Abridged LCA in an SME: A Case Study examining benefits to New Product Development.

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Abstract

Life Cycle Assessment (LCA) can be timely, costly and technically demanding. This often discourages its utilisation in Small to Medium Enterprises (SMEs). This paper presents an example of an abridged LCA. Specifically, it draws on an in-depth case study at Odoni-Elwell, a Welsh based SME. The paper discusses trade-offs between the environmental performance, durability and life-in-service of two common steel coating processes: hot-dip galvanizing (HDG) and powder coating (PC). Results are generated using Sustainable Minds abridged LCA software. The software aggregates a range of indicators to give a single environmental performance ranking. The results identify higher emissions but improved durability and longer lifespans for HDG. Conversely, it presents lower emissions but reduced durability and lifespan for PC. The analysis discusses the impact of real product lifespan versus technical durability on environmental performance. The results advise the use of PC up to an anticipated service life of 20 years. The study shows how abridged LCA can improve understanding and aid decision-making. It illustrates how this improved decision-making capacity can lessen environmental impacts in SMEs.

Introduction

This paper investigates the use and suitability of LCA in SMEs. Specifically, it examines the appropriateness of an abridged LCA methodology in the context of a steel fabricating SME called Odoni-Elwell (OE). It investigates two commonly used steel coating processes: hot dip galvanizing (HDG) and powder coating (PC). It will document the impacts and environmental performance of these processes in the case of an OE product, over a range of life-in-service periods. Analysis will establish and communicate the benefits and limitations of the methodology in the context of an SME. It will aim to facilitate discussion about the suitability of the technique for wider industry application.

Steel Industry Contextual Review

Up to 1500 million tonnes of steel are produced every year[1]. Related energy and industrial processes account for 9% of global anthropogenic C02 emissions[2]. Demand for steel is forecast to double by the year 2050 globally[3], yet by that date we must reduce C02 emissions by a minimum of 50%[4]. To achieve, this would require a 75% reduction in emissions per kilogram of steel produced[5]. The current rate of efficiency improvements, related to steel production, is however insufficient to meet this target[6]. Additionally, rising energy costs have heightened competition. This has increased the difficulty and expense of meeting environmental performance requirements[1]. It is therefore important to explore all means and strategies for improving efficiency and performance.

Life Cycle Analysis (LCA) & Small to Medium Enterprises (SMEs)

LCA is a recognised means of identifying and assessing the environmental impacts of product life-cycles[7]. It can improve understanding and inform ecodesign decision-making. As such, LCA has the capacity to increase efficiency and control environmental impacts. The adoption of LCA can however, be timely and costly. This can often discourage SMEs from integrating it into their New Product Development processes. There is also often a lack of knowledge and technical expertise within SMEs to enable effective utilisation of these techniques. There is even limited understanding as to why LCA should be implemented[8, 9]. To connect with industry and increase LCA uptake in SMEs there is a recognised need to simplify tools and approaches[9]. Sustainable Minds is an accessible and affordable cloud-delivered LCA tool. It utilises validated sources including the EPA and NIST. The abridged LCA approach it adopts, aims to '*make it possible for manufacturers across the value chain – large and small – to dynamically estimate, evaluate, compare and improve their products' environmental performance'*[10]. Simplified LCAs such as this have a reported accuracy of up to 90%[11].

Steel Coating Processes

Hot-dip galvanizing (HDG) and powder coating (PC) are amongst the most common steel coating processes. They are used to prevent and limit corrosion and improve aesthetic appearance.

HDG is economical and very durable[12]. It provides corrosion protection via metallurgical bonding of zinc-iron layers. It has a service life, without maintenance, for periods ranging between 50-75 years in most environments. The provision of this service-life, allows for longer lasting products and structures. This helps facilitate energy and resource savings[13, 14]. The process does however generate both waste and emissions. Waste includes zinc fumes and ash, dross (a zinc-iron alloy), spent acid (including zinc and iron chloride) and quantities of water and general waste. Emissions include C02, hydrochloric acid, sulphuric acid, ammonia, ammonium chloride, zinc and PM10[15].

Whilst PC provides corrosion protection it is primarily used for decorative purposes. Powders are mainly organic and polyester based. They contain no solvents and emit near zero VOCs. Overspray is recyclable and the quantity of waste limited[16]. Defra report limited harmful emissions but highlight the potential release of hydrogen chloride and odour as a result of any steel pre-treatment[17]. A recent LCA study indicates low C02 emissions compared to other coating processes[18]. Whilst difficult to predict, current PC technology has an estimated lifespan of 10-20 years[19, 20]. It therefore fails to match the durability of HDG. PC steel products are also more susceptible to corrosion. Unlike in HDG, there is no chemical bonding between the coating and steel substrate. Consequently, if the coating is chipped and the steel below exposed to the environment, corrosion will occur and accelerate[13].

HDG and PC are also often used together. Research by Van Eijnsbergen, advises the use of this 'duplex' system. Theoretically, its adoption has the capability to lengthen service-life and corrosion protection by approximate factors of 1.5 - 2.5[21].

Research Methodology

The study was undertaken by the author at Odoni-Elwell Ltd (OE). It was completed in collaboration with Ecodesign Centre as part of a Knowledge Transfer Partnership seeking to embed ecodesign principles and practices. OE is a Welsh based SME specialising in steel fabrication in the bicycle storage and steel framed building sector. This case-study considers an OE parking rack called the Spaceman. The product features a wall mounted design and is intended for long-term use in exterior environments. Utilising Sustainable Minds software, the study details the impacts and environmental performance of HDG and PC in the case of the product. The software was chosen because it is an accepted, affordable tool, appropriate to the needs of this and other SMEs. It was also deemed appropriate to the needs and understanding of the author (Clarke); a product designer, with limited LCA experience. Sustainable Minds is used to aggregate an environmental performance rating for iterations of the product. It factors physical properties, material and manufacturing process impacts and provided product service-life. Data is input from detailed CAD models of the design. Material and process information is aggregated using Sustainable Minds' database. Estimated life-in-service spans are informed by literature review, customer feedback and environment of use. The study focuses on environmental performance during the design, manufacturing and use stages. End-of-life procedures, transportation and recycling are not considered as part of the study. Results consider three separate coating scenarios for the product; 1) PC, 2) HDG, 3) Duplex. They show ratings for each scenario over varying estimated life-in-service periods. Each scenario is compared against a bare, uncoated mild steel product with an estimated 1 year service life. This uncoated product is used as a datum against which the scenarios are ranked on environmental performance improvement.

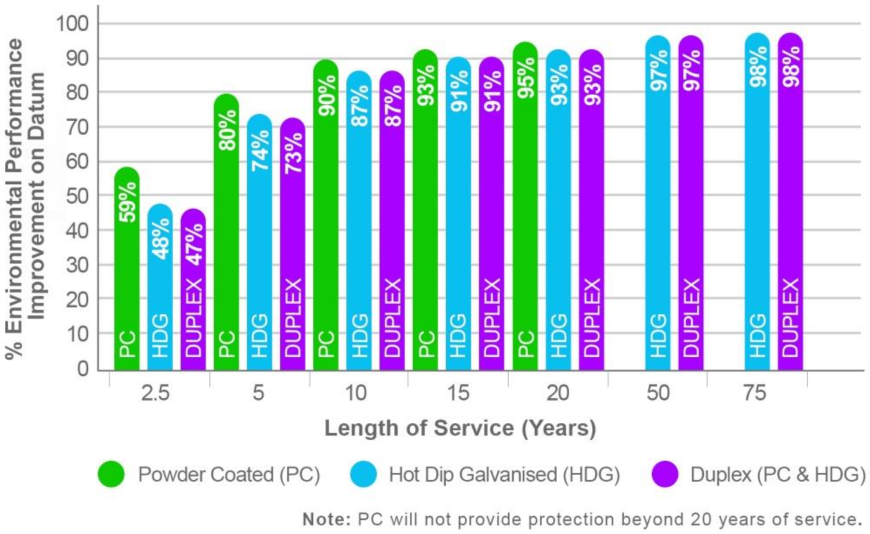
Results

Fig. 1 **Datum Impacts**

	Service Life (Years)	CO2 eq. kg/1 year of use	mPts/1 year of use
Uncoated Mild Steel Product	1	140	26

Fig. 2 **Spaceman Parking Rack**

Fig. 3 **Environmental performance improvement on Datum by length of product service.**



Analysis

Results illustrate the benefit of longer service life to improved environmental performance. For all coatings; the longer the provided service life, the greater the environmental performance improvement. However, PC augmented the greatest performance gains over shorter service lives. (Up to a period of 20 years - beyond which protection cannot be guaranteed.) The significance of actual product lifespan versus technical durability is consequently illustrated. If the product were intended to last 75 years then HDG or duplex (HDG and PC) would facilitate the biggest environmental performance improvement. Conversely, it advises the use of PC for 20 years or less of service. Prior to this study OE utilised a duplex coating system for the Spaceman product. However, evaluation of these results questioned that decision. Allowing for changing trends and user needs, it is unlikely the Spaceman would provide more than 20 years of service before replacement. In this case, the presented research advises the use of PC over a duplex system. This is significant; existing literature largely measures coating environmental performance on service longevity and manufacturing emissions. This research however, also factors the importance of actual or anticipated product lifespan. It therefore offers new insight.

The generated results present the most appropriate coating choice for each designated service length. This significantly improved the understanding of the designer and manufacturer. The results enabled the required service life to be matched with the most efficient corresponding coating choice. This presented the most suitable material for the intended application. The results facilitated quick, well informed decision-making that engendered environmental performance improvements.

There were further benefits of the study. The abridged software was very accessible and time efficient. As a non-expert with limited LCA experience the results were generated quickly (in 2-3 hours) and with no training. As identified in the literature review, SME's are often burdened with time and financial constraints and limited technical understanding. Subsequently, there are benefits of this approach to SMEs, over traditional, more intensive LCAs.

Conclusion

The study advises the use of PC over HDG and duplex coating in the case of this product. Whilst actual product lifespan is neglected in much of the existing literature, these findings demonstrate its significance to coating choice and environmental performance efficiency. The paper illustrates how a simplified LCA can improve understanding of environmental performance considerations in SMEs with limited existing expertise. It shows how this improved understanding can facilitate better informed ecodesign decision-making. Furthermore, it demonstrates how this increased decision-making capacity can lower SME impacts and improve environmental performance. The paper presents evidence in favour of the adoption of this abridged technique in SMEs over more intensive, costly and detailed LCA studies.

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References

1. World Steel Association. (2011) Steel statistical yearbook 2011. Available at:

http://www.worldsteel.org/ statistics/statisticsarchive/yearbook-archive.html
2. International Energy Agency. (2008) Energy technology perspectives—scenarios & strategies to 2050. Paris, France: *IEA Publications*
3. Carbon Trust. (2011) International Carbon Flows: Steel. Available at: https://www.carbontrust.com/media/38362/ctc791-international-carbon-flows-steel.pdf
4. Metz B, Davidson OR, Bosch PR, Dave R, Meyer LA. (2007) Climate Change 2007: Mitigation: Contribution of Working Group III to the Fourth Assessment. *Cambridge, UK: Cambridge University Press.*
5. Moynihan MC, Allwood JM. (2014) Utilization of structural steel in buildings. Proc. R. Soc. A470: 20140170. Available at: http://dx.doi.org/10.1098/rspa.2014.0170
6. Allwood JM, Cullen JM, Milford RL. (2010) Options for achieving a 50% cut in industrial carbon emissions by 2050. *Environ. Sci. Technol. 44, 1888–1894.* (doi:10.1021/es902909k)
7. Finnveden G. et al., (2009) Recent developments in Life Cycle Assessment., *Journal of environmental management, vol. 91, no. 1, pp. 1-21, Oct. 2009*.
8. Le Pochat, S. Bertoluci, G. & Froelich, G. (2007) Integrating ecodesign by conducting changes in SMEs, *Journal of Cleaner Production, vol. 15, no. 7, pp. 671-680*.
9. Sherry, J. Prendeville, S. O'Rafferty, S. O'Connor, F. Decasteau, F. (2012) LCA to Go: Developing a sector based web tool to address the business needs of SMEs. *LCA Conference, 6-7 November 2012, Lille France*
10. Sustainable Minds. (2014) Software. Available at: http://www.sustainableminds.com/software
11. Hur T, Lee J, Ryu J, et al. (2004) Simplified LCA and matrix methods in identifying the environmental aspects of a product system. Journal of Environmental Management 75 (2005) 229–237
12. Sonmez, S. Aktas S. & Acma, E. (2002) A study on the treatment of wastes in Hot Dip Galvanizing Plants Canadian Metallurgical Quarterly (Impact Factor: 0.42). 12/2002; 42(3):289-300. DOI: 10.1179/000844303794406062
13. American Galvanizers Association (2009) Hot Dip Galvanizing for Sustainable Design. Available at: http://courtgalvanizinginc.com/wp-content/uploads/2012/05/HotDipGalvanizingSustainableDesign.pdf
14. Galvanizers Association. (2012) The Engineers & Architects' Guide: Hot Dip Galvanizing.http://www.wedgegalv.co.uk/uploads/file/Engineer's%20&%20Architects%20Guide.pdf
15. NPI, (2012) Emission estimation technique manual for Galvanizing 2012 http://www.npi.gov.au/system/files/resources/76f8fede-5a99-aac4-25ce-a80369a5aadd/files/galvanizing.pdf
16. CEPE (2014) Advantages of Powder Coating. Available at: http://cepe-myeteam.eudata.be/EPUB/easnet.dll/execReq/Page?eas:template_im=100087&eas:dat_im=1024A4
17. DEFRA, (2004). Secretary of State's Guidance for Powder Coating Including Sherardizing and Vitreous Enamelling Dry. Available at: http://archive.defra.gov.uk/environment/quality/pollution/ppc/localauth/pubs/guidance/notes/pgnotes/documents/pg6-31.pdf
18. DSM, (2011) Carbon Footprint Study for Industrial Coatings Applied on a Metal Substrate Focus on Powder Coating. Available at: http://www.dsm.com/content/dam/dsm/furniture/en_US/documents/20.-dsm-carbon-footprint-%20-disclaimer.pdf
19. Riteway Powder Coating (2014) Powder Coating. Available at: http://www.ritewaypowdercoating.com/faq/
20. DPS Industrial Finishers. (2014) Powder Coating. Available at: http://www.dpsindustrialfinishers.co.uk/powder-coating.php
21. Van Eijnsbergen, J.F.H. (1994) Duplex Systems, 1st Edition. Hot-dip Galvanizing Plus Painting. Elsevier Science Ltd