

Lean planning in the semi-process industry, a case study

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Abstract

The lean approach is an idealizing improvement approach that has an enormous impact in the field of Operations Management. The approach is basically very process oriented and there was less attention first for planning and control, this being the profession of dealing with all kind of non-ideal manufacturing and supply-chain restrictions. During the last years, however, planning and control have been integrated in the lean approach, leading to the concept of lean planning. Cyclic schedules form an important element of lean planning, certainly in the (semi-) process industry. The concept of lean planning is rather influential in practice already. This paper describes a lean planning case study in a semi-process production plant. The case study in itself is interesting and illustrates well how lean planning can be applied. The case study shows also that the effect of lean planning or, more specifically, the effect of a cyclic schedule cannot be isolated from the effect of supporting organizational measures and from the effect of the whole improvement process. And these effects are very context dependent. The case study helps to articulate the complexity of developing the lean approach into a theory of production management and production planning. It shows that it is impossible to predict the performance of the “leaned” system.

1. Introduction

During the last years, planning and control has been integrated rather well in the lean approach. Lean planning has an important impact in practice already. This paper describes a lean planning

case study in a semi-process production plant. The case study is interesting in itself and illustrates well how lean planning can be developed in practice. It is also used, however, to show how context dependent the mechanisms are that are coupled with lean planning. That makes the results of lean interventions difficult to predict. The case study stresses in this way the complexity of developing the lean approach into theory.

The lean approach is an idealizing approach (see e.g. Ackoff, 1981 or Ackoff et al., 2006), like TQM and JIT. The lean approach starts with envisaging a world without *waste* (Womack & Jones, 2003) and realizes improvement by fighting waste. There is waste of all kinds and hence the lean approach covers many of the older, more specific idealizing approaches. The lean approach stresses that broad, operational involvement is required to design and implement improvements (e.g. Karlsson & Åhlström, 1996). That necessitates organizational measures. But it is also important to have standard tools available. Tools are important in every idealizing approach. The lean approach includes the use of tools to diagnose waste, to reveal its causes and to design improvements. The tools have to be easy to use to make it possible for the operational people to fight waste where it appears. The lean enterprise institute (www.lean.org) is instrumental in providing these tools. This combination of broad involvement with how-to-do schemes is the main factor behind the popularity of the lean approach. See AberdeenGroup (2006) for an impression of the growth of popularity of the lean approach.

The lean approach is a process improvement approach that gave first less attention to production planning and control. Production planning and control is directed to dealing properly with supply and manufacturing restrictions, to be able to meet a fluctuating and uncertain demand. All practitioners and most academics know that it is necessary to improve the processes first, by removing such restrictions. The lean approach is directed to such improvements. It includes a rather effective appeal to realize *pull* and *flow*. But the limits of the approach are hardly recognized and trade-offs are denied. It is not possible generally to cut all slack and to realize complete flow. But the idealizing character of the approach leads to a structural difficulty in accepting supply and manufacturing restrictions as the basis for an adequate planning and control framework. The design of a planning and control framework requires a more quantitative approach, using OR and simulation. A search on “operational research” on the website of the lean institute gave only one hit: a university applying lean principles (www.lean.org). Especially in the process and semi-process industry the manufacturing restrictions are very hard and

complex generally, leading to a more planning and control oriented approach (Van Donk & Van Dam, 1996).

More recently, Glenday (2006) has yet been able to connect the (semi-)process industry production planning and control problems with the lean approach by stressing the possibilities of *cyclic schedules*. Cyclic schedules lead to *simplicity* and *regularity*. The regularity is helpful in standardizing the production and change-over processes. The simplicity helps the operators to play a role in this standardization. It helps them to understand the production patterns and makes it possible to learn how to deal with deviations and disturbances. Regularity helps to learn faster and to improve the sensitive points in manufacturing and production control. The introduction of cyclic schedules helps also in de-centralizing responsibilities with respect to production control. The ultimate ideal is to produce every product every cycle (EPEC). But it is accepted that this is not possible for all products. So, the approach has to be combined with a distinction between slow-movers and fast-movers. The ideas and concepts are not new of course, but integrating them in the lean movement and tooling them up accordingly has vitalized them. Connecting cyclic schedules with a lean approach has helped in realizing process improvements and improvements with respect to planning and control. This paper gives an illustration of that.

The point that remains difficult, however, is to determine realistic estimates for the performance that can be realized. It is easy to preach that living in a (c)lean house is more pleasant than in a house full of litter. It is also rather easy to develop generic tools for tidying up the house: broom and vacuum (c)leaner. It is difficult however to estimate what efforts it will take and how (c)lean one can get the house in this way. That depends on the holes and corners, the specific structure of the house. Designing a planning and control framework depends on the possibility to estimate the performance of alternative frameworks. The performance depends also on the degree of process improvement that can be realized. This makes a rational design of a lean planning framework idiosyncratic and complicated. This paper illustrates that as well.

To be able to learn from this case study, the pre-intervention situation, the improvement measures, the process of change and the resulting effects are described rather comprehensively. This makes it possible to draw conclusions on the potential of lean planning in this plant. It makes it also possible to draw more general conclusions about the mechanisms underlying simplicity, regularity, flow and pull. It contributes to the insight in the possibility to describe

these mechanisms in general terms and to make them predictable. It sheds also some light on the question whether it makes sense to try to predict the performance of the “leaned” system.

The next section describes the situation before the intervention. Section 3 describes the intervention. Attention is given to the course of the project as well as to the implemented changes. Section 4 describes the results. Section 5 discusses the causal mechanisms behind the results. Section 6 gives conclusions, on the value of the intervention for the company as well as on the possibility to draw more general conclusions from the case study.

2. **The pre-intervention situation**

The plant is the main Sara Lee plant for liquid coffee. Liquid coffee is produced for the “out-of-home” market. It is used in coffee machines. The plant combines the production of liquids with the production of instants, but the case study is restricted to the liquids. See Figure 1 for a sketch of the material flow. Roasting is a shared operation and extraction is partly shared, but in the rest of the process the resources are dedicated to either liquids or instants. Liquids use one of the extraction batteries. The liquid production is given priority on this battery. That, in combination with the buffer between roasting and extraction, made it possible to restrict the case study to the liquids. Liquids are produced in about 10 different blends. Packaging increases the variety drastically to (about) 50 stock keeping units (sku). The customers are the Sara Lee operating companies (Opco) all over the world. There are about 20 Opco’s. The largest Opco has 40% of the turnover, the next one 10%. For the larger blends, almost all Opco’s have their own sku, for smaller blends there are only few different sku’s. The largest blend has about 65% of the turnover. The liquids are made-to-stock. For part of the Opco’s, the Opco stock is visible for the supply network planning (SNP) of the plant and is integrated in their stock control. These are called the “collaborating” Opco’s. Other Opco’s (non-collaborating Opco’s) give just orders. These are the Opco’s with the smaller turnover. For these last Opco’s the demand can be rather lumpy. The demand for some blends is seasonal, because part of the demand is for hotels and restaurants. For one of the blends the high season demand can be more than three times the average demand.

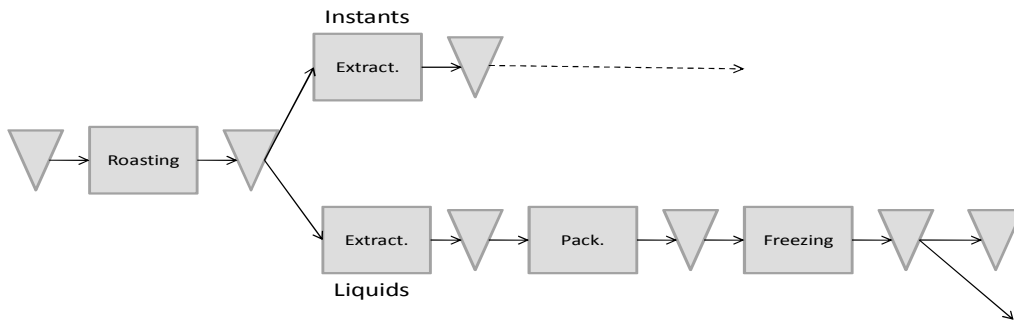


Figure 1: Material flow

Detailed process descriptions

The production step indicated as “extraction” in Figure 1, is in fact a rather complex process of different production and storage steps. See Figure 2 for an overview.

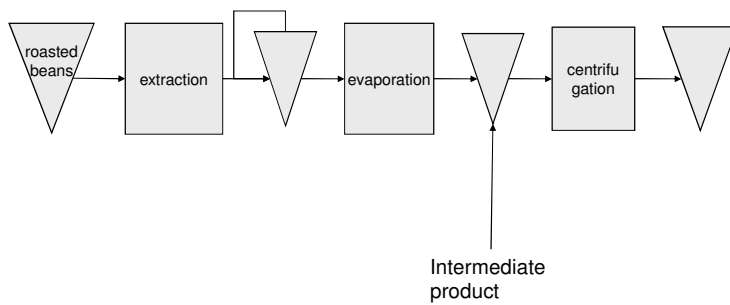


Figure 2: Extraction phase

The extraction itself is leading in this production phase, because of the delicate quality control and the change-over problems. Extraction is executed in a battery with 8 connected cylinders, filled with grinded coffee. Water is put under high pressure through the cylinders. A couple of times per hour one of the cylinders is filled with new roasted and grinded coffee. Depending on the production process (standard, improved quality and total quality) the product flows between cylinders and tanks differ. In some cases the flow from the first couple of cylinders is split from the flow through the last four cylinders and processed in another way. One of the blends has to be mixed with an intermediate product from another extraction battery. The yield of the extraction step varies significantly over the blends. The yield is defined as the ratio of output (translated to dry material) and input (grinded beans). The yield per blend varies also over the weeks. Change-over losses are sequence dependent. In case mixing of subsequent blends is not allowed, a change-over leads to a production loss of 4 cylinders. Other change-overs are possible without production loss; but there are yield effects then. The minimum run size is 8 - 12 cylinders, depending on the yield per blend. This is due to a minimum production quantity in centrifugation. The maximum run size is between 12 and 16 cylinders, due to the volume restrictions of the tanks. For reasons of tracking and tracing, it is not allowed to mix different runs of the same blend in one tank. There is ample evaporation and centrifugation capacity, but the coordination of these steps with extraction, with each other and with packaging is nevertheless complex because of the work-in-process restrictions and the daily cleaning stops. There are work-in-process time restrictions because of quality reasons and work-in-process quantity restrictions because of the restricted number of tanks. The intermediate that has to be added to one of the blends is also complicating planning and scheduling. Stopping and restarting the extraction battery leads to serious yield problems for the first 10 cylinders. The loss of energy is also important. About 5% of the capacity is necessary for tests for product and process development. There is a planned cleaning and maintenance stop of 36 hours every 6 weeks. Each week there is a "cleaning" stop of 8 hours for the parts of the line between extraction and packaging. It is possible to use the extraction battery during this cleaning stop for the production of instants. Extraction and roasting work in a 5-shift system, except for two weeks in the summer and one week at Christmas.

The liquid coffee is packaged in boxes of 1.25 liter or 2.0 liter. The packaging line has two steps. The first step puts the coffee in blank sacks. The second step puts it in printed carton board

boxes. This last step creates the product variety, but the line is integrated and it is not possible to store the intermediate product. The carton supplier is nearby and produces the cartons well in advance. A blend change over takes 5 minutes, with an additional 10 minutes in case cleaning is needed, due to mixing restrictions. A size change-over takes about 25 minutes. The packaging line is faster than the preceding processes, including extraction, except in case of packaging certain high yield blends in 1.25 liter boxes. It is important therefore to alternate properly between the two types of boxes. Due to technical restrictions, the speed of the packaging line has to remain between a lower limit and an upper limit. The packaging line works in a 3-shift system and has even in this 3-shift system sufficient capacity to package the whole week extraction. But during and just after the weekend it is rather complex to adhere to the maximum work-in-process time restrictions.

The packaged goods are transported at intervals of about 3 hours to a nearby village for the outsourced freezing process. It takes 5 days to freeze a batch. There are 5 freezing tunnels in use for the liquid coffee. For the normal blends the final quality control takes place after a week, right after the freezing is completed. For the high yield blend the quality control can only be finished after two weeks, because of more delicate dosing properties. So, depending on the blend, it takes one or two weeks to be able to judge whether a tank of liquid coffee (packaged and frozen) can be accepted or has to be rejected. The rejection percentages vary from blend to blend. For the most sensitive blends this percentage is about 3%.

Transportation frequency to the Opco's is at most once a week. The transportation scheduler tries to organize full truck loads for the larger Opco's and or tries to combine efficiently in case of smaller Opco's. Knowing the Opco stock is helpful here. For the other Opco's there is no transportation quantity flexibility and hardly any transportation timing flexibility. The transportation time varies from 1 day to 6 weeks. The Opco's far away are Opco's that place orders. The plant is responsible for the transportation, but a logistic service provider takes care of the transportation itself.

Planning and control

The main input for the operational planning and scheduling is the Demand Plan (DP). The DP gives the estimated requirement per Opco at sku level, for two years ahead. The DP has been checked already at the Annual Operating Plan. The DP is the input for the weekly updated

Supply Network Planning (SNP). The SNP is MRP-based and coordinates procurement, production and distribution. It works with week buckets and has a horizon of 40 weeks. The SNP information is shared with the supplier of packaging material, to facilitate the production of the required packaging material well in advance.

The first 5 or 6 weeks of the SNP are fixed (depending on the throughput time for freezing/testing). This makes it possible to fix the production over the next 3 weeks. In week $t + 2$, the SNP is used to make an aggregate packaging plan for week $t + 4$. This packaging plan is input for the detailed planning and scheduling (roasting, extraction and packaging). The SNP is supported by SAP R3, the detailed planning and scheduling is supported by SAP APO. For the scheduling of the packaging line, to realize an adequate alternation of 1.25 liter boxes and 2 liter boxes, they also use a home-made excel application. The detailed packaging plan is used to call off the packaging material (in week t for week $t + 1$).

In week t , it is decided what to distribute to which Opco. This is called the Deployment plan and is also supported by SAP APO. In the Deployment plan, the more recent changes in the requirements and the production disturbances are taken into account. The really available inventory and production is allocated as good as possible. The SNP based coordination, plus the deployment and the transportation scheduling is performed by a group of three people, the supply chain coordination group (SCCG). The detailed planning and scheduling, plus the calling off of the green beans, is performed by another group of three people (DPSG). There is a third group of two people (OCOS) who take care of the operational coordination of the packaging material, the (outsourced)freezing and other outsourced processes for instants. All three groups report to the logistics manager who is also a member of the management team of the plant.

3. The intervention

Background

The project was stimulated by the company wide attention for lean manufacturing and lean planning (see above). In the plant there was a lean manufacturing group active (the “lean team”). They realized various manufacturing improvement measures by relooking at the manufacturing processes, together with the operational people involved. One of the principles that had some appeal was the principle of regularity. The expectation was that quality improvement was

possible by generating more regularity in manufacturing. The ideal was to let each coffee bean have the same course of life. One of the problems in this respect was the difference in shift system between extraction (5 shifts) and packaging (3 shifts). The group put some pressure on introducing also a 5-shift system in packaging. The planning people supported that because of the planning and scheduling complexities due to this shift system difference. Next to that these people had anyway the impression that the planning and scheduling complexity was too high and the realized flexibility too low. In combination with a 5-shift system for packaging, the principles of Glenday (2006) about cyclical planning seemed to be applicable. The plant management supported the idea, also because being active in lean planning would contribute to the position of the plant within the Sara Lee organization. Existing contacts with the Operations Management group of the University of Groningen (UofG) were refreshed to get some support. The UofG people proposed to combine the project with building a detailed simulation model of the situation, to be able to evaluate the different solutions. This idea was accepted.

Improvement approach

The causal mechanisms foreseen at the start of the project are illustrated in Figure 3 below. Cyclic planning creates regularity and simplicity. Simplicity and regularity together facilitate the operational people to see their role and to understand how they can contribute to process improvement. This holds as well for the manufacturing processes as for the processes of planning and control. Together with customer integration it helps also to improve the customer service processes.

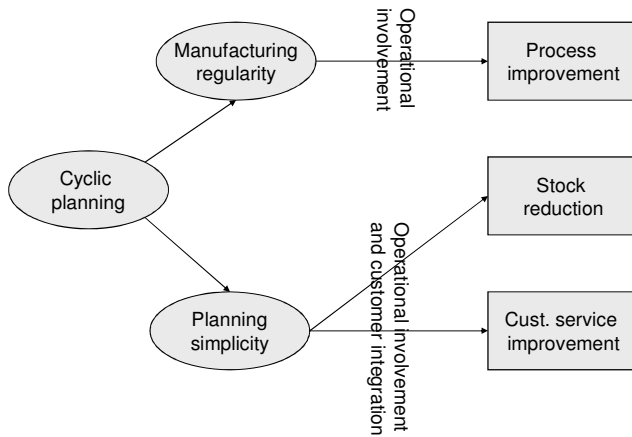


Figure 3: Lean principles used

As mentioned already in the introduction, this cyclic planning approach is stressed by Glenday (Glenday, 2006) and embedded in the general principles of lean manufacturing. He explains the importance of “leveled production” and “EPEC” (= every product every cycle) as means to realize “flow” and “pull” and he advises a fast mover-slow mover approach to organize cyclic plans. He shows how such an approach can also be successful in the semi-process industry and in food production. His approach was communicated and applied widely within Sara Lee. This project fitted in this company wide improvement program.

The project

The project started in March 2007. The project team consisted of the logistics manager of the plant, a representative of the lean manufacturing team, the head of the supply chain coordination group (SCCG), the head of the detailed planning and scheduling group (DPSG) and three people of the UofG, one expert in production planning, one expert in simulation and a junior researcher. The logistics manager was responsible for the project. The junior researcher worked almost full time for Sara Lee during the project and did most of the preparatory and executive work. He did also the simulation modeling and experimentation. The project has run for about 10 months. There were 10 project meetings of 2 – 3 hours each. First the focus was on analysis and diagnosis, later the focus shifted to the detailed design of the new planning system. The deadline

for having that design ready was September 1, because it was decided to have a 5-shift system pilot for the packaging line from September until Christmas. The detailed design was ready in time. The simulation model was not available yet, however. Its main function during that phase was to enforce the necessary precision in the design of the planning system (see van der Zee et al., 2007). Later on it has been used to fine tune the system (and it is still used that way). In May a project execution team was established, to transfer the proposals to the people who had to do it and to enhance their involvement. This team met weekly from the end of May until the end of July. Together with the start of the pilot, the plant management introduced also a daily production meeting (DPM) of about 30 minutes. Participants are the group leaders (roasting/extraction and packaging), their “first” operators, people of the planning groups, people of the “lean team” and people of technology support and quality control. The meeting is chaired by a representative of the lean team, to contribute to the openness of the meeting. Issues regarding safety, production, development and planning and logistics are discussed. Problems are resolved within a week or put on a structural project agenda.

The changes

It was decided to introduce cyclic planning for the production of liquids, with a fixed week-pattern, together with a transfer to a 5-shift system in packaging and a reduction of the number of workers per packaging shift. See Figure 4 for a sketch of the weekly cyclic pattern.



Figure 4: Weekly cyclic pattern

The choice of the blends to include in the fixed part of the cycle was based on the turnover of the blends, the regularity of the blends and technological considerations (sequence preferences). During the first three months pilot, six blends were included in the fixed part of the cycle. Three

of the blends were produced all weeks, three others only once every two weeks. The cycle start was Friday, 0 h. The end of the fixed part of the cycle (part with the cyclic blends) was Tuesday, 15 h. This position of the cycle in the week was chosen because of technological and organizational reasons. The number of batches for all cyclic blends was fixed for the whole three months period, except for the “breathing” blend. Due to disturbances in the time required for the fixed batch sizes and occasional breakdowns or stops, the finish of the fixed part of the cycle would fluctuate. The last blend in the fixed part of the cycle is “breathing” therefore. The batch size of this blend could be adapted to keep the finish of the fixed part of the cycle as close as possible to Tuesday, 15 h. The variable period was for the non-cyclic blends, for extra runs of the cyclic blends, for experiments with new blends and process changes and for the weekly cleaning of part of the equipment (allowing in between the production of instants). Each sixth week this variable period is reduced with the six-week maintenance stop.

This leads to a two level production planning scheme (see Figure 5). The execution is added to these two planning levels, because there is also some decision freedom at that level. The top level is the determination of the *cycle parameters*. These include the cyclic blends, their sequence, the run-lengths (number of tanks per blend) and the position of the cycle in the week. The determination of inventory control limits for the blends belongs also to this level of planning. It was decided to determine the cycle parameters once every 3 months (two maintenance periods). Given that the plant worked from now on in a 5-shift system, the weekly pattern was rather arbitrary. It was a consequence, however, of the way SAP was implemented. The supply chain world within Sara Lee is organized in weeks. It did not make sense to deviate from that. Changes would have required heavy efforts at company level. Another important decision is to have not only a fixed cycle sequence, but also completely fixed run-lengths per blend. The reason for that was the preference for real manufacturing regularity, hoping that that would lead to quality improvements. It was made possible by the relative stability of the demand of the cyclic blends. The decision was not based on extensive analysis or simulation, however. But it was certainly something to reconsider after the pilot period.

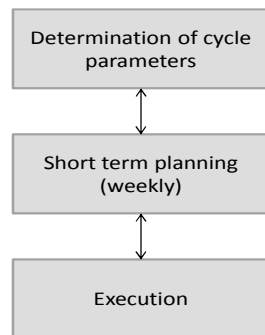


Figure 5: Three layers of planning and execution

The lower level is the *short term planning*, determining the run-lengths of the non-cyclic blends and the allocation of the blend runs to the sku's. Special attention is given here to an adequate alternation of 1.25l and 2l boxes during the production of blends with a relatively high yield. The short term planning is executed weekly. It is run-out time based. Just before the start of the cycle, the necessary information (inventory, work-in-process, orders, predicted requirement) is downloaded from SAP. An Excel application (LP-solver) is used to determine the allocation of the cyclic batches to the sku's and also to determine suitable runs for the non-cyclic blends. This is done by the SCCG group. The information is transferred to the DPSG group, to take care of the timely availability of green beans plus the roasting schedule and to determine the packaging sequence and the schedule of the variable period. The resulting production schedule is uploaded to SAP, to keep the SAP transaction processing complete.

At the *execution level*, the people have to determine the precise evaporation and centrifugation sequence and timing. They also have to know how to deal with extraction disturbances and to determine the extent to which the breathing blend has to buffer these disturbances. There is also some freedom left in the packaging sequence. During the pilot the simulation model is used to explore the possibility to guide this decision freedom with simple rules.

4. The results

This section reports the results of the three months pilot. We distinguish the following elements:

- a) the degree to which the planned cycles have been executed
- b) the manufacturing regularity and the resulting improvements in yield and quality
- c) customer service
- d) inventory and work in process
- e) organizational consequences
- f) financial consequences

These elements will be discussed here subsequently.

Cyclic planning

The cyclic planning has been realized rather precisely. The starting point was kept, the run-sizes (in number of tanks) of the cyclic blends were kept. The disturbances in extraction led to a run-size variation in the breathing blend of up to 10% . The finishing time of the fixed part of the cycle did not vary more than 15 minutes.

Manufacturing regularity, quality and yield

There are two elements of manufacturing regularity. In the first place the cyclical regularity of the fixed cyclical sequence. This makes it possible to give more attention to the change-overs. In the variable period the sequence is also kept as constant as possible. The second element of manufacturing regularity is the regularity of in-process times. The in-process times with an important quality impact are the time between extraction and centrifugation, the time between centrifugation and packaging and the time between packaging and freezing. The standard deviation of the time before centrifugation and the time between centrifugation and packaging have both been reduced with about two hours. The time between packaging and freezing has also been reduced because there are now 6 freezing tunnels in use which makes it possible to synchronize packaging and freezing.

There was indeed a small yield increase and a substantial yield variation reduction. The people involved tend to subscribe these changes to the introduction of cyclic production. But the pilot has been too short to draw final conclusions here.

Customer service and inventory

The changes have not been discussed very explicitly yet with the Opco's. This is partly due to the fact that within Sara Lee the contacts with the customers are the end responsibility of Value stream management (VSM), a unit that does not fall under plant management. That makes the decision process about changes in these relationships more complicated.

The delivery reliability for the non-collaborative Opco's is defined as the percentage of the deployment plan that is realized. That percentage has not changed. For the collaborative Opco's the local sku inventories are relevant. There is a norm safety stock that varies from 3 – 5 weeks (depending on the blend). During the pilot it appeared to be possible to keep the safety stocks right on this norm, while before the pilot, the safety stocks varied from 0 to 8 weeks. This improved control of safety stocks resulted in a reduction of overtime stock. The pilot has also led to a more systematic measuring and reporting of the run-out times at sku level.

The total inventory has increased. The total inventory was at the start of the pilot below the critical limit. The increase during this period is partly normal, because of demand seasonality and because of the yearly winter-stop. The run-sizes for the cyclic blends in this pilot were above average, to realize this increase. Thereafter the run-sizes have been reduced.

Organization

The first, very general impression is that all operational people (planning and scheduling people and production people) are indeed more aware of the material flow. The production people understand better how their decisions influence the synchronization of the subsequent production steps. The SCCG people, in making their short term planning, are more aware of the scheduling consequences. The short term plan is closer to execution than before. Before it was the output of rather mechanistic MRP type calculations. In-attractive scheduling consequences were discussed of course, but only if the people of the DPSG group asked for adaptations. The sku allocation through the excel LP-solver makes a decision routine necessary that is not embedded in SAP. Downloading, allocation and uploading necessitate a well maintained script. The distance

between the SCCG group and the floor is smaller and the role of the DPSG group is smaller with respect to liquid production and packaging. Working in cycles with a week pattern that starts on Friday complicates the DPSG task a little. They have to upload the production runs of two subsequent cycles (Monday to Thursday of one cycle and Friday to Sunday of the next one) to SAP, because SAP works with calendar weeks.

An important change that is not completely coupled with the pilot, but that is certainly inspired by it, is the introduction of the daily production meeting (DPM). It helped to implement cyclic production, but it is also used to make the communication in general more effective and to activate the problem solving potential.

All operational people are asked about their experiences and opinions regarding all changes. These are in general positive. But it is hard to determine what the contribution is of the individual elements cyclic production, 5-shift system and DPM.

The packaging line works in a 5-shift system now. They are expected to be able to follow centrifugation rather closely, to keep the flow time between centrifugation and packaging stable. The production speed ratios of packaging and the other resources depend on blend and box size. It necessitates a high flexibility of the packaging line. This turns out to be difficult for the packaging operators. There are many small stops now. That is perceived as a problem by the packaging people. As long as the stops are not longer than half an hour, it does not lead to quality problems.

Financial consequences

There are many financial consequences:

- a) Transfer to a 5-shift system for the packaging line. This has been combined with a reduction of the shift size. Reducing the fixed shift size led to the need to deploy more temporary personnel.
- b) Transfer to a 5-shift system in the freezing facilities. This includes the deployment of an extra freezing tunnel.
- c) Transportation cost. Transportation from the plant to the freezing facilities is at regular intervals. Since the packaging line works longer per week now, there are more transports.

- d) Planned maintenance is done now on weekdays instead of during weekends. In the weekends unplanned breakdowns may occur that need immediate repair. This has also financial consequences.
- e) Energy use. More stability leads to less use of energy.
- f) Yield and quality effects. It is not clear yet how big these are.
- g) Inventory reduction. This has not been realized yet. But it is possible to realize it from now on, because the run-out time variations have been reduced indeed.
- h) Influences on the size of the planning groups. On one hand there is more work, because of the more complex downloading and uploading procedures. On the other hand there is more repetition and simplicity. It is not clear yet what the total effect is.

It is not possible to draw final conclusions. The first estimate of the financial consequences is not right away positive, but there are many possible improvements that could not be estimated yet or deployed. The management decided to continue this way of production. The financial results were not considered to be prohibitive and the potential improvements were sufficiently attractive.

5. Discussion

Here we try to interpret the results and discuss what can be learned from the project. There are at least three important designed changes, cyclic planning, 5-shift system in packaging and daily production meeting. Cyclic planning and 5-shift system in packaging are so intertwined that it can be interpreted as one combined change. But the introduction of the daily production meeting was not really implied. Participation could have been arranged in another way. It is not easy to relate the results to the separate changes. Most results are caused by combinations of changes. Moreover, there are situation specific characteristics that influence these causal relationships. This complicates the interpretation and makes it necessary to be broad in describing the possible influences.

More regularity with respect to change-overs is directly due to the introduction of cyclic planning. This makes it possible to pay more attention to these change-overs and to realize a higher yield and quality during these change-overs. But the realized yield and quality

improvement is also due to the technological characteristics of the process and to the way the improvement activities are organized. The relevant technological characteristics are: the number of parameters, relationships of the process parameters, stability of the process, frequency of change-overs, etc. The daily production meeting is relevant in the way the improvement process is organized. But there are more organizational factors: contact pattern of production personnel and technology support staff, the time available for improvement actions, support of the lean team, etc.

The variance of the run-out times of the sku's has been reduced. So, the sku stocks are better under control. This is due to the reduction of the fixed period in the SNP and to another way of supporting the SNP (using Excel LP-solver on downloaded SAP information). The characteristics of the demand are sufficiently stable to estimate this effect by an adequate model. The reduction of the sku run-out time variance is not a straightforward consequence of the introduction of cyclic planning. It is rather so that the improvement is due to explicitly distinguishing a blend level and an sku level in the production planning. This distinction is more or less enforced by the cyclic planning, but it is also possible to introduce such a distinction without cyclic planning. This two-level planning needs a way of support that is not provided in SAP. This support can easily be provided by Excel, but it requires some organizational courage to deviate from standard Sara Lee SAP, and extra organizational discipline to maintain the procedure.

Better sku stock-control makes it possible to reduce the Opco control limits. However, this requires also a more intensive communication between the SCCG group, the plant management and the Opco's. The separate value stream management organization is responsible for the contacts with the Opco's. This makes that such changes require a higher level and broader decision making process. The project was mainly a plant project. The results make it possible to reconsider the relationships with the Opco's. This requires to broaden the project.

The downside of cyclic planning as implemented here is the loss of flexibility at blend level. This can also be estimated by a suitable model. The available simulation model may be useful here.

The cyclic planning, in combination with this other way of supporting SNP brings the SCCG group closer to Production. The operators become also more involved in planning and control in this way. The task of the DPSG group has been reduced a little because of that. Maybe it is

possible so to integrate the DPSG group and the SCCG group and/or to reduce the total number of people required for planning and control.

A straightforward consequence of more regularity and a 5-shift system for the packaging line is the need for speed fluctuations in packaging or the acceptance of many short stops. This leads to questions about the efficiency of the packaging operators and the quality of labor of such a “flexible” packaging line. A cyclic schedule for the bottle-neck operation requires flexibility of the other operations to be able to realize flow.

The most important mechanisms are illustrated in Figure 7. Some of the relationships are very straightforward (e.g. cyclic schedules → simplicity), some others depend heavily on the precise organizational and technological characteristics (e.g. manufacturing regularity → yield and quality improvement or simplicity → integration). Some improvements can be estimated by modeling and simulation (e.g. the improvement of sku stock control), some others require extensive empirical research or, if the effects are very situation specific, learning by doing (e.g. integration).

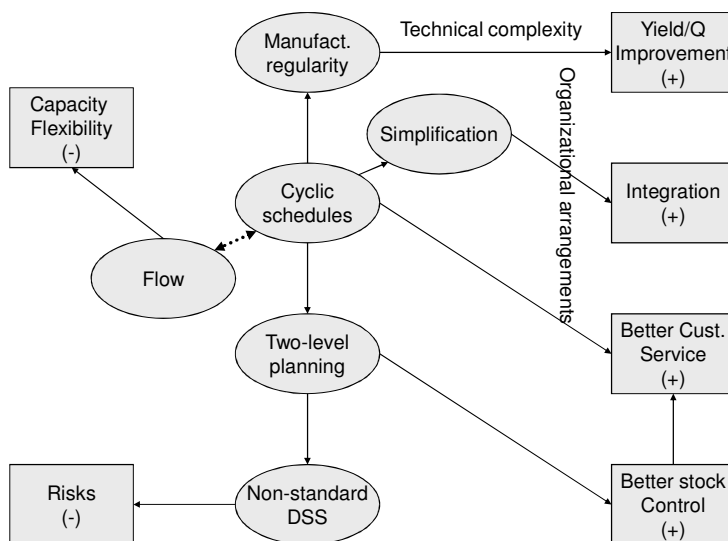


Figure 7: The mechanisms illustrated.

It is also possible to learn from the process. The company wide attention for lean planning and EPEC (every product every cycle) contributed very much to the willingness of the plant management to start the project and to allocate resources. It fitted in the general move of rethinking processes and improving operator involvement.

The combination of a project team and an (overlapping) project execution team worked well. The participation of the chairman of the lean team and the logistics manager (also management team member) were very important. The participation of the junior researcher from the university of Groningen in both teams was also essential. The aim of building a detailed simulation model to design, analyze and support the new control structure helped in getting the right focus in the project meetings. The planning and control expertise of the university members of the project team was helpful in deciding to deviate from SAP.

6. Conclusions

The combination of cyclic planning with lean manufacturing has potential for including planning and control in the lean movement. Looking at the causal mechanisms in this case, we conclude that lean planning has led indeed to more *simplicity* and *regularity*. Depending on the accompanying organizational arrangements, it may also lead to more involvement and more internal and external integration. The combination with *flow* and *pull* is less straightforward. In this case it was possible to realize a better synchronization with the demand by exploiting the distinction between blend level and sku level. This may not always be possible, however.

ERP software turned out to be a complicating factor in introducing cyclic planning. It was necessary to design situation specific decision support, together with downloading and uploading procedures. Given the structural inflexibility of ERP, this may be expected to be general.

Simulation is useful in the detailed design of the new planning and control structure, not only because of its evaluation possibilities, but also because the design of the simulation model helps also in being sufficiently specific with respect to the questions that have to be answered around planning and control. Preparing the simulation and especially the process of conceptual modeling is just as useful as using the simulation (see Robinson, 2004).

The case study confirms the lean principles formulated in the introduction. It shows also that some of the effects need further research. For instance the quality and yield improvement effect:

how do the involvement of operational people and the characteristics of the technology and its use lead to improvements? In case of a well standardized technology, the positive effect of more regularity may be conjectured to be smaller. Another point that needs more research is the organizational efforts required for the development, use and maintenance of ERP work-arounds: what do comparable experiences with respect to downloading and uploading learn about the complexity of maintaining such procedures? And, maybe, the possibility to realize production lines with variable speed: how to keep operators effective and efficient?

The effect of cyclic planning cannot be estimated in isolation. It is intertwined with the effects of more involvement, more organizational and inter-organizational integration, another way of decision support, etc. Some of the effects can be estimated beforehand, by analysis or simulation. For some other effects there is some empirical evidence. The just mentioned research possibilities may also be added here. But most of the effects are so situation specific that one may not expect to be able to translate such research results right away to concrete estimates for this situation. This is certainly so for the effects on the total financial result, as it is a combination of all results.

Case studies are directed to understanding and theory development (e.g. Meredith, 1998), and not to theory testing. That is how we use this case study. Important relationships have become clear and it leads to suggestions about future research. But understanding the relationships leads also to the conclusion that it is very complex to overcome the situation dependence of (the combination of) all these effects. Case studies, if sufficiently rich described, show us the restrictions of model oriented research and aspect wise survey research. Case studies are not only useful for understanding and theory development, but form also the most important means to test the *applicability* of the theory. This case study learns us that it is impossible to develop theory that can be used to predict the performance of the “leaned” system. We have to be satisfied with models, tools for diagnosis and change, partial theoretic results and rules of thumb. And as long as that is so, it is valuable to report our experiences honestly and thoroughly. That is what has been done here.

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