Discovering lean innovation good practices: three industrial case studies in the UK

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***Abstract*—**Although lean thinking is widespread in manufacturing, there are still only few companies implementing lean principles in the End-to-End Innovation process. This paper introduces the Lean Innovation Model as a framework to discover which lean practices innovative firms opt to adopt, and describes the findings obtained after interviewing three companies from different sectors in the UK. As it will be further described, there is not one single way or recipe to kick-off the lean journey or to develop a roadmap. Nevertheless, different practices can accelerate the development of new products, enabling teams to identify customer value, engaging them to collaborate cross-functionally, changing their mindset towards a knowledge-based and continuous improvement environment and, as a consequence, ensuring the competitiveness of the company by providing valuable products to customers while eliminating waste.

***Keywords*—** best practice, innovation, knowledge-based environment, lean product development, lean thinking, set-based concurrent engineering, visual management

I. Introduction

ALTHOUGH lean thinking has generated important benefits for several manufacturing companies, companies still urge for a new model that goes beyond lean manufacturing to allow their transformation into a lean environment which will enable them to launch new products in a more efficient way. The implementation of lean principles along the End-to-End innovation process can have a significant impact.

Innovation can be defined as the process of translating an idea or invention into a product or service which creates value in the market, for which the customer is willing to pay and which is viable for the business. Therefore, implementing lean principles along the End-to-End innovation process significantly increases market success, achieving long-lasting benefits and providing higher customer value while reducing waste. Lean innovation looks to address customer requirements in an integrated way by aligning marketing, design, product development (PD) and manufacturing teams; this results in a win-win outcome by connecting internal multifunctional teams with the final users and maximising the company return on investment and business impact [10].

The objective of this paper is twofold: 1) to introduce the Lean Innovation Model (illustrated in Fig. 1) developed by the Lean Analytics Association with its 4 building blocks and 12 enablers, as a framework to discover which lean practices companies from different sectors implement in their journey to increase the efficiency of their innovation process, and 2) to present the findings of the research conducted based on face-to-face interviews carried out with three companies in the UK, to capture and document the good lean practices implemented in their innovation process by applying the Lean Innovation Model.

This paper is structured as follows: section 2 contains a review of the relevant literature, section 3 describes the Lean Innovation Model, and section 4 introduces the Best Practices Discovery Project and a summary of three industrial cases.

II. Review of the Relevant Literature

Lean Thinking is a management philosophy which derived mainly from the Toyota Production System (TPS). It is the practice which considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination. Value is any action, process or service that a customer would be willing to pay for. The main principles of Lean Thinking are: Specify Value, Map the Value Stream, Create Flow, Establish Pull from Customer and Pursue Perfection [2].

The application of Lean Thinking in product development design is called Lean Product Development (LeanPD). It focuses on value creation, the provision of a knowledge environment, continuous improvement and a set-based concurrent engineering (SBCE) process that encourage innovation and collaboration. LeanPD provides a process model and associated tools which consider the entire product life cycle. It provides a knowledge-based user-centric design and development environment to support value creation for the customers in terms of innovation and customisation, quality, as well as sustainable and affordable products [9].

The introduction of lean practices in Process Development was a subject of study during the decade following 1995. Morgan and Liker [5] carried out a study based on the method Toyota used in Product Development. They had identified

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some of the challenges that some innovative companies faced, such as the need to launch the product to the market faster, less costly and with higher quality. One of the results of this research study was the identification of 13 management principles which enabled companies to create LeanPD processes. These principles are part of the model "Toyota lean product development system" proposed by these two authors and are grouped in three areas: skilled people, process, and tools and technology. Kennedy [6] and [4] are also considered good references used in the LeanPD literature regarding the tools, methods and mechanisms of LeanPD.

Ward et al [7] discovered that the Japanese manufacturers' approach was based on considering multiple solutions in the styling activity rather than investigating only one solution. Therefore, Ward concluded that the real success came from the Toyota Product Development System rather than their production system. Sobek et al. [8] defined this approach as follows: "Design participants practice SBCE by reasoning, developing, and communicating about sets of solutions in parallel". As the design progresses, they gradually narrow down their respective sets of solutions based on the knowledge gained. As they narrow them down, they commit to stay within those sets so that the others can rely on their communication. The principles of SBCE were described in a conceptual framework and are the following: map the design space, integrate by intersection and establish feasibility before commitment. Morgan and Liker [5] remarked that Toyota made use of trade-off curves and decision matrices to evaluate the solutions considered, but the authors did not provide a detailed SBCE process model.

Al-Ashaab et al. [9] conducted a case study at Rolls-Royce based on introducing the SBCE model to transform the current product development process into a lean environment. This study was performed in two stages: 1) integrating the principles of SBCE into an existing product development process by defining activities and tools in each of the stages, and 2) implementing the developed model in an industrial case study of a helicopter engine. This study confirms the relevance of SBCE to transforming and influencing the product development process.

In spite of all these different research studies that proposed a variety of models and tools, a current challenge companies face is understanding how to start their lean journey in a systemic way. Their transformation will require a new mindset and an integrated approach which does not only rely on a single set of tools or principles. Therefore, the Lean Innovation model is proposed as a framework to discover and diffuse different practices that innovation practitioners could consider to create and develop their own tailored roadmap aligned to their specific company culture, needs and business priorities.

III. Lean Innovation Model

Fig. 1 illustrates the Lean Innovation Model [10]. It consists of four building blocks: 1) Strategy and Performance, 2) Skilled People and Collaboration, 3) Efficient Process and Knowledge-Based Environment, and 4) Continuous Improvement and Change. Each of the blocks contains three enablers.

A. Strategy and Performance

- **Customer value:** this enabler aims to understand and identify the needs of the customer to develop new products. Some key practices to be considered could be: Lean start-up, QFD, customer journey maps, identification of people, Kano model and ethnography studies.

- **Strategy & leadership commitment:** this enabler focuses on developing and communicating a strategy across the company to enable alignment with the implementation of lean thinking. One well-known practice in this enabler, that will be explained further on, is Hoshin Kanri. Other tools are the stakeholders' map, the business model design and the value proposition definition. Top management support is indispensable for ensuring lean thinking is cascaded to all levels.

- **Track performance:** this enabler describes the importance of selecting and tracking few but relevant key performance indicators to measure the innovation process success. The creation of scorecards and Obeya rooms are two well-known approaches which are already implemented in several companies for this purpose.

B. Skilled People and Collaboration

- **Human skills**: this enabler represents the need of having well-trained, high-skilled and capable people to achieve company targets. Successful companies have developed internal lean innovation certification programs in which employees are motivated and trained to apply lean approaches to their innovation projects.

- **Chief engineer:** a chief engineer is usually a senior, very experienced employee who is responsible for leading the innovation strategy. In a lean innovation environment, the person in this role will ensure the alignment between the top management vision and the innovation teams, guiding and coaching them towards the goals and ensuring targets are met; teams will have the right tools and are trained accordingly. This person has strong technical skills and business knowledge.

- **Cross-functional collaboration:** cross-functional collaboration is needed to align the different departments during the project. To ensure this, cross-functional teams will be created from the early stages and will communicate the progress periodically using visual communication techniques which will enable them to be engaged and learn from each other from idea to launch.

C. EFFICIENT PROCESS AND KNOWLEDGE-BASED ENVIRONMENT

- **Sustainable innovation process:** this enabler consists in ensuring teams are aware of the internal development process, clarifying expected deliverables and business rules. Besides the economic returns, teams will be challenged to develop new products while also considering the economic and social impact. Some typical tools are Stage Gate and Value Stream Mapping.

- **Lean thinking tools & methods:** Lean thinking tools and methods are necessary to allow designers to work in an efficient and innovative manner. In this case, most companies have internally defined their toolkits, which might include: Set-Based Concurrent Engineering, Design Thinking, Value Stream Mapping, A3 Thinking, 5 Why's, FMEA, De Bono Lateral Thinking, TRIZ, Trade-off curves, etc.

- **Co-create, share and reuse knowledge:** knowledge management allows companies to avoid repetitive actions, confusion or misunderstandings between departments. The key challenge is to identify how to codify knowledge to ensure others can reuse it. Knowledge that is not reused, could be considered the biggest waste.

D. CONTINUOUS IMPROVEMENT AND CHANGE

- **Continuous improvement system**: continuous improvement is necessary to get employees involved to continue improving and thinking outside the box. In other words, teams will always think of how to do things differently for the better.

- **Internal and external partnerships:** this enabler refers to the creation of networks of experts that can accelerate the innovation process by bringing their expertise to solve challenges faster. This is widely referred to as Open Innovation.

- **Communicate, manage and reward change:** communicating, managing and rewarding change is essential to sustain and grow the vision and future of a company. Employees are strongly motivated when their efforts are recognised by their leaders and quick hits or positive project results are shared and celebrated.

IV. BEST PRACTICES DISCOVERY PROJECT

In 2015, the Lean Analytics Association (LAA) and the Ecole Polytechnique Fédérale de Lausanne (EPFL) in Switzerland launched the global Best Practices Discovery Project which runs on a yearly basis and aims to discover, document and diffuse lean practices companies have been implementing in their innovation process.

In 2017, six companies joined the project, three of which are based in the UK. Companies that participate in this project have been officially implementing different lean practices to their innovation projects for several years; therefore, they have experienced the improvements and impact. Their interest to join is based on a desire to document and share their implemented practices and network with other practitioners, aiming to also learn and exchange the lessons learned which will further inspire them in their journey. The following subsections introduce a brief description of the lean practices identified under the different enablers of the Lean Innovation Model.

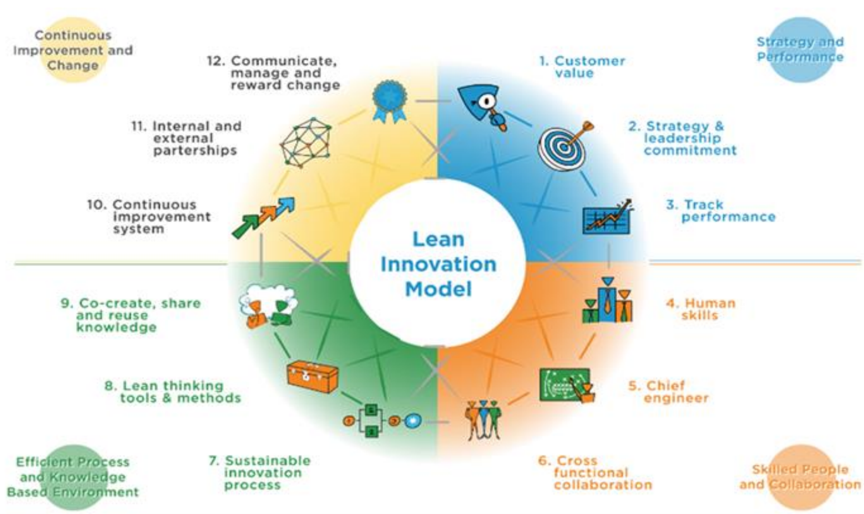

Figure 1. Lean Innovation Model [10]

SERVOMEX CASE STUDY

Servomex (www.servomex.com) is an internationally recognised manufacturer of gas analysers and gas analysis systems, providing gas measurement solutions to industries worldwide.

The Servomex UK Technical and Service Centre has been implementing lean thinking principles across the organisation since 2014, with the introduction of the Servomex Business System (SBS). A lean journey was kicked off to improve operational efficiency and empower the workforce to make a positive change. In 2016, as part of the ongoing SBS journey, lean PD methodologies were introduced to help reduce the time to market, improve the value and quality for customers and continue to develop the engineering team.

Servomex PD practices were identified and structured according to the four building blocks of the Lean Innovation Model shown in Fig. 1.

1. STRATEGY AND PERFORMANCE

One of the strategic elements of Servomex's journey was the definition of four key strategic principles, namely: 1) Develop the right thing, 2) Design what you need, not more, 3) Do not re-invent the wheel and 4) De-risk early. In addition, a Hoshin Kanri [11] practice was introduced to align all business activities with the company goals.

Another strategic in-house developed tool is the Servomex ship, illustrated in Fig. 2, which was introduced to represent the As-Is state of the company as well as the To-Be state towards which the company is moving. This tool was created by the top management team which collected information from directors and managers to represent the As-Is state. The Servomex ships also highlight the current PD and operational challenges they are facing. An As-Is state example is provided in Fig. 2, where the ship is divided into compartments which represent the different departments of the company. Each compartment contains their KPIs, improvement activities and current challenges and issues. The ship also illustrates the set target to achieve.

Another good practice was the introduction of an Obeya room. The Obeya room [14] was introduced as a beneficial practice to align cross-functional teams, track progress and decide on future steps while removing the waste of excessive meetings and emails. An Obeya room, illustrated in Fig. 3, is a visual innovation room where the walls are lined up with boards, charts or graphs depicting projects, progress to-date or deliverables. Participants of the Obeya room are cross-functional teams such as managers, team leaders, designers or manufacturing engineers who meet frequently in the room to review and make decisions on the ongoing activities of the company.

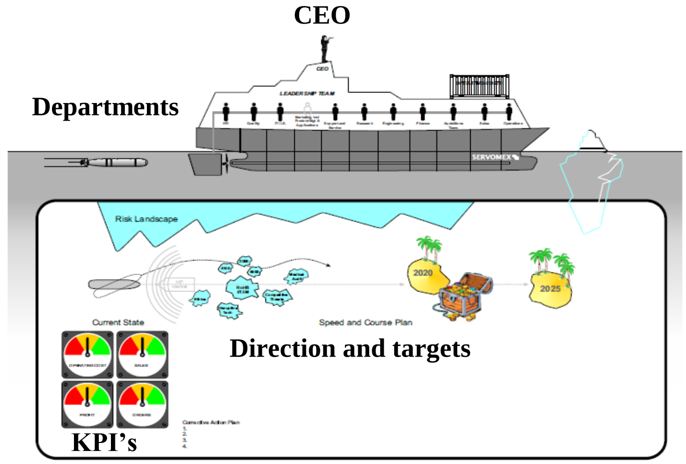

Figure 2. Servomex ship: A representation of the As-Is situation in the company

Figure 3. A representation of the Obeya room

Servomex also introduced the definition of KPIs related to the quality, delivery, cost and people productivities in order to measure the engineering department's performance.

2. SKILLED PEOPLE AND COLLABORATION

Servomex identified human skills as one of the fundamental assets to transform their product development process. For that reason, coaching sessions are carried out by the engineering director to develop the team leaders in all aspects of running a department. In addition, coaching sessions on front-end knowledge are carried out with engineers, as it is considered a key component of making PD work. Servomex also invests part of the time to align cross-functional teams with the ongoing projects by carrying out workshops, sessions and frequent meetings in the Obeya room or simply watching some of the visual management tools.

3. EFFICIENT PRODUCT DEVELOPMENT PROCESS AND KNOWLEDGE-BASED ENVIRONMENT

3.1 Front-End product development practice

Aligned to the goal of strengthening the exploration phase, Servomex introduced the Production Preparation Process (3P) to look at manufacturing processes at a very early stage and gain valuable information in a short period of time. A key advantage of the 3P is the possibility to make changes at zero cost. The 3P involves cross-functional teams, such as designers, manufacturing engineers, production engineers and, sometimes, key suppliers, who carry out one workshop which results in two different boards.

The first board illustrated in Fig. 4 maps the proposed production build and test process based on a provided sketch. Each step is evaluated against the list shown in Fig. 4B. This provides the focal improvement areas for the further brainstorming activity.

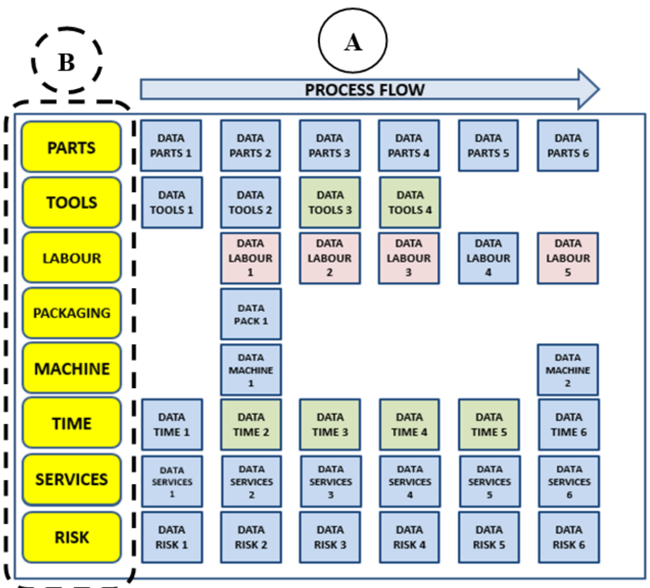

Figure 4. 3P (Production Preparation Process): illustration of the first board as it results from the workshop

The second board illustrated in Fig. 5 maps the key issues to consider in the specific activities relating to a product under development, as shown in Fig. 5A. For example, the risk in fitting the component the wrong way around. The workshop uses the second board to brainstorm on a future state that could help Servomex solve the potential issues identified in the selected process. This is done by applying the *7 how's* (shown in Fig. 5B) to come up with different ideas. In each *how*, engineers consider the risk, time and tools, as illustrated in Fig. 5C. At this point, if possible, a mock-up prototype for rapid evaluation is made for each of the *7 how's*, as illustrated for the first and fifth *how*. To evaluate the ideas proposed, engineers make use of an Impact Matrix (shown in Fig. 5D) to determine an optimum solution (high benefit/low effort), by considering merging ideas and having "easy wins" to improve the product design, process design, tool design and production method.

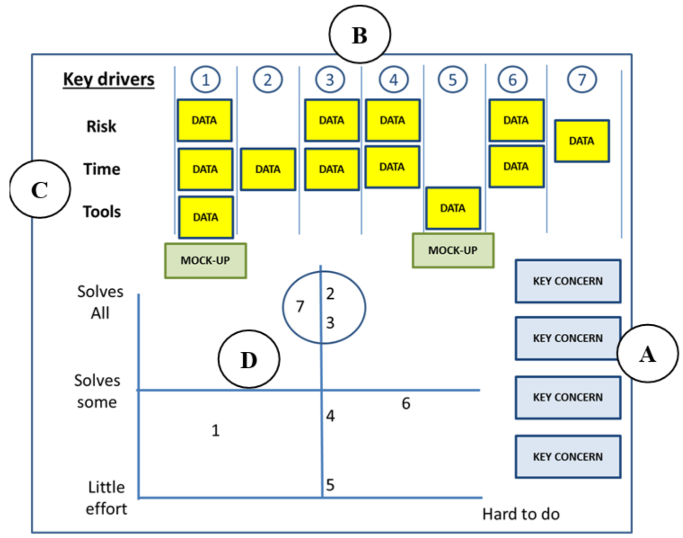

Figure 5. 3P (Production Preparation Process): illustration of the second board as it results from the workshop

3.2 Product development process practice

Another tool established within the Engineering Department is the Engineering Change Board illustrated in Fig. 6.

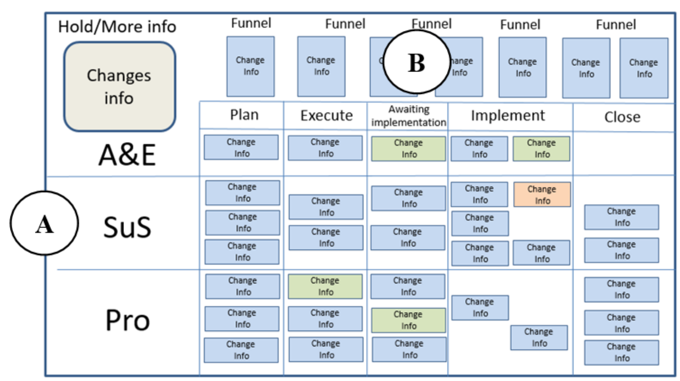

Figure 6. Engineering Change Board: a visual board for changes requested and/or implemented

This visual board is used within the change cell to help the cross-functional team manage change. The cross-functional team includes designers, engineers, operators, purchasers, compliance officers and product managers. Engineering change requests can be triggered by anyone in the company. The change cell reviews the request and approves or rejects it based on defined criteria. Once a request is approved, it is placed on the board in the form of a card. The PD team classifies each change request into one of the three categories illustrated in Fig. 6A: 1) Accident and Emergency (A&E), 2)

Sustainable (Sus) or 3) Project (Pro) to start a 5-step implementation process as shown in Fig. 6B: 1) Plan, 2) Execute, 3) Awaiting, 4) Implement and 5) Close.

3.3 Horizontal Development practice

In 2017, Servomex introduced the Lego pieces approach based on Technology Re-use which is one of the principles of the company. This practice aims to identify and outline solutions from their 12 sister companies from the same group in order to accelerate the time to market, reduce the risk associated to designing from scratch, and allowing the engineers to focus on value adding engineering.

3.4 Knowledge-Based Environment

Servomex took the two following new initiatives in order to start creating a knowledge-based environment to support product development. These are the K3 briefs based on a standard template, and the Knowledge Capture Process.

3.4.1 K3 brief

In 2017, the K3 brief in the form of a standard template was created to capture significant information from technologies or products, as illustrated in Fig. 7. This K3 template reflects the following: Fig. 7A) the primary and essential secondary functions, Fig. 7B) how they are critical to its functions and the range of criticality, and Fig. 7C) a brief overview of the product or technology pointing out its main features. K3 briefs have been considered a key practice in identifying knowledge Servomex has not considered before, in getting the right knowledge and in knowing what could affect the main functions of some of their technologies or products.

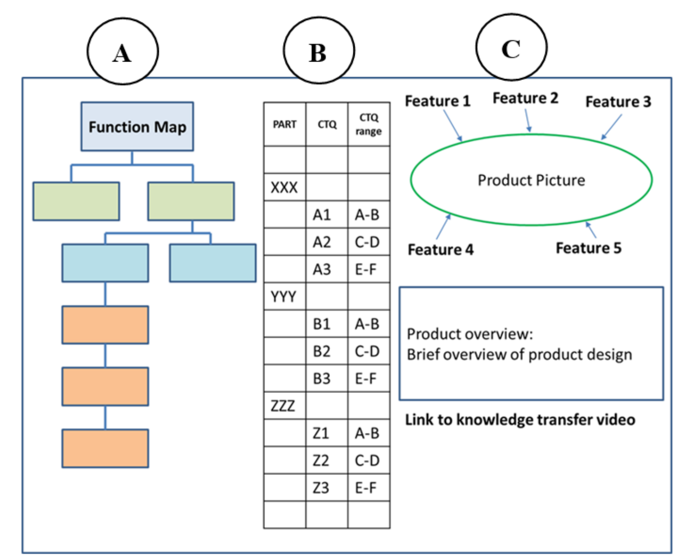

Figure 7. K3 Briefs: template to capture significant knowledge from products, technologies and measurements

3.4.2 Knowledge Capture Process

In parallel to the K3 briefs, Servomex has developed a Knowledge Capture Process in the form of a template in order to explore and capture the knowledge required to develop the different products or product parts proposed, as illustrated in Fig. 8. This tool is used to: Fig. 8A) develop an initial concept or idea, Fig. 8B) identify its risks, Fig. 8C) gain the knowledge required to eliminate these risks, Fig. 8D) carry out rapid activity actions to get that knowledge required, and Fig. 8E) finally obtain significant results from the actions.

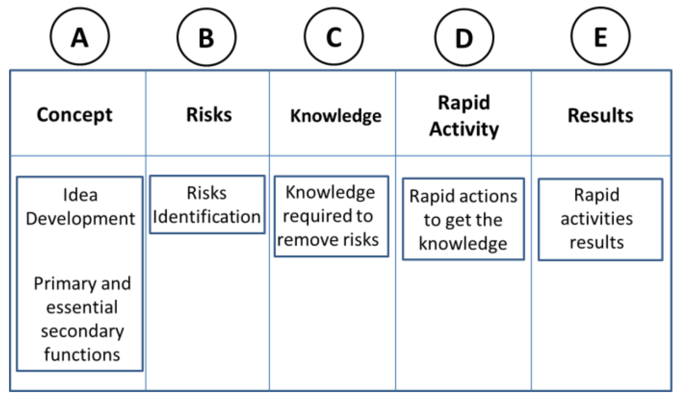

Figure 8. Knowledge Capture Process: template to capture rapid knowledge to develop products or parts

4. CONTINUOUS IMPROVEMENT AND CHANGE

Servomex's parent company, Spectris, created a Continuous Improvement Plan which is based on engaging with 12 other companies to share their corresponding best practices, together with participating in European projects (LeanPPD) and visiting companies regularly.

Also, as part of the Servomex lean journey, 400 to 500 before and after improvements per year were achieved by empowering employees to adopt and use lean tools.

CALTEC CASE STUDY

Caltec Ltd. (www.caltec.com) is a company built on the oil and energy industry, offering a wide range of solutions to extend the life of oil and gas assets. One of their products is the Surface Jet Pump (SJP) shown in Fig. 9, a device used to enhance the productivity of oil or gas extraction in oil and gas wells, by using the energy from a high-pressure fluid/gas to boost the pressure of a low pressure fluid/gas to an intermediate level.

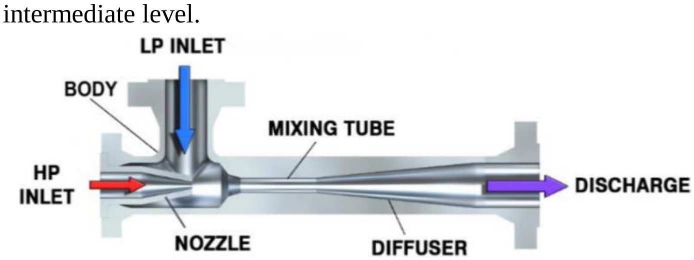

Figure 9. Cross section view of the Surface Jet Pump (SJP)

The SJP device was used in certain Research & Development (R&D) projects [12] with the help of the LeanPD Research Group at Cranfield University in order to enhance the design performance and reduce the manufacturing cost, by using the SBCE process model shown in Fig. 10.

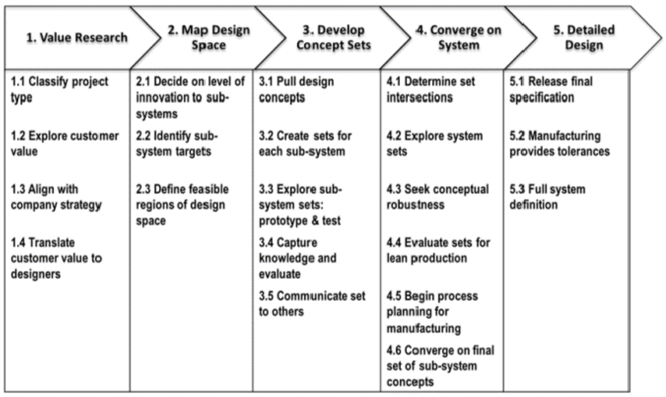

Figure 10. The SBCE process model [13] [9]

The case study of LeanPD practices at Caltec is related to the "Efficient Process and Knowledge-Based Environment" block of the Lean Innovation Model, shown in Fig. 1. This paper briefly describes the application of the SBCE process model to the SJP, and discusses its benefits for Caltec. The following paragraphs present the selected activities of SBCE shown in Fig. 10 that were used in this case study.

1. VALUE RESEARCH

1.2 Explore customer value: 38 customer values were identified and classified into groups in order to be analysed. Through an Analytical Hierarchy Process (AHP), key value attributes (KVA) and values of consideration were selected. Finally, system targets were described in order to achieve the KVAs defined.

2. MAP THE DESIGN SPACE

2.1 Decide on the level of innovation to the subsystem: The SJP was divided into subsystems, as shown in Fig. 11. For each of the subsystems, one of the following levels of innovation was assigned: 1) No changes, 2) Low level, 3) Medium level, 4) High level and 5) R&D.

2.2 Identify subsystem target: feasible subsystem targets were determined in order to reduce over-engineering as well as to enhance the development of innovation.

2.3 Define the feasible region of design space: this activity consisted in defining the design space, which contains the boundaries for designers and engineers when exploring and communicating the different conceptual solutions.

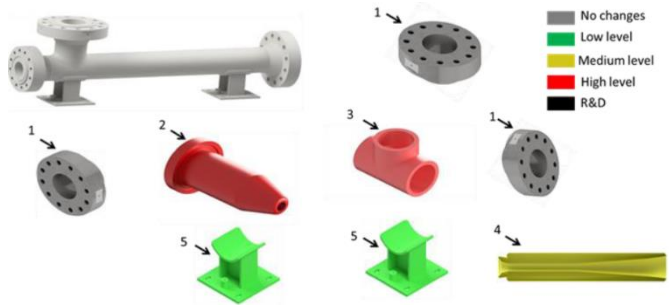

Figure 11. Level of innovation of the SJP subsystems

3. DEVELOP CONCEPT SETS

3.2 Create sets for each subsystem: design solutions for each subsystem were developed considering the subsystem targets defined in activity 2.2 and the boundaries set in activity 2.3. As a result, 60 system solutions could be generated, as illustrated in Fig. 12.

3.3 Explore subsystem sets: prototype & test: conceptual solutions were evaluated by simulating their impact in the performance of the SJP. This was achieved by using a specific software. Based on the simulation, Trade-off Curves (ToC) were used to narrow down the solutions in each subsystem, reducing the possible configurations from 60 to 18.

4. CONVERGE ON SYSTEMS

4.1 Determine the sets' intersection: in this activity, the final designs of the SJP system were generated. In order to reduce the 18 potential configurations, a simulation analysis and ToC were used to discard those configurations that did not increase the SJP's design performance. As a result, potential system solutions were narrowed down from 18 to 3.

4.6 Converge on system's final set: a final narrowing down process was carried out in order to obtain the final optimum SJP design. Through brainstorming sessions, subsystem sets of solutions were marked in relation to the KVA and ToC to finally come up with an optimal configuration, which was the one with the highest score.

5. DETAILED DESIGN

5.1 Release final specification: the optimum design of the SJP was presented in a form of a drawing which contained the final specifications and dimensions, as illustrated in Fig. 13.

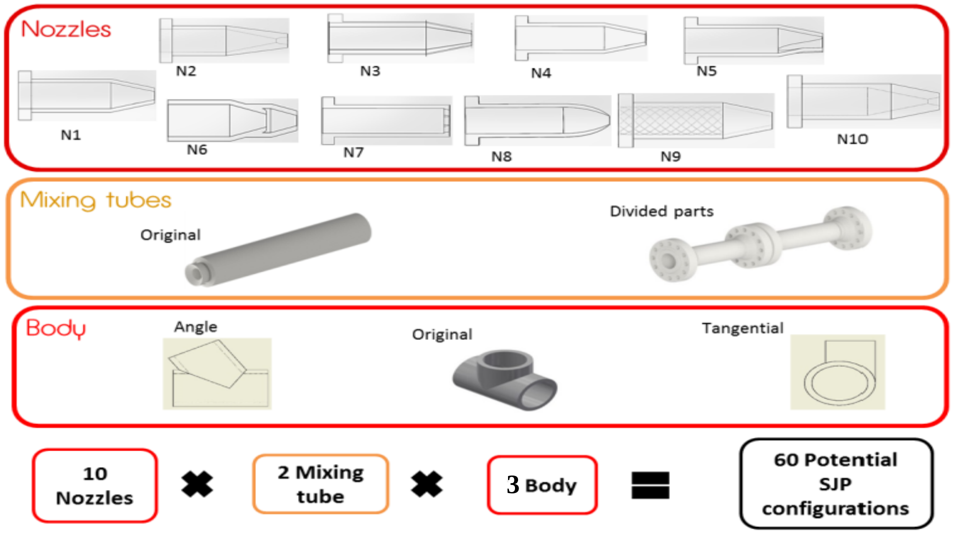

Figure 12. Possible conceptual design solutions for each subsystem

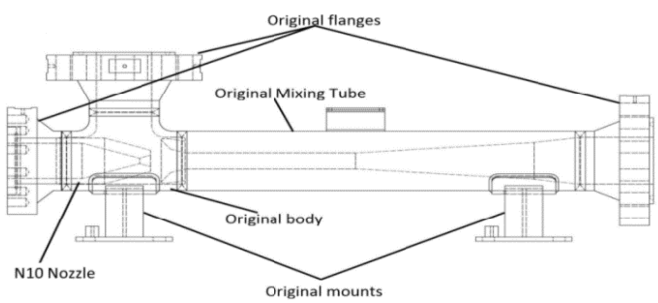

Figure 13. Engineering drawing of the optimal SJP system (without dimensions for confidentiality purposes)

The application of the SBCE process model on the SJP has enhanced Caltec's product development process by increasing the innovation and knowledge creation level. SBCE has enabled the exploration of multiple alternatives, by considering key factors such as the manufacturability, cost or design performance.

The benefits of applying SBCE to the SJP were the improvement of the gas compressor suction pressure by 59%, a reduction of the low pressure by 39%, giving an advantage for the SJP to revive the dead oil well, and an increase of the high-pressure/low-pressure (HP/LP) ratio, improving the boosting performance of the SJP. Also, by applying the SBCE approach, the success rate increased from 33% to 96% and the risk of having a design failure decreased from 20% to 0.8%, based on probability tests.

METSEC CASE STUDY

Voestalpine Metsec plc (www.metsec.com) is the UK's largest specialist cold roll-forming company, providing products for the construction and manufacturing industries.

The case study of LeanPD practices at Metsec is related to the "Efficient Process and Knowledge-Based Environment" block of the Lean Innovation Model. This paper describes Metsec's journey towards the need to create a knowledge-based Product Development Process.

Metsec's product development process was represented using Integration Definition for Function Modelling (IDEF0) in order to illustrate product value and non-value-adding activities, as shown in Fig. 14. This is a consequence of the need to formalise and structure the product development process in order to make decisions based on proven knowledge and experience.

The IDEF0 activity together with some face-to-face interviews with engineers helped identify the following types of waste within the product development process:

- No formal NPD procedures or documentation
- Key Performance Indicators do not measure process outputs, cost, schedule adherence and first time right.
- Poor communication resulting in delays and capacity issues.
- Little to no involvement of suppliers or production.
- Sales and Engineering own agendas have no common goals/objectives.
- High levels of multitasking and personnel turnover.
- Existing product data hard to find/retrieve.
- No feedback mechanism from production/Quality identifying problems associated with the product/process.

As a result of the above types of waste, Metsec identified the following actions:

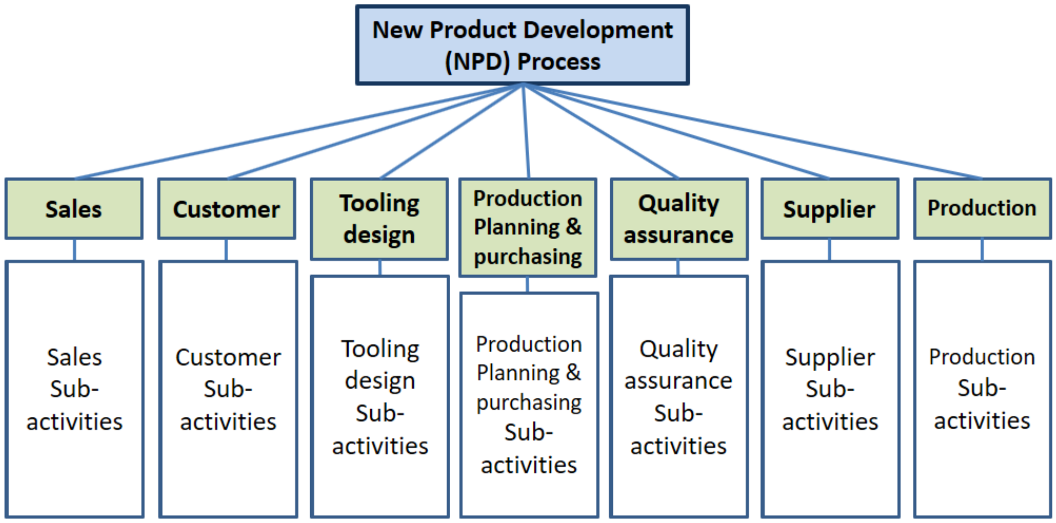

Figure 14. Top level key Product Development activities and sub-activities for each department

- The organisation needs to formalise its product development process, by capturing and defining only value-adding activities,
- and those activities need to be supported by proven engineering knowledge and experience, which needs to be identified, captured, formalised and presented in a way that will allow its utilisation in future product development programs.

In order to provide knowledge to support the product development process, a requirement to capture the knowledge from the manufacturing processes within the organisation was identified. This knowledge was considered to consist in the 4 following activities:

i) Identification: The identification of knowledge required to develop new products, including product specifications, processes, tooling, and material capabilities.

ii) Capture: how the knowledge is captured stored and retrieved.

iii) Formalise and Present: how knowledge can be formalised and presented to ensure its use in existing and future projects.

iv) Utilisation: how the knowledge identified, captured and formalised can be integrated into products and decisions, and applied to other projects.

Metsec identified that the design process was based on the engineers' own experiences and understandings, and was not supported by specific knowledge related to processes, materials, resources, design rules, capacity and other constraints. Fig. 15 illustrates the product/tooling cost for three product development strategies used by Metsec, where the cost is lower when reusing existing products, tooling and knowledge.

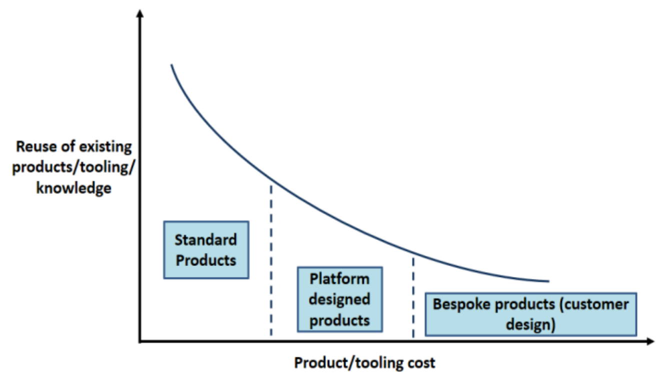

Figure 15. Product/tooling cost analysis for the three product development strategies used by Metsec

A case study [15] was conducted to create a knowledge environment to support the decisions throughout the product development process of three different cold roll profiles. The case study pointed out the use of knowledge, such as the suitability of the material used or profiles' physical size, to evaluate the manufacturability of the profiles and their cost in order to finally meet the requirements of the customer. Together with the knowledge, discussions were held within Metsec and further studies on structural properties were carried out. Metsec achieved the standardisation of the profiles, thus reducing the tooling cost and the lead time for delivery.

V. Conclusion

It is very important to share lean practices between companies. However, this could be challenging without a well-structured approach to follow. Therefore, the Lean Innovation

Model has proved to be a useful framework to discover and share good practices to inspire innovation practitioners to start their lean journey. This is because the model addressed the elements of Strategy and Performance, Skilled People and Collaboration, Efficient Process and Knowledge-Based Environment, and Continuous Improvement and Change. These elements are a good representation of lean principles. This paper presents three companies in the UK which adopt different points of view with respect to lean PD. Servomex has been implementing a range of practices aiming to establish a front-loading PD approach. This is supported by the knowledge environment via the application of K3 briefs and a Knowledge Capture Process where the focus is only on their key competence of gas measurement. Caltec made good progress in implementing SBCE in their R&D project to enhance the design efficiency and reduce the manufacturing cost. Metsec has been working towards establishing a standardised PD process and, at the same time, emphasising the importance of capturing and re-using design and tooling knowledge.

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