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# The Set-based Concurrent Engineering application: a process of identifying the potential benefits in the Surface Jet Pump case study

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**Abstract**

The Set-Based Concurrent Engineering (SBCE) is the methodology that can improve the efficiencies and effectiveness of product development. It is found that the SBCE approach provided a suitable knowledge environment to support decision making throughout the development process. This paper presents the potential tangible benefits gained from the application of the SBCE in an industrial case study of a Surface Jet Pump (SJP) that is used to revive the production of oil/gas from the dead wells. The well-structured SBCE process model and the process of identifying the potential benefits proposed in this paper will clarify the gap in the development of the SBCE in the company. The potential tangible benefits are established in a few key areas such as product innovation, product performance, manufacturing cost, and project success rate.


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*Keywords:* lean product development; set-based concurrent engineering; trade-off curves; creating knowledge; visual knowledge; oil and gas production; surface jet pump.

## 1. Introduction

Product development is important for company growth and success in business profitability. It is also used in the introduction of a variety of models, and most importantly. to keep the cost low. The demand for a quality, reliable product at an affordable price has put pressure on manufacturing companies to make a product that meets these criteria. It is impossible to make a transformation in product development without deliberating the current product development challenges [1] [2], which could be addressed by adopting Lean Product Development (LeanPD) and Set-based Concurrent Engineering (SBCE), for instance, in design rework, knowledge provision, and lack of innovation [3]. SBCE is a core enabler as it represents the method that guide the process of developing a product [4] [5], however, its constructive measure in real industrial applications is still ambiguous [6]. Thus, this paper aims to identify the potential benefits gained from the application of the details of SBCE process model in the SJP case study. The papers are structured into four sections, namely an introduction, a review of the SBCE related literature, SBCE case study, and SBCE potential benefits.

## 2. A review of the SBCE related literature

The literature emphasises on the importance of having SBCE in product development applications [3] [8] [9] [10]. This is because SBCE represents the definition of the process to be followed in order to develop a product. Toyota is famous for its production system, but it is commonly presumed that this is not the only factor of the success, because Toyota Product Development System


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(TPDS) is also playing an important role in this achievement [11]. Ward et al. [12] proved that the real success of Japanese manufacturers' is not derived from their production system, but from the TPDS. Later on, [10] shown a detailed description of the 13 principles that shaped the Toyota Product Development system. They provided a conceptual model called Lean Product Development System, which is divided into three subsystems: Process, Skilled People, Tools and Technology which entails of 13 principles.

SBCE is considered as the core enabler in Lean Product Development as it represents the process that guides the development of a product in a lean environment [16]. SBCE works on entirely different principles than point-based advance. A point-based design approach is the traditional PD practice where it only considers one best solution and later it is iteratively modified till it meets the acceptable result. The SBCE approach considers it desirable to develop various sets of solutions in parallel rather than working with one idea at a time. SBCE means; design participants practice SBCE by reasoning, developing, and communicating about a set of solutions in parallel. As the design progressed, they gradually narrow their respective set of solutions, based on the knowledge gained. As they narrow, they commit to staying within the sets so the others can rely on their communication [11].

Khan et al. [14] created the SBCE baseline model, consisting of five phases which are, 1) Define value, 2) Map design space, 3) Develop concept sets, 4) Converge on system, and 5) Detailed design, as illustrated in Figure 1. In addition, [14] and [7] described the SBCE in a step-by-step process in the SBCE process model. This is to ensure the implementation is followed correctly at the first time, as illustrated in Figure 2.

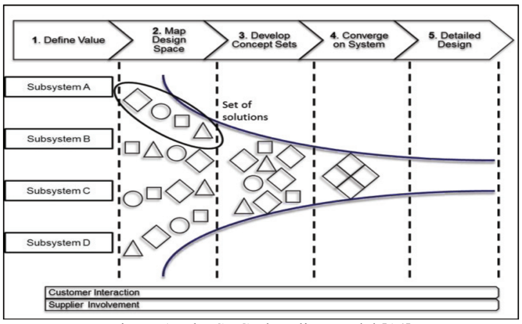


Figure 1: The SBCE baseline model [14]

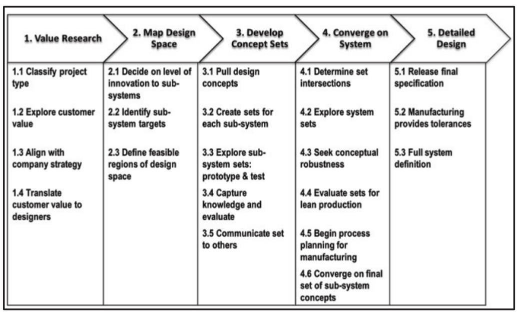


Figure 2: The SBCE process model [7] [14]

A limited number of SBCE case studies have been carried out in order to identify its potential and benefits to the industries [7] [15] [16]. However, there are no details of step-by-step application of the SBCE process model identifying the tangible benefits in the case studies where this paper will clarify the gap.

## 2. Industrial case study of a Surface Jet Pump (SJP)

The SBCE process model was implemented during the case study of SJP in collaboration with Caltec Ltd. The SJP as shown in Figure 3, is a device used to enhance 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 from the wells. The following paragraphs present the selected activities of SBCE from Figure 2 that have been used in the case study.

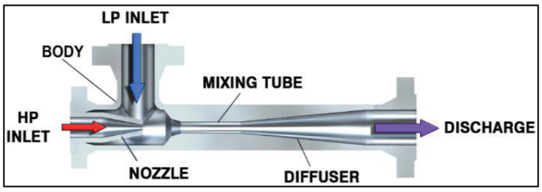


Figure 3: Cross-section view of SJP courtesy from Caltec Ltd.

**Phase 1: Define Value**

The initial concept of the SJP is defined in the Define Value stage, which has the subsequent SBCE activity.

**1.2 Explore customer value**

Customer needs must be clearly understood in order to identify the system targets, which focuses on the improvement of the SJP design performance. At first, Identified 38 values are listed and then the values are classified into a singular value which is cost, customization, design performance, manufacturability, reliability, durability, and installation as shows in Figure 4 section A.

Through the Analytical Hierarchy Process (AHP), values that have been classified as high importance were analysed [17], This led to define the key value attributes (KVA) as shown in Figure 4 section B where the 3 highest percentage were selected, these are; 1) Design Performance, 2) Manufacturability, 3) Cost and 4) Durability. In addition, cost was classified as KVA due to company's preference choice which has the major impact in the creation of this order. The values which remain (durability, reliability, customization, and installation) were assigned as values of consideration. The loads for the KVA in Figure 4 section B are calculated respectively by AHP value in Figure 4 section A. The result of the KVA are; 1) Design Performance; 38.5%, 2) Manufacturabilty; 37.5%, and 3) Cost; 24.0%