three units the new cell configuration. Then changing the layout, reducing up to annul the process waiting and transfer times, bringing the machines in order to have more collection space of finished products. Secondly, we intervene on set-up times.

### 5 The simulation tool

#### 5.1 The Cell Simulation “as is”

In order to analyze production process performance of EPDM foam cell and then to define the variables on which to intervene a cell simulation as it is today has been conducted. The interesting performance measures are plant productivity and resources utilization since the last target is to validate the system after the introduced changes.

The first step in problem definition is the simulation time horizon where lower bound is the minimum time all events occurring: in this case 25 days, that is a month of work, and system will start from empty condition. The second step is data input
acquisition divided into design constraints, and
decision and stochastic variables.

The detail level is function of available time and
simulation goal: in this phase the target is to
individualize productivity and resources use, to
locate the process bottleneck and to verify that
queues are not present in operating normal
conditions. In addition, in order to make this model
useful for future changes it has to be flexible. The
hypotheses are:

- WIP buffers among work stations are not
  present since the pacemaker process is the
  first one of the series;
- not all of the resources machine are
  assigned failure probability distributions, as
  in some of them it is assumed that the repair
  is very small;
- some downtime, as well as troubleshooting
  and set-up, are modeled as a reduction of
  the daily time available for the production
- other downtime, such that for lack materials
  and for lack orders are assumed zero.

Starting from the cell “as is” flow chart the
Arena model “as is” is built, as shown in Figure 8

![Figure 8: Arena model “as is”](image)

Judging the outcome sufficiently faithful to
reality, the model can be considered valid. The
program output highlights that the bottleneck
resource is the foaming machine, giving the
production cadence to the downstream stations, it is
the pacemaker. In order to introduce the new model
production it is necessary to expand the production
capacity or by system choices, for example
duplicating it, or by the use of management levers.
Since the high costs of first choice, it has been
chosen to consider three shifts per day supported
through simulation results.

Different is for other machines having reasonable
investment costs, except for the shearing machine.
However inside the plant there is another shearing
disposed of, which could easily be refitted and
placed in the analyzed cell. Since there are no
particular problems of space, the layout can be
reconfigured adapting to the cell design dictates to
the specific situation. In this respect the operating
machines should be located close to each other, so
as to obtain a continuous flow (Figure 9).

![Figure 9: Future cell layout](image)

Once the changes to make to the “as is” system
are defined, the campaign simulation can be
redesigned in order to analyze the impact of these
changes on system performances.

5.2 The Cell Simulation “to be”
The cell “to be” Arena model is similar to the one
“as is” the model is very similar to that “as is”,
except for certain input data relating to the operating
conditions:

- times related to different phases are
different since handling transfers are almost
eliminated;
- the difference on set up times between the
new model and the old ones. The new
model production is 648 unit/day, and the
old ones are 260 unit/day. Then, it is
necessary to define how and when carry on
the set up. Two different alternatives are
assumed in set up management. Both
alternatives are considering to start the day
with new model production. Alternative A
proposes to make the set up at the end of
first and third shifts. Alternative B proposes
to make set up when the daily demand
production is completed.

Alternative B is more close to reality, and it is
more flexible. In a lean environment, simulation must
support operations plant, and then the second
approach it looks like better, although the long, the push logic will mismatch production and demand, creating inventory and useless waiting times. Both alternatives have been modeled through computer simulation as above described.

The simulation campaign of alternative A is 11 run lasting 25 days and 11 hours, with a transient time of 11 hours obtaining that the system bottleneck is the minitandem, as it is the one presenting a greater use. Other resource work stations are quite underutilized. The cell so redesigned is able to meet the average daily demand of the two codes.

The results of alternative B simulation campaign shows the lower productivity of old model regards the “as is” situation that it is explained by the introduction of the mold changes, stopping production at daily demand reached of 260 units.

The values of resource utilization are equal to those of alternative A.

6 Conclusion
This paper goal is the integration of lean manufacturing tools and simulation, in the context of new product industrialization. This study has been conducted starting from Lean Manufacturing theories through a system production approach identifying the radical and incremental change, both necessary in a competitive market. Furthermore this concept is related to decision timing. The simulation tool has been introduced, showing how helpful can be in order to achieve the best new product development and industrialization. Of course, this simulation tool can be very helpful for better managing the production firm from push to pull system.

References:


