Comparative Life Cycle Assessment of Remanufacturing and New Manufacturing of a Manual Transmission

Jens Warsen[1], Marlisa Laumer[1], Wolfgang Momberg[2]

[1] Volkswagen AG, Group Research Environmental Affairs Product, Wolfsburg, Germany

[2] Volkswagen AG, Remanufacturing Powertrain, Kassel, Germany

Abstract

A newly manufactured 5-speed manual transmission is compared with a genuine remanufactured transmission of identical design. The Life Cycle Assessment covers the entire product life cycle from production through to disposal. In all the environmental impact categories considered, the remanufactured transmission performs significantly better than the newly manufactured unit. The environmental improvements are attributable to the substantial reduction in material and energy consumption. Transport of used transmissions to the remanufacturing facility accounts for only a small fraction of total life cycle environmental impacts. Energy consumption is reduced by 33 % for the remanufactured transmission compared with a newly manufactured transmission.

Keywords:

Comparative LCA; Remanufacturing; Transmission

1 INTRODUCTION

Volkswagen is committed to developing vehicles and components with better environmental properties than their predecessors over the entire life cycle. Life Cycle Assessments (LCA) are used to document the environmental performance of vehicles, technologies and processes. We have been using Life Cycle Assessments to enhance the environmental compatibility of our cars and their individual components since 1996. As part of an integrated product policy, the LCA considers not only individual environmental aspects such as the driving emissions of the vehicle but its entire life cycle. The Life Cycle Assessment issued by Volkswagen are in accordance with ISO 14040/44 [1, 2] and are verified by independent experts, e.g. by TÜV NORD.

Volkswagen today has a 60 year history of remanufacturing. The so called „Exchange Parts Programme“, a take-back scheme for used vehicle components, was launched back in 1947 in order to meet raw material shortages in the post-war era. Initially the scheme was confined to five product groups: fuel pumps, clutch pressure plates, steering boxes, carburettors and cylinders with front and rear axles and industrial engines following during the subsequent years. Being extremely successful, the programme saved substantial amounts of raw material and energy as a large part of the components usually can be directly reused. For these component parts the complex production process of smelting, casting and forming is saved. Nonetheless genuine part quality is guaranteed for all remanufactured components.

The aim of this LCA-study is to analyse and compare the environmental impacts of a newly manufactured transmission model with a genuine remanufactured transmission of identical design. More detailed information about this analysis can be found at **www.mobility-and-sustainability.com.**

2 MATERIALS AND METHODS

2.1 Data origin of LCI analysis

The data used for preparing the Life Cycle Assessment can be subdivided into product data and process data. “Product data” describes the product itself, and among other things includes information on parts, quantities, weights and materials. “Process data” includes information on manufacturing and processing steps such as the production of materials and semifinished goods, fabrication and the provision of electricity and other consumables. This information is either obtained from commercial databases or compiled by Volkswagen as required [3, 4].

The data selected are as representative as possible. This means that the data represent the materials, production and other processes as accurately as possible from a technological, temporal and geographical point of view. For the production processes carried out at the Kassel plant chiefly primary data is used. Upstream supply chains and external production steps are modelled using published industrial data. As the transmissions are remanufactured centrally by Volkswagen in Kassel, as far as possible data related to Germany is applied. Where German data is not available, European and occasionally global conditions are reflected.

The Life Cycle Assessment model for transmission production was developed using Volkswagen‘s slimLCI methodology [5]. The transmission parts list was used as data source for product data, and data on weight and materials was taken from the Volkswagen material information system (MISS). This information was then linked to the corresponding process data in the Life Cycle Assessment software GaBi.

2.2 Data quality

Material inputs, processing procedures and the selection of data in GaBi are standardised to the greatest possible extent, ensuring that the information provided by VW slimLCI is consistent and transparent. In sum, all information relevant to the aims of this study was collected and modeled completely. The modelling of components on the basis of transmission parts lists ensures that the model is complete, especially with respect to the manufacturing phase. In addition, as the work processes required are automated to a great extent, any differences in the results are due solely to

J. Hesselbach and C. Herrmann (eds.), *Glocalized Solutions for Sustainability in Manufacturing: Proceedings of the 18th CIRP International Conference on Life Cycle Engineering, Technische Universität Braunschweig, Braunschweig, Germany, May 2nd - 4th, 2011*,
DOI 10.1007/978-3-642-19692-8_12, © Springer-Verlag Berlin Heidelberg 2011

changes in product data and not to deviations in the modelling system.

2.3 Impact assessment

The Impact Assessment is based on CML methodology [6]. The assessment of environmental impact potentials in accordance with this method is based on recognized scientific models. A total of five environmental impact categories were identified as relevant and were then assessed in this study:

- eutrophication potential (EP)
- ozone depletion potential (ODP)
- photochemical ozone creation potential (POCP)
- global warming potential (GWP) for a reference period of 100 years
- acidification potential (AP)

Besides this, primary energy demand has been also recognized. These six categories were chosen because they are particularly important for the automotive sector, and are also regularly used in other automotive related Life Cycle Assessments [7, 8, 9].

3 CASE STUDY

3.1 Objective and target group of the assessment

The objective of this Life Cycle Assessment was to compare the environmental profiles of newly manufactured and remanufactured transmissions. For this purpose, a manual 5-speed MQ 250 transmission, currently Volkswagen`s highest-volume transmission, and a corresponding remanufactured unit have been assessed.

3.2 Function and functional unit

The functional unit for the Life Cycle Assessment was defined as the manufacture of a Type MQ 250 transmission. Table 1 shows the key technical data of this transmission. The two transmissions are comparable as the remanufactured unit is guaranteed to have the same quality as a genuine newly manufactured gearbox.

	5-speed front wheel drive car transmission
Torque	250 [Nm]
Max Power	132 [kW]
Length	370 [mm]
Weight	41.3 [kg] , with oil
Design	Twin-shaft gearbox
Synchromesh	3rd to 5th gears: single-cone Borg-Warner, 1st and 2nd gears: triple-cone Smith Reverse gear Reverse brake (input shaft)
Housing	Diecast aluminium

Table 1: Technical data of MQ 250 transmission.

3.3 Scope of assessment

Figure 1 shows the scope of this Life Cycle Assessment. It was defined in such a way that all relevant processes and substances are considered, traced back to the furthest possible extent and modeled at the level of elementary flows. The material fractions generated during recycling are the only exception.

The manufacturing phase was modelled including all manufacturing and processing stages for all transmission parts and components. The model includes the transport of the old transmission to the plant, the dismantling, cleaning and testing of the old transmission, the production of replacement parts and the reassembly of the transmission. The model therefore covers all steps from the extraction of raw materials and the manufacture of semifinished products right through to assembly.

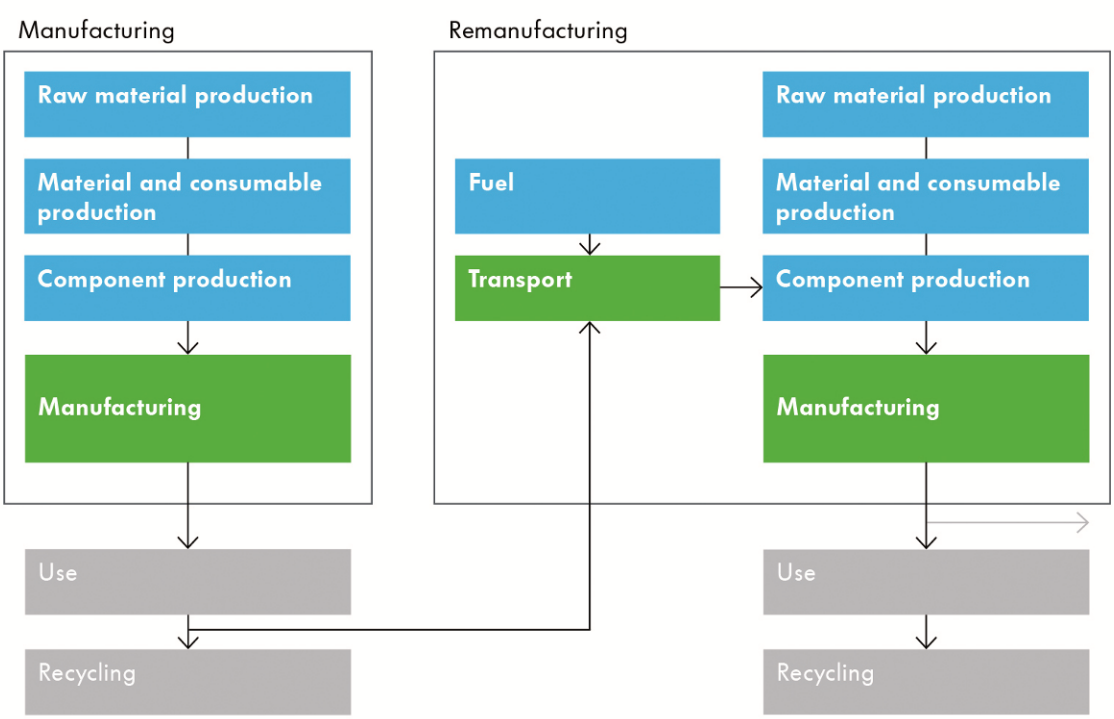

Figure 1: Scope of Life Cycle Assessment.