Antwerpen
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1 Creating flow with 5S & TRIZ.

1.1 Abstract.

5S is one of the keystones of lean manufacturing. The 5S approach is more than cleaning the work floor; it helps to remove all waste or muda. In fact 5S helps to create a better flow in production. One of the most difficult to overcome steps in 5S is the last step of 5S, the discipline of the operators. Especially when a lot of tools need to be returned to the right spot, order seems to turn to chaos. TRIZ overcomes the disorganisation by following the patterns of evolution of technological systems (e.g. decreased human involvement) and looking at basic functions. The combination of 5S and TRIZ is applied to a case study e.g. the preparation before a bake out process. This process was traditionally improved through the 5S technique resulting in a better flow. An even bigger improvement was found using functional analysis. Using functional analysis helps to fix on the real problem without having o use trial and error to find a solution direction and using the technological knowledge TRIZ posses a breakthrough can be found.

1.2 Keywords.

5S, lean, TRIZ, ideality, time dependent functions, production system, state of the system, technology, efficient maintenance, flow, fool proofing

1.3 . 5S keystone of lean manufacturing

5S tries to help minimise lot size, breakdown, defects, inventory, material handling and lead time to zero (1). 5S is therefore one of the keystones of lean manufacturing, TPM, six sigma… Mostly 5S is mistaken with cleaning the workplace and is only seen as housekeeping. 5S is rich of layout improvements, inventory control methods and line balancing techniques.(4) One of the nice elements in 5S is taking pictures. Taking pictures is so simple and powerful to see the improvement afterwards because the past is easily forgotten.

1.4 . Clean or lean?

The in lean manufacturing popular word “waste” or “muda” is more than dirt or filthy literary. Waste is anything that adds cost to the product without adding value. The 5S approach makes sure that excess (e.g. the number of components, the amount of stock, the method of assembly, even the way we treat people) is considered as “dirty” and should be “cleaned”. The 5S technique tries to improve flow within the company rather than clean the floor.

Not within lines
Figure 1

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To result in a better material flow and a fool proof environment all objects need to be immediately seen by the operator in a glance. After usage the objects need to be moved to the correct position. This is not only applicable for the work in process but also true for the tooling, the fixtures, the pallets, the cranes, all movable equipment…. Decreasing the number of objects on the work floor eliminates the need to transport them across the work floor. In fact one could argue for manufacturing companies that the operator only transports or moves all the objects across the work floor. It is not the operator that fastens a bolt, but the wrench. The operator only moves the wrench in the right position and then takes it back to its waiting position. It is not the operator that paints but he moves the powder coat gun.

Hose loose on the floor causing possible safety problem

Hose returned trough hang up mechanism but operator can't handle tool easily

Hose coming from behind worktable

No hose present
Tool moves only in fixed position
(XY plane)

Loose position
Figure 2: 5S law on position & controllability applied to a hose and powertool

It is not the operator that welds but the welding torch, the operator only moves the torch towards the piece and back again. The operator needs to get control on the objects. And as soon as the object is under the control the further movements are predictable.
So it is advisable to have fixed **position** and **quantity** and **identified objects**.

1.5 Basics of 5S: on discipline and how to overcome it.

The 5S approach is popular known in 5 steps but also exists in 3 phases. The 5 steps are known as:

1. Seiri or Sort (Organization)
   - Perform "Sort Through and Sort Out," by placing a red tag on all unneeded items and moving them to a temporary holding area. Within a predetermined time the red tag items are disposed, sold, moved or given away.
2. Seiton or Straighten (Orderliness)
   - Identify the best location for remaining items, relocate out of place items, set inventory limits, and
   - install temporary location indicators

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3. Seiso or Shine (Cleanliness)
    - Clean everything, inside and out.
4. Seiketsu or Standardize (Adherence)
    - Create the rules for maintaining and controlling the first 3S's and use visual controls.
5. Shitsuke or Sustain (Discipline)
    - Ensure adherence to the 5S standards through communication, training, and self-discipline

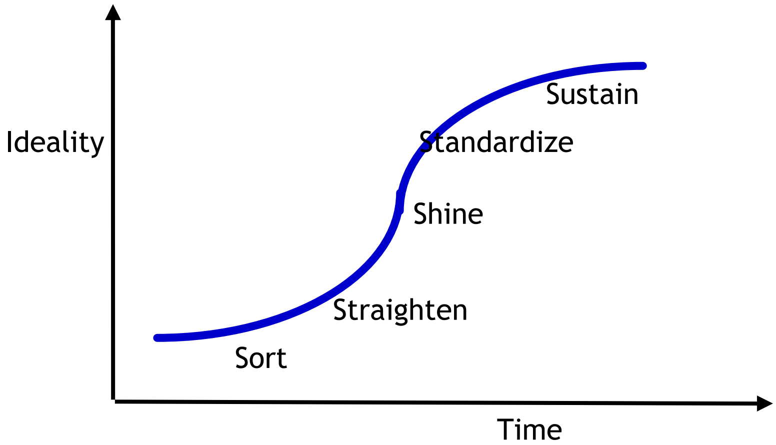

Figure 1.1 creating order out of chaos

The first 5S phase starts curative with enabling the possibility of flow and eliminating the flow stoppers. Quick solutions as shown in figure 3 can be used but only if the duration is limited. One of the worst things one can tell to an operator is that we're busy finding a solution. It is better to give a deadline or decide and tell them to do nothing even if it is a great idea"! The standard should be that the operator removes the excess of oil until the problem is resolved. Ideal would be to overcome this problem at once.

Figure 3: Temporarily solutions

It should be made clear what the rules are to ensure good quality and flow! Therefore it is necessary not only to do 5S as housekeeping but to connect it directly with quality and flow and efficient maintenance!
Standardising is about making rules to ensure that the litters are cleaned as prescribed.

The second phase emphasises eliminating all other losses e.g. too much parts in the workplace (stock). In all phases the 5th step (Shitsuke) seems to be the most difficult

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one, trying to bring everything back to its original place doing the actions in the similar way as described. In quality we call this “sustain” that these actions are always performed in this same way. This is why we write procedures, make checklists to avoid mistakes. Regularly doing audits makes sure that everybody understands the importance of order but as soon as the focus diminishes, the order diminishes. But chaos peeks around the corner and returning the equipment at the right spot, placing a box within the lines seems to be a fire fight. Using the law of decreased human involvement and thus eliminating the errors of human is the better way to handle

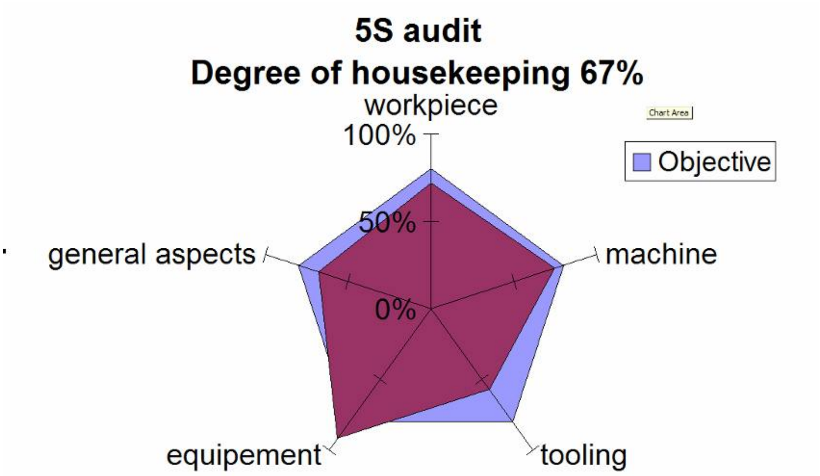

Figure 4: example of 5S audit

The final phase in 5S approach is a preventive one: make sure it will never become dirty, that no waste can ever be present.
Finding a solution so the litters are not needed anymore is part of the 3rd phase of 5S.

In this paper we wish to give an example of the last phase.

The 5 preventive steps are:

1. Preventive Seiri: Sort (Organization)
2. Preventive Seiton: Straighten (Orderliness)
3. Preventive Seiso
4. Preventive Seiketsu
5. Preventive Shitsuke

Ideal would be that the object return themselves, identify themselves and limit themselves in quantity though this sounds rather futuristic. The best solution is that no objects – read tooling - are needed but then you will not be able to make anything.

1.6 Preventive 5S, an example. On maximizing functions in the preparation before a bake out process.

The case study concerns a bake out process. To speed up this bake out process it is necessary that the work piece is wrapped completely, in order to create a higher pressure. This was formerly done through 2 fixtures: middle & head fixture and a tail fixture (see figure 5). These were placed on the work piece and screwed together. Then the piece was put on a machine to tape the whole piece. After the bake out process the piece is returned to eliminate the tape and unscrew the nut and place the fixtures back to their correct position. The system is constrained by not to change the bake out process and look for ways reach a higher order level through 5S.

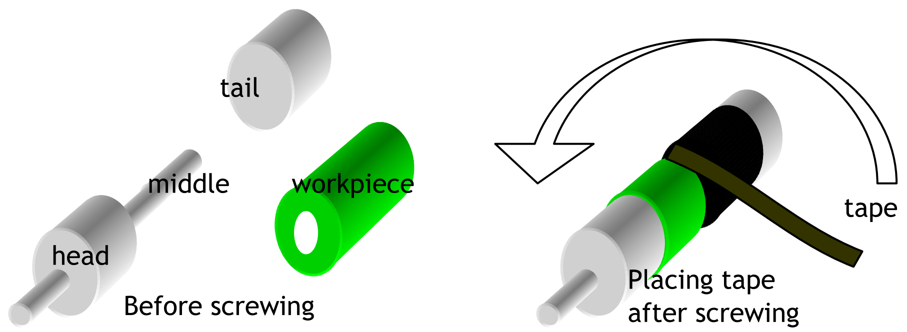

Figure 5

Before the 5S approach all the fixtures were jumbled and the needed fixture was not easily found. Applying the 5S approach all the parts were identified placed at a fixed location so it was easy to find the right fixture (see picture 6). This increased productivity and quality. But one of the problems was the discipline. Not at first but after three months the operators not always placed the fixtures back correctly and since the supervisor had other focuses, the procedure degraded. How could we ensure that the operator always places the fixtures on the right spot?

All fixtures are identified and labeled in rack
and easily found: Sorted, Straightend and Shining
Picture 6

One of the first alternatives that one thinks of is make sure that the supervisor keeps a hard focus. One thing is clear only by means of a "decreasing human involvement" direction we will not find a fitting solution. If we keep depending on the reliability of people we'll always end up at the same lane. So discipline could be seen as a characteristic of humans, or better lack of discipline.

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1.7 *Functional System description, a TRIZ approach.*

A functional system description provides information on the relevant objects and the relations between these objects as shown in figure 7.

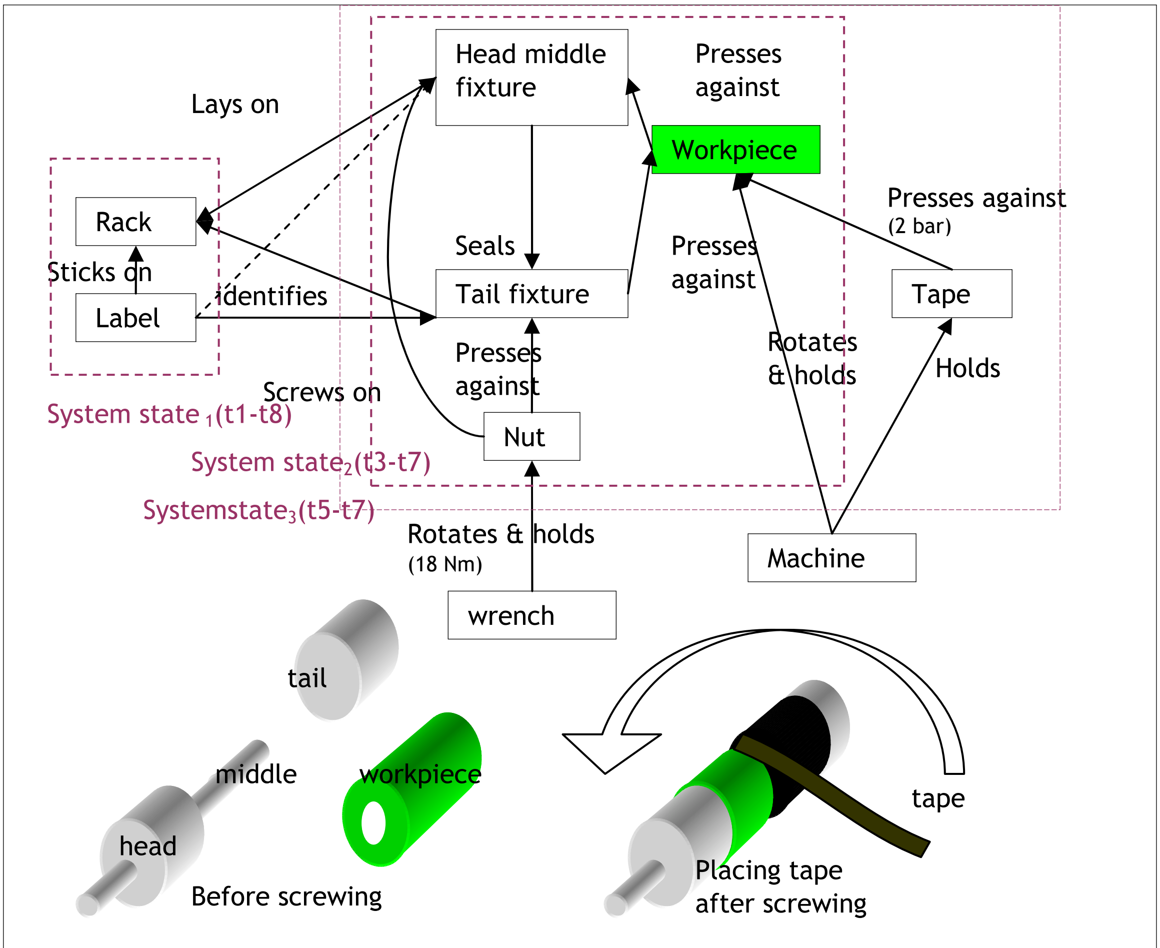

Figure 7

The process is described as a series of subsystem states that are described at equilibrium. The most difficult part in this exercise is to determine those objects of the system that are relevant, within the problem world and promising to find a solution. Excluding objects from the super system limits directions for improvement.
Without going much in detail how this was achieved, assume that the above could be one version.

The first system state (1) is when the fixtures were taken from the rack. Nothing is happening at that moment with the rack. This state only exists as long as the fixtures are taken away. This temporarily subsystem is shown with dashed lines around the rack objects important for this case. The subsystems itself contains several objects such as screws, bars,… but to describe these would be irrelevant in relation to the goal of this

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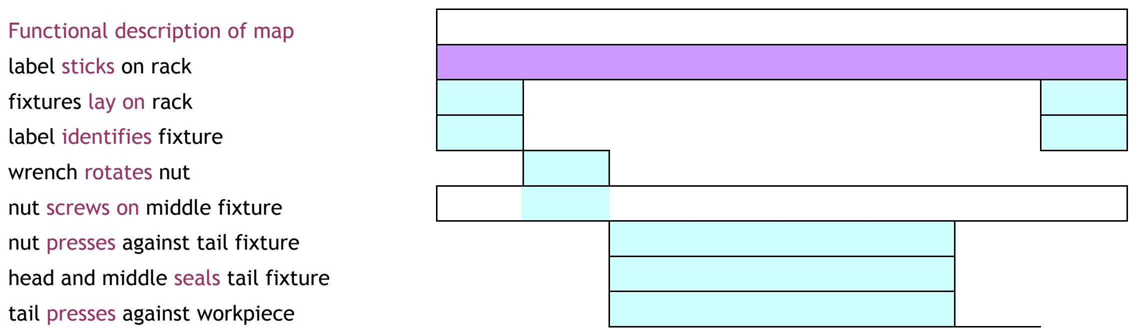
exercise e.g. “How could we ensure that the operator always places the fixtures on the right spot?” The operator has no business with the nuts and bolts of the rack, only with the rack itself. Besides, the nuts and bolts don’t deliver the function lay on concerning the fixtures, nor do the plates and bars or labels. Only the entire assembly (the rack itself) delivers this function.
The functional system describes gives the information of an insufficient function (dashed line) e.g. identify. In fact is it the operator that misplaces the pieces so they get mixed up. The operator however is present in every action in this system description. To eliminate drawing arrows from and to almost every object which will make the description less readable is why the operator is not included. Besides, the operator is performing labour, and labour is not a system state function! (for further discussion on Man and Technical System see 9)

The second system state is when the nut is screwed on the middle fixture and presses against the tail fixture. But as soon as the nut is screwed and at its end-position it is not screwed any more it has reached its dynamic equilibrium which is called system state2 (t3-t7). Yet the analysis seems to mislead and tell us that it is still screwed on. The function could be changed to “Middle fixture holds nut”. In fact at first the objects middle, head and tail fixture and screw are combined to form later on a system (system state2) as noted with dashed lines. The fixture consisting of head, middle and tail piece at a later state acts as if it is one subsystem (system 2) existing only of one object e.g. the fixture. The labour was performed by the wrench (probably done by the operator) but as soon as the system arrived at the end state the wrench stops. The wrench is only important during the fixation not afterwards. The nut will press against the tail as long as needed (see figure 7). The same is the case with the operator. Note that this “object” is not present at the current analysis!!

Afterwards the tape is taped on the work piece. As soon as the end state is reached the machine is no longer needed. Eventually the subsystem state 3 is reached. It is this subsystem consisting of tape, work piece, nut, head, middle and tail fixture that is placed in an oven to create the necessary conditions to bake out the work piece.

This means that the functional model describes several states of the system where labour is done until equilibrium is reached, only the final end state is important (state 3) yet a lot of labour has taken place to achieve this end result.

But in order to improve the system it is important to take into account all the objects and the functions needed. Note that the functions as described in the functional analysis are not present at the same time some as seen in figure 8 . Some of the functions are present at every moment (sticks of labels), some will only appear when equilibrium of the subsystem is reached (e.g. presses, seals through nut and fixture)



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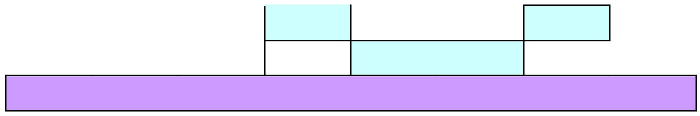
machine holds and rotates workpiece
tapes presses against workpiece
machine holds tape



process steps 1 2 3 4 5 6 7 8

1. place fixture on workpiece
2, srew nut
3, place workpiece on machine
4, tape the workpiece
5, bake out
6, Return piece to finish
7, release tape and fixture and return to rack

All objects from the system (rack, labels, nut, wrench, tape, machine, fixtures) will be eliminated if a different system can provide the same function of “press against”.

This analysis let us realise that the whole process can be described as a sequence of labour and states to arrive at the moment where the primary function will be delivered e.g. bake out. All the labour doesn’t add value to the product, it is merely done to let the work piece arrive at a state where the true added value can be achieved. This means that the former can be viewed as waste.

1.8 Finding alternatives

The end state (state 3) has the basic function to deliver “pressure”. Even the subsystem 2 (fixtures) has as a purpose to deliver pressure on the work piece in order to speed up the bake out process. Once this apparently simple conclusion is formed and the system is fully analysed, alternatives can be found.

How could we ensure that the operator doesn’t misplace the fixtures so that discipline has no impact?

Several directions of improvement can be made at this point, lets consider only three.

One direction could be to find objects within the system (and this is the place where you could have forgotten objects that could manage this function) that provide the desired function of either “lay on” or “presses”.

Another direction could be to find a rack that provides the better functioning such as sound and light picking systems for instance. If you think about automating the subsystem “rack & label” (with or without the fixture!) to bring it to a higher “degree of decreased human involvement” consider to think about a system where it doesn’t matter which piece you put into the system, it determines itself where to put it and if you require one it will always deliver the right one. Normally we are tempted to go in this direction, but don’t forget that eliminating waste or preciser maximizing functionality (provide pressure) is to look at the end state!

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Thus: another direction could be to eliminate the whole system and replace it with a system that provides the same function. One of the questions is now:" How many technological systems are there to create pressure on the work piece?"
This direction will deliver a completely new system. The general idea is to get rid of the fixtures, wrench, machines and tape.

The answer to this question is provided by TRIZ.
Looking back at the basic function other ways to result in a "X pressing against" is through mechanical such as gravity, pneumatic, hydraulic and magnetic, chemical, electric and electromagnetic fields. No other fields in the world exist today that can create pressure. Each field can be accomplished by one or more effects and technologies. An effect is the representation of a function in a certain scientific domain. A technology is a specific set of objects working together creating the system function. A technology which helps to create a pressure in our example is nut, wrench, tape, machine, fixtures.

Looking at a pneumatic field, the technology "autoclave and air pressure" can easily do the trick. In fact, this increased the productivity from 2,8 hours to 20 min with a ROI of one hour and a decrease in product cost of 10%. Clearly the old system is not needed to provide the pressure. No fixtures can be misplaced besides the autoclave of course. The autoclave replaces rack, labels, nut, wrench, tape, machine, fixtures so a lot of area will not be used any more.

1.9 Conclusion

Triz takes 5S a lean step further. Using functional analysis the degree of solutions is highly expanded. The fundamental function is replaced by another technological system which delivers the same function but not having the disadvantages of the first system. The question in lean should not be how to eliminate the wastes but how to how maximize the functionality of the production☺

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P41 realizes radical innovative improvements quickly in production tools and organization jumping 2 steps forward in design and/or production, always taking in consideration quality, safety, environment, energy, maintenance, purchase and internal transport. P41 combines TRIZ with industrial engineering.
Ives De Saeger has got an degree in physics and is civil engineer has worked as consultant for Volks Wagen Brussels, Picanol, DAF trucks, Daikin, Johnson Controls to improve processes.

1.11 Resources

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