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Development and implementation of FaRSLeSS approach at aircraft composite manufacturing industry : A case study

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Abstract. FaRSLeSS approach is integration between Lean and Six Sigma methods to reduce the failure rate in manufacturing production line. It represents 'Failure Rate Reduction and Sustainability through Lean and Six Sigma". Many manufacturing industries carry out corrective actions for their production line failure rate by using either lean or six sigma methods separately. This may prolong the failures or defects and sometimes even could not be solved effectively. FaRSLeSS approached was developed as guidance to manufacturing companies on the appropriate steps needs to be taken in order to solve the production line failure rate faster and effectively. Besides, this approach also suggests on how to sustain the performance once the failure rate was reduced to the ultimate target. During developing the FaRSLeSS approach, a case study was carried out at aircraft composite manufacturing industry (company A).

1. Introduction

The implementation of integration between lean and six sigma approaches should be properly organized in order to achieve the main objectives of any project. Six sigma methods alone are very hard to be implemented since involves data mining, analyzing and monitoring. In another words, it involves numbers. It is very difficult to get employees' commitment to involve in this type of approach. Therefore, the integration between six sigma and lean approach which involve more on how to reduce waste and how to ease the jobs and processes, expected to be accepted by the employee easier. The first main task need to be focused on by the researcher is how to create a lean and six sigma culture among the employees in the company. This culture is very important in order to ensure that all levels of employees from operator to manager level within the factory is speaking with a 'common language', which is 'lean six sigma language'. Every problems and actions taken need to be carried out with a guidance of lean and six sigma approaches, not with a traditional approach; doing daily 'fire fighting' to solve problems at the production line. The ultimate objective is to create a lean six sigma culture in the company.

2. Methodology of FaRSLeSS development, implementation and its sustainability

Figure 1 shows the process flow on the methodology to complete FaRSLeSS (Failure rate Reduction & Sustainability through Lean & Six Sigma) approach. The flow includes all the three main objectives of this study which are :

a) development and implementation of FaRSLeSS approach at company A,

b) enhancement of lean six sigma culture and
c) sustainability of the approach in the company.

For a development of FaRSLeSS, it starts with previous papers review and data collection/analysis from company A. Numbers of papers in a similar research study and scope were selected for the review purposes. The paper review process concluded that for aircraft composite panel industry, there is still lack of research done related to application of both lean and six sigma in solving the failure rate reduction at the production line, mainly in composite manufacturing production.

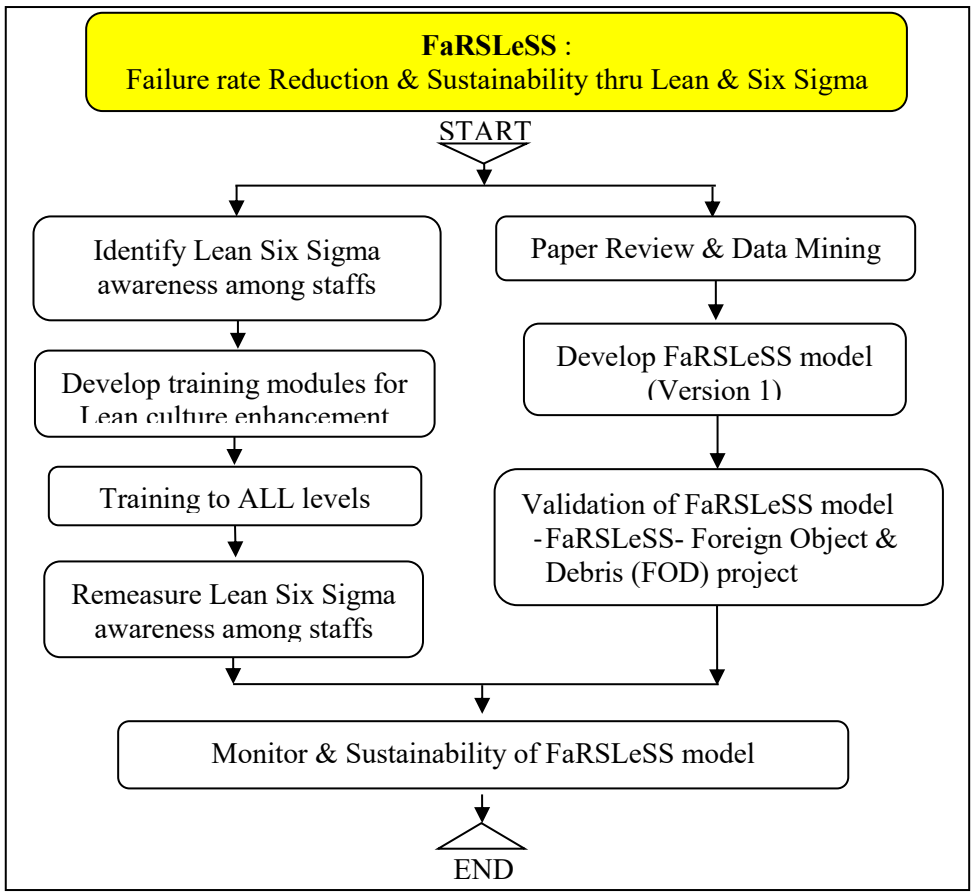

Figure 1. FaRSLeSS approach development

There is also no study so far on keeping the production yield at a desired value set by the management team for aircraft composite manufacturing. Besides that, the review also found that most of the research carried out at manufacturing production line was using either six sigma or lean tools separately. Therefore, FaRSLeSS is developed to come out with a new approach in order to consolidate both lean and six sigma tools for a better result, especially at aircraft composite panel manufacturing industry.

During the stage of FaRSLeSS approach development, data collection activities were carried out simultaneously in company A. From the overall failure rate pareto in one year as shown in figure 2, there were two most important processes in company A which contributed to 85% of the total failure items. The two processes were trimming (53.3%) and hand layup (38.2%). The most probable reason for these two processes with the highest failure rate is because of both of them mainly are manual processes by operators. Manual process will always exposed to high process variation and production waste. Therefore both trimming and lay up processes were

selected for the study since it is expected to give a bigger impact to the overall result later, in term of failure rate reduction, production pass yield and productivity, which all of them will lead to reduce parts disposal and simultaneously increase profit to company A. The FaRSLeSS approach will look into two main items; firstly on how to reduce the failure rate for both processes and secondly how to sustain the failure rate after the reduction achieved.

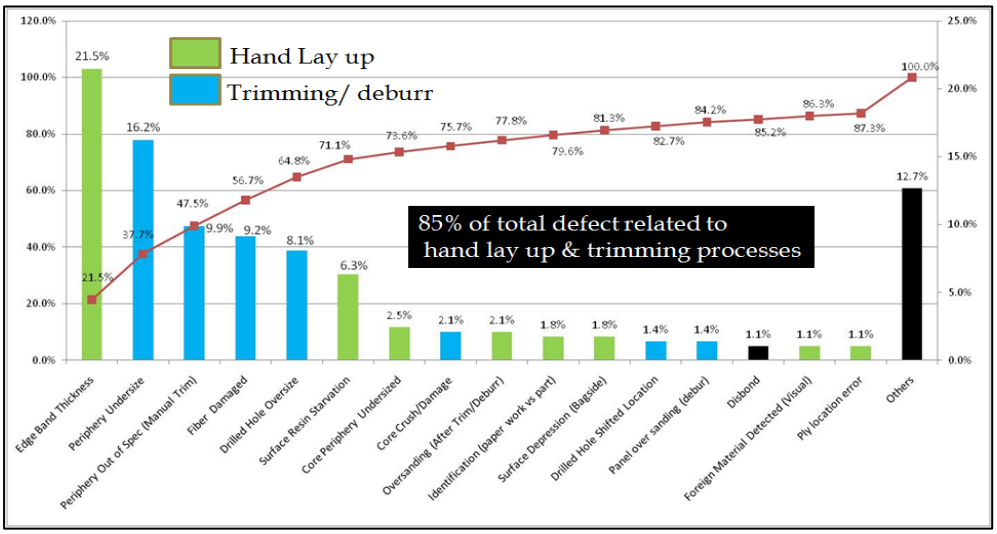

Figure 2. Overall failure rate at company A production line

3. FaRSLeSS Model

By referring to the situation above, a guided lean six sigma integrated with lean technique is required to be applied in aerospace composite panel manufacturing company. By this application, the manual process variation could be reduced statistically and unwanted production waste could be eliminated from the production line in order to give a higher productivity and quality of the product. FaRSLeSS model is then developed as shown in figure

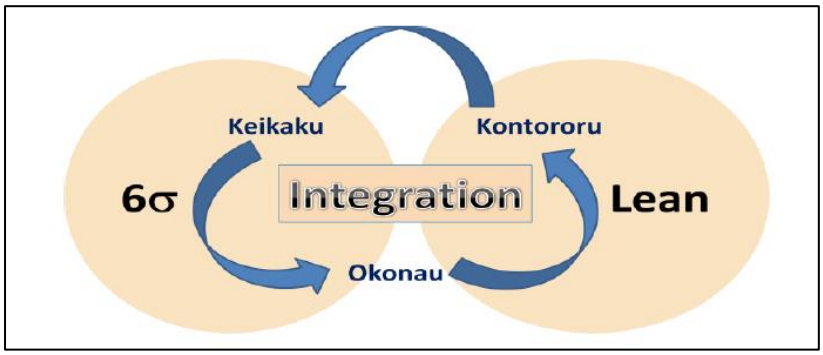

Figure 3. FaRSLeSS model

The integration between lean and six sigma approaches in FaRSLeSS model is guided by the KOK cycle which is from three Japanese words represents three main steps involved; *Keikaku* (Planning), *Okonau* (Executing) and *Kontororu* (Controlling). These three steps are in a cycle in order to complete the implementation and sustainability purposes.

3.1. Step 1 - Keikaku (Planning)

The FaRSLeSS model begins with Keikaku step. In this step, a proper plan need to be conducted by the team involves production engineers and top management. The problem needs to be identified, recognized and defined clearly and need to be transparent to the whole team members. Then, the problem statements, objectives and scopes of the problem need to be determined and written. It is a good practice if a project name to be allocated for the visibility of the project and easy monitoring. For instance in company A, one of the major issue rose in year 2014 is very high parts disposal cost. Therefore the parts disposal reduction by 50% was selected as a key performance index (KPI) to link with the lean and six sigma approaches research.

3.2. Step 2 - Okonau (Executing)

Okonau means executing the project by measuring, analyzing and improving activities. Measuring has two main purposes ; gather data to validate and quantify the problem (opportunity) and begin teasing out facts and numbers that offer clues about the causes of the problem. For example, the first year period part disposal data was gathered and monitored. From the company's parts failure by items data, overall scenario of the pareto for model X disposal parts need to be measured. After measurement completed, the data requires analyzing. One of the big challenges during analyzing data is to select right tools. When causes go deeper or when the relationship between the problem and other factors is complex and hidden, more advance statistical techniques may be required to identify and verify the cause.

Training to employees needs to be conducted in order to familiarize them with lean six sigma culture. The training could be conducted includes basic production innovation (PI), kaizen and waste (Muda) management and motion ergonomic. Then for lean, waste at production line and the overall factory need to be identified by using Value Streaming Mapping (VSM) and other related tools. As for six sigma, analysis need to be carried out for a second and third level pareto of finding a root cause for the part disposal issue. This could be achieved by using six sigma tools such as Cause and Effect diagram, Analysis of Variance (ANOVA), Failure Mode Engineering Analysis (FMEA) and Design of Experiment (DOE). The analysis step conclusion is then concluded before move to a next step. At this analysis step, the knowledge and theory about advance composite materials and its manufacturing processes need to be known and understood well by the researcher and team members. Discussion and brainstorming sessions among team members need to be carried out regularly. All the limitations such as specification by the customers need to be understood as a scope of the analysis.

A traditional method of improving and solving problem, the repairer or engineer tends to straight away try to look into a temporary solution or countermeasure without finding as actual root cause of the problem. This method also sometimes happens in company A. The disadvantage of this method is although the problem is solved, it may be repeated since the actual root cause is not solved. With systematic tools in a lean six sigma approach, the cause of a problem could be solved until the root of it. From a lean point of view, an improvement could be done on the continuous waste management practice. This includes Kaizen implementation, 5S and 3 M's (Muda, Muri, Mura) improvement. As for a six sigma view, production line processes need to be improved according to the statistical and non statistical result obtained from analysis step.

From the FaRSLeSS model developed in company A, the Okonau step could be specified more detail as in figure 4. This detail sub steps is also included in the FaRSLeSS model development for a proper sequence of lean and six sigma tools the management need to use for achieving a desired production failure rate target.

3.3. Step 3 : Kontororu (Controlling)

Control and sustain step is very important in order to make the improvement carried out in previous step could be remained. Otherwise the problem and the similar cycle of solving might be repeated again and again. Firstly, the improvement items need to be reviewed regularly. The

reasonable frequency for review process is in weekly basis, depends on the production output quantity. If the result found diverting from its lower and upper control limit, action need to be taken immediately.

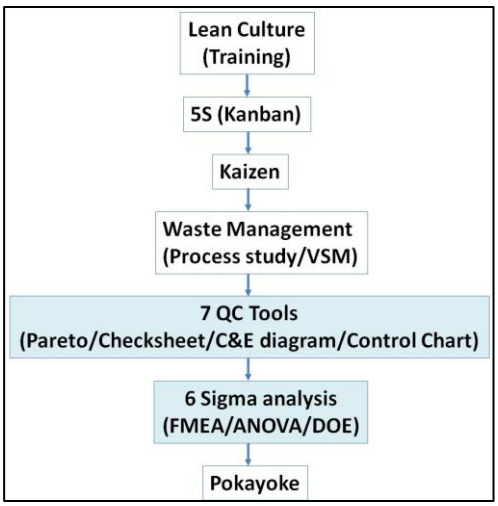

Figure 4. Okanou (executing) steps

A system standard document for process sustainability needs to be created by the team for easy monitoring. The most common lean six sigma tools to serve this purpose are Standard Operating Procedure (SOP) or Work Instruction (WI), Process Flow, Statistical Process Control Chart (SPC), continuous Kaizen activities and Continuous Quality Improvement (CQI). Specific control tasks that must be completed by the teams include developing a monitoring process to keep track of changes they have set out, creating a response plan for dealing with problems that may arise and helping focus management's attention on a few critical measures that give them current information on the outcomes of the project.

4. Conclusion

From figure 1, the FaRSLeSS model was validated at one of a project in company A which is called Foreign Object & Debris (FOD) failure reduction project. It is about foreign object contamination defects for aircraft composite panel. In year 2016, there are 28 cases of FOD failure in company A production line. The FaRSLeSS approach was implemented in early year 2017 for this FOD issue and monitored until end of the year. There is very significant reduction in the FOD failure rate after the approach implemented where only 3 cases recorded. This 90% reduction in FOD failure rate proven that the FaRSLeSS model could be accepted as a good guided approach for failure rate improvement at manufacturing production line. The continuous monitoring is carried out at company A. As a further confirmation, this approach should be validated at other manufacturing industries.

References

[1] Everton D. & Sergio E.G., 2013, *Lean, Six Sigma and Lean Six Sigma: an analysis based on operations strategy,* International Journal of Production Research

[2] Frida A., Astrid H., 2014, Design for Manufacturing of Composite Structures for Commercial Aircraft – the Development of DFM strategy at SAAB Aerostructures, CIRP Conference on Manufacturing System: **17**(2014) 362-367

[3] A. R, Chaple., S. S, Khedakar., S. R, Dharmadhikari., N. R, Chaple., 2015, *Newly Developed Automatic Lay-Up Process for Manufacturing of FRP Sheets,* International Journal Of Computational Engineering Research, **3**, pp.1