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DESIGN INNOVATION, MODELLING AND SIMULATION: SUSTAINABILITY OF ANALYSIS OF BENCH REACTOR FOR KINECTIC STUDY OF HYDRO CARBON REMOVAL USING LAND FARMING

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Abstract

Design as a tool for innovation has developed rapidly in recent years, resulting notably in concepts such as strategic design, design management and design thinking. Innovation policy and support, as well as education systems, have not yet caught up with these developments. Design thus contributes to creating unique competitive advantages that help the move away from pure price competition, not least through the creation and strengthening of identities and brands. "Engineering without labs [and design] is a different discipline.We agree with this modified quotation that design and laboratory sessions are at the heart of an engineering education. One of the preferred methods for the remediation of fuel contaminated soil today is land farming. This is particularly true for remote sites because the method required minimal equipment and is therefore by far the lowest cost option. The term land farming generally refers to the process whereby hydrocarbon contaminated soil are spread out in a layer about half a meter thick, nutrients are added periodically and the soils may be mixed. During land farming, hydro carbons can be lost through volatilization or bioremediation and thus land farming refers to the combination of the two processes. The purpose of the bench reactor is to determine certain coefficients or efficiencies needed for the design The scope of this research are to design, model ,simulate: optimize and the sustain analysis of bench reactor. Designers make decisions on the use of resources, modes of consumption and the lifecycles of products and services. Environmentally sustainable design (also referred to as 'green design' or 'eco-design') aims to ensure that products, services and systems are produced and provided in a way that reduces the use of non-renewable resources and minimizes environmental impact

Keywords Design Innovation Design Process, Optimization, Sustainability Analysis and Land farming

Introduction

Good design is an increasingly important means for businesses to hold their own in international competition. Design has the power to make products and services more attractive to customers and users, so they are able to sell at a higher price by being differentiated from the competition by virtue of new properties, values and characteristics. **Design** is the creation of a plan or convention for the construction of an object, system or measurable human interaction (as in architectural blueprints, engineering drawings, business processes, circuit diagrams, and sewing patterns) Design has different connotations in different fields. In some cases, the direct construction of an object (as in pottery, engineering, management, coding, and graphic design) is also considered to be design.

The term land farming refers to the process where mixed hydrocarbon contaminated soil are spread out in a layer of 0.3-1.0m thick, nutrients are added and the soils are mixed/tilled periodically. During the process of land farming, the total petroleum hydrocarbons, may be lost through volatilization or biodegradation. Land farming refers to the combination of two processes. Treatment regimes, for land farms vary with climate, location, and temperature and soil type. Enhanced bioremediation of contaminated soil typically involves the addition of nutrients and water, and periodic tilling to mix and aerate the soil (Mccarthy et al, 2004

Ex situ studies of land farming have focused on nutrients (Ferguson et al,2003;braddock et al,1997)bio augmentation (Mohn and Stewart,2000,Van Veen et al,1997) Cold adapted organisms (kunihihiro et al,2005;Mikan et al,2002, Oxygen depletion(Zytner et al ,2001) and water content (ferguson et al,1997)but the extrapolation to field studies is often difficult (Zytner et al,2001), In this study, laboratory reactors were designed to model the trial land farm established at Resolution island and to investigate the effect of temperature on volatilization and bioremediation

Innovation is defined simply as a "new idea, device, or method". However, innovation is often also viewed as the application of better solutions that meet new requirements, unarticulated needs, or existing market needs. This is accomplished through more-effective products, processes, services, technologies, or business models that are readily available to markets, governments and society. The term "innovation" can be defined as something original and more effective and, as a consequence, new, that "breaks into" the market or society. It is related to, but not the same as, invention.

In ecology, **sustainability** (from sustain and ability) is the property of biological systems to remain diverse and productive indefinitely. Long-lived and healthy wetlands and forests are examples of sustainable biological systems. In more general terms, sustainability is the endurance of systems and processes. The organizing principle for sustainability is sustainable development, which includes the four interconnected domains: ecology, economics, politics and culture. Sustainability science is the study of sustainable development and environmental science. Sustainability can also be defined as a socio-ecological process characterized by the pursuit of a common ideal. An ideal is by definition unattainable in a given time/space but endlessly approachable and it is this endless pursuit that forms a sustainable system in the process (ibid). Healthy ecosystems and environments are necessary to the survival of humans and other organisms. Ways of reducing negative human impact are environmentally-friendly chemical engineering, environmental resources management and environmental protection. Information is gained from green chemistry, earth science, environmental science and conservation biology. Ecological economics studies the fields of academic research that aim to address human economies and natural ecosystems

Simulation methods of analysis, supported by increasingly powerful and user-friendly software tools, are gaining greater acceptance as an indispensable aid to business managers, engineers, and analysts seeking productivity improvements. Simulation modeling and analysis, along the specialized province of mathematicians and computer science specialists, has entered the mainstream of methods available to help organizations (whether business, governmental, educational, or military) increase their efficiency and effectiveness. The proved abilities of simulation to attack a wide range of problems and investigations rest on its abilities to accommodate stochastic variation, analyze discrete or continuous variables, or both, and provide visualization via animation. Humans have always strived to do things efficiently. Throughout history, tools and implements were developed to perform tasks that were designed to complement human physical strength. The invention of the wheel is probably the most revolutionizing optimization tool developed by humans. In today’s complex business and industrial environments, the solution of operational problems cannot be achieved by technological advances alone. The multitude of options available for implementing an operational plan has mandated the development of systematic procedures for selecting the options that best benefit the organization as a whole. The optimization models of operations research are designed to solve such complex problems. An optimization system may be regarded generally as a resource allocation problem in which limited resources are assigned to activities in a manner that will produce the best value for a selected measure of performance. Such a measure of performance may typically involve minimization of cost or maximization of profit. A simple example of an optimization system involves the determination of the level of production of a number of products that compete for limited raw materials, with the objective of maximizing the total profit for all products. In this situation, each product represents an activity whose optimal production level is determined from the solution of the mode (see table below)

“A course which does not use professional software is preparing our students for a type of work which does not exist anymore” (Paris, 1991). “Engineering without labs [and design] is a different discipline. If we cut out labs [and design] we might as well rename our degrees Applied Mathematics” (Eastlake, 1986).
Simulation is a powerful approach to modeling manufacturing systems in that many complex and diverse systems can be represented. Can predict system performance measures that are difficult to

assess without a model. It is a proven, successful tool and has been in use since the 1950s. The current languages take advantage of the capabilities of today's microprocessors and provide the user with the needed on-line support for model development, management, and analysis. CAD (computer-aided design) has its roots in interactive computer graphics. Before the CAD era, engineering drawings were prepared manually on paper using pencils and drafting instruments on a drafting table. The advent of interactive computer graphics replaced the drafting table with a computer monitor and the pencil with an input device such as a light pen or mouse. Instead of using physical drafting instruments, software commands and icons on the computer display are used. The drawing can be created, modified, copied, and transformed using the software tools. At the time, CAD stood for computer-aided drafting. Drafting was confined to 2D because of the paper limitation. With the computer, such limitation is removed. Three-dimensional CAD systems were developed in the 1960s. In 3D CAD, objects are modeled using 3D coordinates (*x, y,* and *z*) instead of 2D coordinates (*x* and *y*). The need for modeling parts and products with complex surfaces motivated the development of free-form surface modelers

DESIGN RECOMMENDATIONS

Some general rules for minimizing materials-related costs are as follows:

- Use commercially available mill forms so as to minimize in-factory operations.
- Use standard stock shapes, gauges, and grades or formulations rather than specials whenever possible. Sometimes, larger or heavier selections of a standard material are less costly than smaller or thinner sections of a special material
- Consider the use of prefinished material as a means of saving costs for surface-finishing operations on the completed component.
- Select materials as much as possible (consistently with functional requirements) for processibility. For example, use free-machining grades for machined parts, easily formable grades for stampings, etc. It pays to take the time to determine which variety of the basic material is most suitable for the processing sequence to be used.
- Design parts for maximum utilization of material. Make ends square or nest able with other pieces from the same stock. Avoid designs with inherently high scrap rates.

APPLYING COMPUTERS TO DESIGN

No other idea or device has impacted engineering as computer has. All engineering disciplines routinely use computer for calculation, analysis, design and simulation .Many of the individual tasks within the overall design process can be performed using a computer. As each of these tasks is made more efficient, the efficiency of the overall process increases as well. The computer is especially well suited to design in four areas, which correspond to the latter four stages of the general design process. Computers function in the design process through geometric modeling capabilities, engineering analysis calculations, automated testing procedures, and automated drawing

GOOD DESIGN IS SUSTAINABLE DESIGN.

It results in objects, systems or services that work aesthetically, functionally and commercially, improving people's lives and making the smallest possible impact on the planet.

It is a process…

Good design is a verb, not just a noun. It is a sequence of steps that defines problems, discovers solutions and makes them real.

…joining creativity and innovation…

Creativity generates ideas and innovation exploits them. Good design connects the two. It links ideas to markets, shaping them to become practical and attractive propositions for customers or users.

…and delivering value.

Good design is a quantifiable benefit, not a cost. Its value can be measured economically, socially and environmentally.

SOCIALLY RESPONSIBLE AND ENVIRONMENTALLY SUSTAINABLE DESIGN

An increasingly relevant development is design as a tool for sustainable innovation, i.e. innovation that takes social, environmental and economic considerations into account. In the 1960s, designers began actively to consider design's wider implications for society. Several approaches emerged, including 'green design', 'responsible design', 'ethical consuming', 'eco-design' and 'feminist design'.

Accessibility and inclusiveness also received a great deal of design interest

THE POTENTIAL OF DESIGN FOR INNOVATION

Design is an important part of the innovation process. Research shows that design-driven companies are more innovative than others. Although finding a universally agreed definition of design is not the purpose of this document, it does aim to clarify the links between design and innovation so that ultimately an operational definition of design can be agreed and embedded in a European innovation policy context. Design is considered a strategic tool for user-centered innovation. As such, it is a holistic and multidisciplinary problem-solving approach that takes user needs, aspirations and abilities as its starting point and focus. The potential of design to make products, services and systems correspond better to environmental and social needs has also received increasing attention in recent years. Design as an innovation activity is complementary to R&D in that it transforms research into commercially viable products and services, and brings innovation closer to user needs.

It is argued that although discrepancies currently exist between companies of different sectors and sizes, design has the potential to be more widely used, particularly in SMEs, low-tech companies and the service sector.

PROPER MATERIALS SELECTION

The choice of materials is a major determinant for the successful functioning and the feasible, low-cost manufacture of any product. The design engineer must tread a course (which is often a narrow one) between functional requirements on one hand and cost considerations on the other. In some cases, there will be a real conflict between function and cost in the selection of a material. In other cases, happily, the choice is easy: There is a particular material that does the job functionally and which minimizes the cost of production. It is the purpose of this section of the handbook to provide information about the properties, relative costs, and fabric ability of materials so as to aid the designer in making such favorable choices. There is a real need for economy in materials costs because, for most products, these costs account for a major portion of the total: 50 percent is a common order-of magnitude percentage. However, the objective is not necessarily minimum materials cost but minimum overall cost, including the initial price of the material, the cost of processing and assembling it with other materials into a product, the cost of guaranteeing the durability of the product and servicing it, etc. Thus, in the long run, the lowest-cost material may not be the material with the lowest price tag.

BENCH REACTOR

The reactor was constructed with stainless pipe cut at 375mm length as shown in fig 1. The length of pipe was chosen to accommodate 1.3kg of soil such that the soil level was below the mid-point of air inlet to the reactor, shown in fig.2 The land farm aeration process was simulated by inverting the reactor pipe. At the reactor base a cap was wielded in while at the top of the reactor pipe a removable cover was press shown in fig 4. Air as passed through the reactor at mid height through a 16mm brass fitting which was screwed. For the airing the air passages outtake, a 16mm brass fitting was 80mm higher than inlet at an angle 120’ to it. A ball valve was screw beside the outtake of reactor to allow water to be added to the system shown fig.5. This arrangement allowed the inversion of the tube without soil entering the air passages. Source air was passed through 16 mm long charcoal which ensured that hydrocarbon contamination from the source line was eliminated. Hydro carbon was captured at each reactor the air outlet of reactor with a granulated activated coconut char-coal (GAC) trap shown in fig 3

Methodology of operation. A fluidized contaminated sand bed was incorporated in the reactor main frame compressed air at daily atmospheric temperature was passed through a fluidized adsorbent bed contained in the arm of the reactor chamber. The analysis of the rate of adsorption is used to analysis the rate of hydrocarbon removal from the contaminated soil.

MODELLING OF THE COMPONENT OF BENCH REACTOR

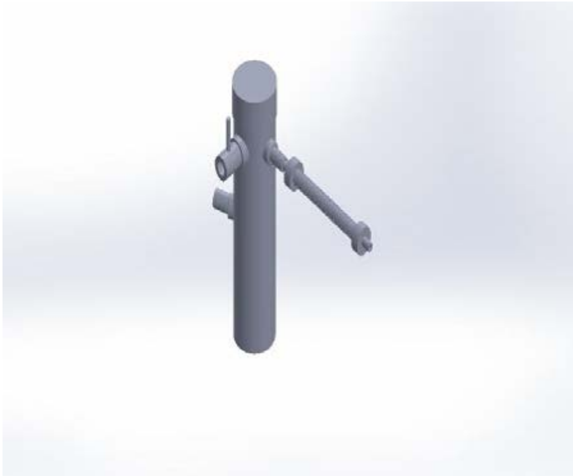


Figure: 1 Final Design of Reactor

Figure: 2 contaminated soil

Figure 3:

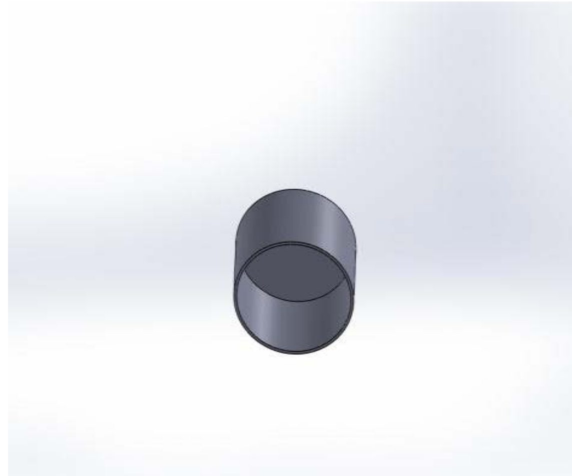


Figure: 4 cover

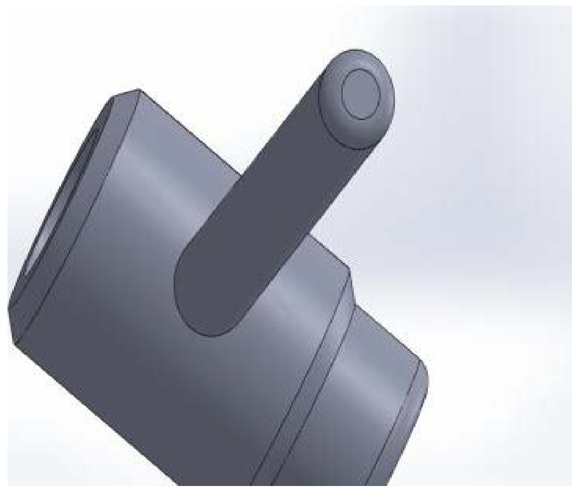


Figure: 5 Valve

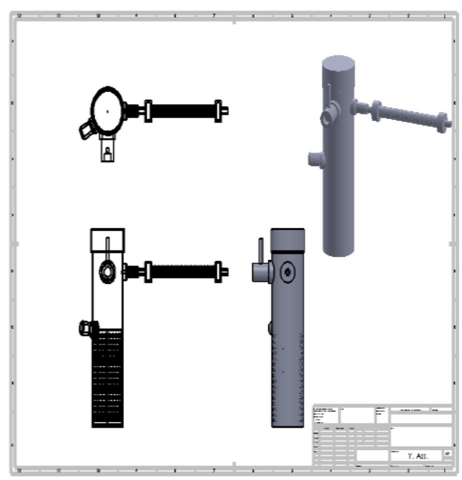


Figure: 6 Multiply Views

SIMULATION OF THE COMPONENT

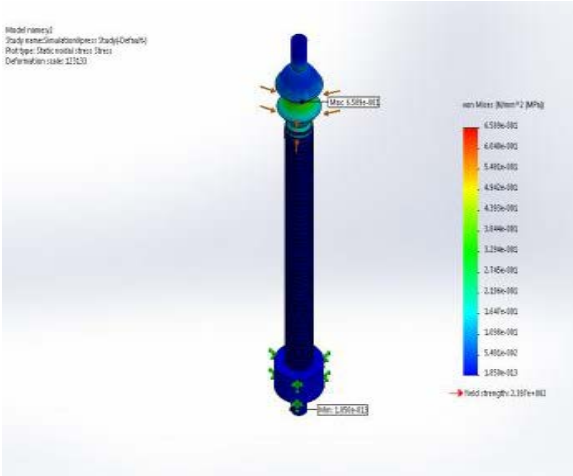


Figure: 7 static node stress

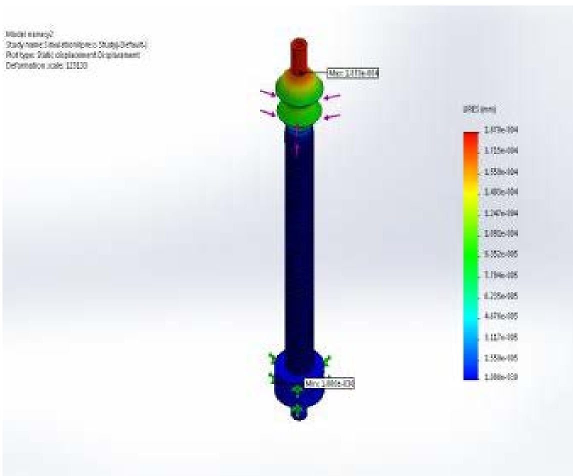


Figure: 8 displament

Figure: 9 deformed shape

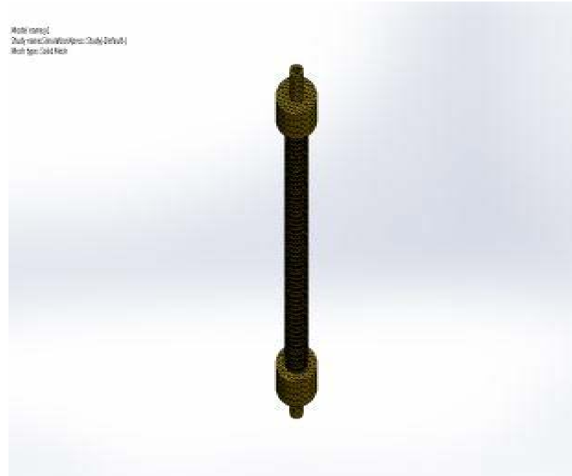


Figure: 10 Solid mesh

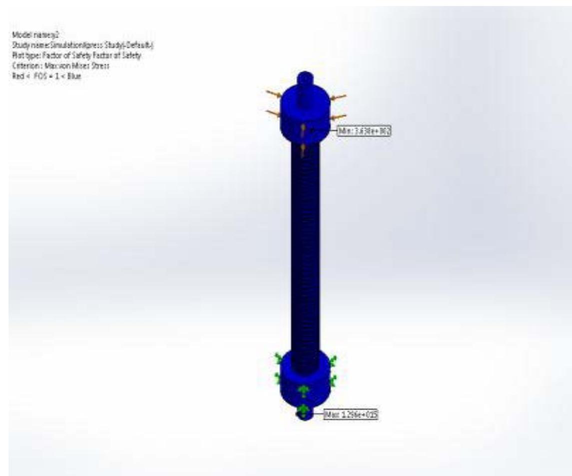


Figure: 11 factor of safety

Figure: 12 under stress

Table 1:

VARIABLE VIEW	RESULT	
	Initial	optimal
D7stetch1 (0.005)	10mm	5mm
Factor of safety	363.740040	390893013
Mass	0.771004kg	0.36463kg
D7stetch1 (.0.005)	5mm	5mm
Max displacement	0.00014mm	0.000014mm
mass	0.36463kg	0.36463kg
D7stetch1 (0.01452)	5mm	5mm
Max stress	6.1318e+00M/N^2	6.1318e+00M/N^2
Mass	0.36463kg	0.36463kg

Using optimal value 5mm (max stress 613180M/N^2

Table 2:

D7stetch1 (0.141362)	14.13517mm	5mm
Max stress	6.2248e+005 N/m^2	6.1318e+005N/M ^2
Mass	0.3759kg	0.3643kg

SUSTAINABILITY ANALYSIS OF BENCH REACTOR

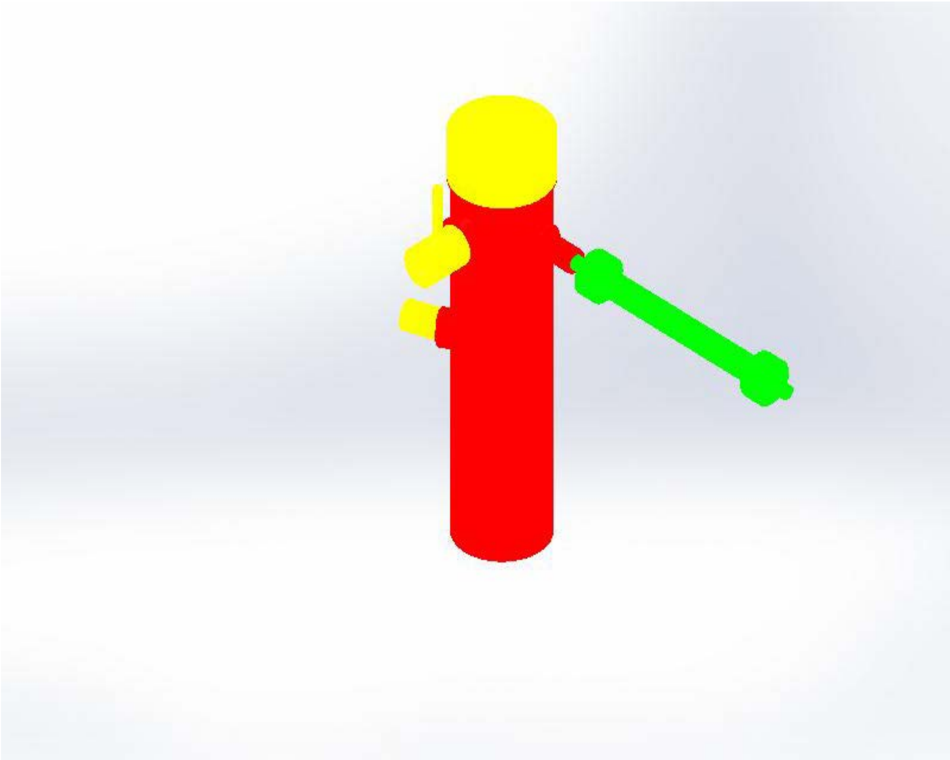


Figure 13 Sustainability Analysis

Sustainability Report

Model Name:	Y. Ass.	Weight:	2868.42 g
		Built to last:	10 year
		Duration of use:	1.0 year

Component Environmental Impact

Top Ten Components Contributing Most to the Four Areas of Environmental Impact

Component	Carbon	Water	Air	Energy
y	12	0.039	0.060	120
valve	3.3	6.9E-4	9.3E-3	46
Y3	2.2	7.3E-3	0.012	24
cover	1.6	5.2E-3	8.2E-3	17
Nipple	0.913	4.0E-4	0.010	9.9
y2	0.967	3.9E-4	3.7E-3	12

Sustainability Report

Model Name:	Y. Ass.	Weight:	2900 g
		Built to last:	10 year
		Duration of use:	1.0 year

BASELINE

Environmental Impact Comparison

New Design: Better Worse

Original Design: Baseline

Carbon Footprint - Comparison

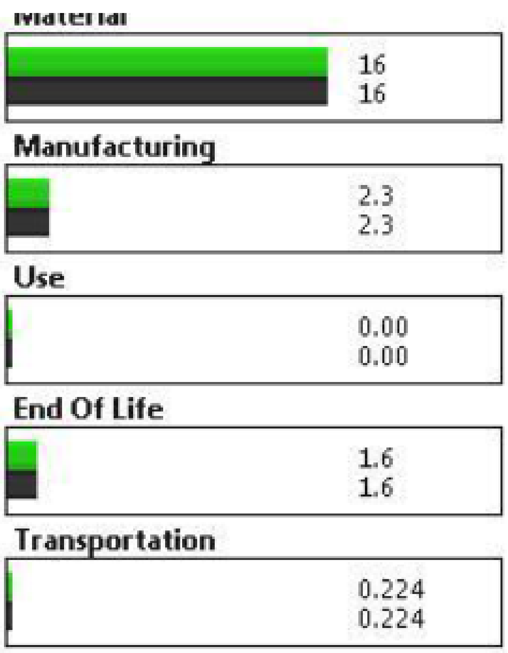
Total : 20 kg CO_2e

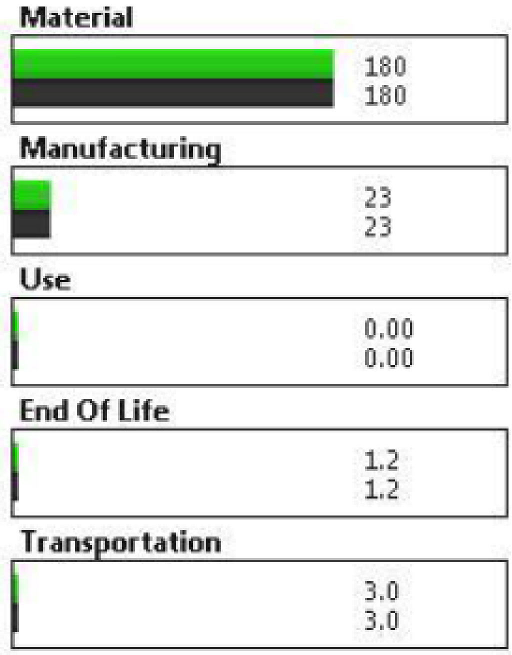
: 21 kg CO_2e

Total Energy Consumed – Comparison

Total : 210 MJ

: 210 MJ





Air Acidification - Comparison

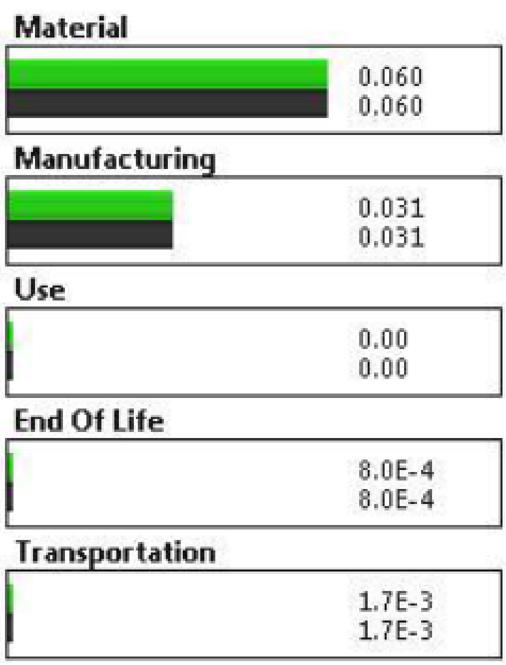
Total : 0.093 kg SO_2e

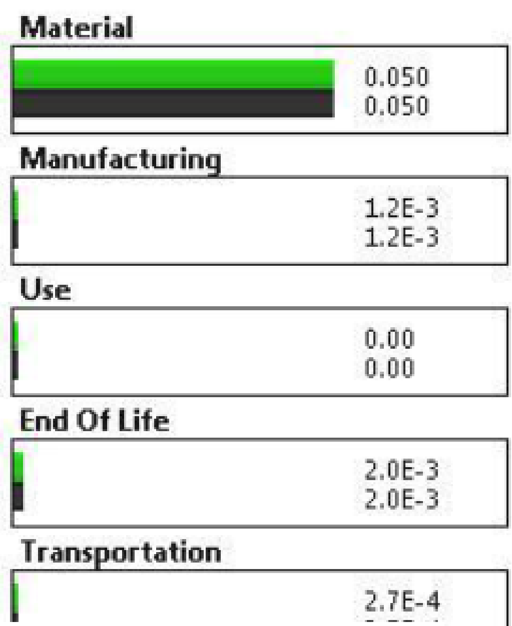
: 0.092 kg SO_2e

Water Eutrophication - Comparison

Total : 0.053 kg PO_4e

: 0.055 kg PO_4e





Material Financial Impact Comparison

RESULTS AND DISCUSSION

Engineers use CAD to create two− and three−dimensional drawings, such as those for automobile and airplane parts, floor plans, and maps and machine assembly shown in fig; 2 while it may be faster for an engineer to create an initial drawing by hand, it is much more efficient to change and adjust drawings by computer. In the design stage, drafting and computer graphics techniques are combined to produce models of different parts. i. Using a computer to perform the six−step 'art−to−part' process: The first two steps in this process are the use of sketching software to capture the initial design ideas and to produce accurate engineering drawings. Next, engineers use analysis software to ensure that the part is strong enough. Step five is the production of a prototype, or model. Fig 6 shows multiply views of the Bench reactor. In the final step the CAM software controls the machine that produces the part, during the design of the Bench Reactor and the drafting, software was used to draw the orthogonal views, Isometric views, exploded drawings ,the detailed drawing of the Bench Reactor, modeling and simulation was done before the commencement of the fabrication processes.

MODELING

Modeling is the process of producing a model; a model is a representation of the construction and working of some system of interest shown in fig 1. A model is similar to but simpler than the system it represents. One purpose of a model is to enable the analyst to predict the effect of changes to the system. On the one hand, a model should be a close approximation to the real system and incorporate most of its salient features. On the other hand, it should not be so complex that it is impossible to understand and experiment with it. A good model is a judicious tradeoff between realism and simplicity. Simulation practitioners recommend increasing the complexity of a model iteratively. An important issue in modeling is model validity. Model validation techniques include simulating the model under known input conditions and comparing model output with system output. Generally, a model intended for a simulation study is a mathematical model developed with the help of simulation software. Mathematical model classifications include deterministic (input and output variables are fixed values) or stochastic (at least one of the input or output variables is probabilistic); static (time is not taken into account) or dynamic (time-varying interactions among variables are taken into account). Typically, simulation models are stochastic and dynamic

SIMULATION

A simulation of a system is the operation of a model of the system. The model can be reconfigured and experimented with; usually, this is impossible, too expensive or impractical to do in the system it represents. The operation of the model can be studied, and hence, properties concerning the behavior of the actual system or its subsystem can be inferred. In its broadest sense, simulation is a tool to evaluate the performance of a system, existing or proposed, under different configurations of interest and over long periods of real time. Simulation is used before an existing system is altered or a new system built, to reduce the chances of failure to meet specifications, to eliminate unforeseen bottlenecks, to prevent under or over-utilization of resources, and to optimize system performance. For instance, simulation can be used to answer questions like: What is the best design for a new network? What are the associated resource requirements? How will a telecommunication network perform when the traffic load increases by 50%? How will a new routing algorithm affect its performance? Which network protocol optimizes network performance? What will be the impact of a link failure? The subject of this tutorial is discrete event simulation in which the central assumption is that the system changes instantaneously in response to certain discrete events. For instance, in an M/M/1 queue - a single server queuing process in which time between arrivals and service time are exponential - an arrival causes the system to change instantaneously. On the other hand, continuous simulators, like flight simulators and weather simulators, attempt to quantify the changes in a system continuously over time in r e s p o n s e t o controls. Discrete event simulation is less detailed (coarser in its smallest time unit) than continuous simulation but it is much simpler to implement, and hence, is used in a wide variety of situations. Figure 1, 7-12 is a schematic of a simulation study. The iterative nature of the process is indicated by the system under study becoming the altered system which then becomes the system under study and the cycle repeats. In a simulation study, human decision making is required at all stages, namely, model development,

SUSTAINABILITY –

Simulation technology has been a significant tool for improving manufacturing operations in the past; but its focus has been on lowering costs, improving productivity and quality, and reducing time to market for new products. Sustainable manufacturing includes the integration of processes, decision-making and the environmental concerns of an active industrial system to achieve economic growth, without destroying precious resources or the environment. Sustainability applies to the entire life cycle of a product fig: 13 also detailed component environment impact. It involves selection of materials, extraction of those materials, of parts, assembly methods, retailing, product use, recycling, recovery, and disposal will need to occur if simulation is to be applied successfully to sustainability. Manufacturers will need to focus on issues that they have not been concerned with before

OPTIMIZATION

An optimization system may be regarded generally as a resource allocation problem in which limited resources are assigned to activities in a manner that will produce the best value for a selected measure of performance. Such a measure of performance may typically involve minimization of cost or maximization of profit. A simple example of an optimization system involves the determination of the level of production of a number of products that compete for limited raw materials, with the objective of maximizing the total profit for all products. In this situation, each product represents an activity whose optimal production level is determined from the solution of the model. Illustrated in table 1 above

Conclusion/Recommendation

Design for Environment (DFE) is the systematic consideration of design performance with respect to environmental, health, safety, and sustainability objectives over the full product and process life cycle. The motivation for adopting practices such as DFE goes beyond ethics and good citizenship—it is ultimately a strategic business decision. In simple terms, business value is the most important driver of DFE. In fact, corporations all over the world have recognized that sustainability makes good business sense and is essential for their survival and growth. Many CEOs have asserted a belief that sustainable business practices will improve both enterprise resource productivity and stakeholder confidence. An engineer must always design products that are safe for the end user and the artisans who construct the product.it is impossible to design completely safe products because they would be too costly. Therefore, the engineer often must design to industry standards for similar product.

The rate of hydrocarbon removal as detailed from the bench reactor will be presented in the future work where the reactor was demonstrated on a contaminated demonstration etc

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