USE OF CONTINUOUSLY VARIABLE TRANSMISSION IN AUTOMOBILES AS AN ADVANTAGE IN REDUCING FUEL CONSUMPTION AND EMISSIONS LEVEL.

Leonardo Serfert Junior[b], Thiago B. Murari[b], Lilian Lefol Nani Guarieiro[a]

[a], Centro Universitário SENAI CIMATEC, Av. Orlando Gomes 1845, 41.650-010, Salvador, BA, Brasil

[b] Ford Motor Company Brasil LTDA, Avenida Henry Ford, 2000, 42816-900, Camaçari, BA, Brasil.

Abstract:

Performed a quantitative study, using a group of Continuously Variable Transmissions and a group of Automatic Transmissions "Planetary" type, with the objective of proving which one offers the better fuel economy and the lowest level of emissions.

Initially, a bibliographic search was carried out in order to identify results of studies where were evaluated: fuel consumption as a reason for choosing CVT transmission; comparisons of types of automatic transmissions regarding fuel consumption, emissions and efficiency studies of CVT transmissions.

The data, consumption and emissions, was extracted from the annual publication of vehicle approval issued by INMETRO (National Institute of Metrology, Quality and Technology), and then developed a Model, per cluster analysis, in order to understand transmissions behavior.

Keywords: CVT; Planetary; fuel economy; transmissions comparisons.

USO DE TRANSMISSÃO CONTINUAMENTE VARIÁVEL EM AUTOMÓVEIS COMO VANTAGEM NA REDUÇÃO DO CONSUMO DE COMBUSTÍVEL E NÍVEL DE EMISSÕES.

Resumo:

Realizado um estudo quantitativo, utilizando um grupo de Transmissões Continuamente Variáveis e um grupo de Transmissões Automáticas do tipo "Planetária", com o objetivo de comprovar qual delas oferece a melhor economia de combustível e o menor nível de emissões.

Inicialmente, foi realizada uma pesquisa bibliográfica para identificar resultados de estudos nos quais foram avaliados: consumo de combustível como motivo da escolha da transmissão CVT; comparações de tipos de transmissões automáticas em relação ao consumo de combustível, emissões e estudos de eficiência de transmissões CVT.

Os dados, consumo e emissões, foram extraídos da publicação anual de homologação de veículos emitida pelo INMETRO (Instituto Nacional de Metrologia, Qualidade e Tecnologia), e posteriormente desenvolvido um Modelo, por análise de cluster, para entender o comportamento das transmissões.

Palavras-chave: CVT; Planetária; economia de combustível; comparações de transmissões.

1. INTRODUCTION

The objective of this study was to compare a group of Continuously Variable Transmissions with a group of “Planetary” Automatic Transmissions, to better specify the level of consumption of each one, using comparison methods by clusters, based on the Consumption Table INMETRO; assessed the fuel economies that each of these types of transmission had offered.

Thereby, demonstrate which type of transmission offers the best fuel economy and try to prove that the emissions level of the most economical transmission is also lower than that with the higher fuel consumption transmission.

Nowadays, the research and development of quality products that meet the desire and budget of consumers are essentials, observing the broad competition of the market and the current relevant legislation (Route 2030: Law Nº 13.755). In addition, it is essential that these products are within the Goals to achieve Sustainable Development Goals (SDGs), inserted in the 2030 Agenda of the United Nations (UN), which Brazil has ratified.

Regarding to the automotive industry, it is necessary to respect the targets and indicators, which aim to avoid climate change and its adverse impacts and promote an inclusive, sustainable and low carbon economy; theme regulated by SDG 13, Agenda 2030 and by the “Nationally Determined Contributions” (NDC) of Brazil. (Brasília, 2016a).

With the objective of aligning research and product development to help to achieve the goals of SDG 13 and the Brazilian NDC, this study aims to contribute to the study that the automotive industry's choice of Continuously Variable Transmission (CVT), brings more savings to the consumer and contribute to the sustainable development of the planet than the Planetary Transmissions.

The Continuously Variable Transmission (CVT), imagined by Leonardo da Vinci more than 500 years ago, is the one capable of simulating an infinite amount of gear ratios. It contains a system of two pulleys of different sizes, which are interconnected by a metal belt of high resistance, instead of gears with determined sizes.

In a CVT transmission, torque transfer is done by friction between a belt and two pulleys. The torque transmission capacity of the CVT is directly related to the axial forces of the primary and secondary pulleys, these forces are the result of hydraulic pressure from the transmission pumping system. This hydraulic pressure plus the friction of the metal belt with the pulleys are the main points of efficiency losses: oil pump / hydraulic actuation system that works between 50 and 70 bar (a Planetary automatic transmission is less than half of this pressure) and the very high friction torque transmission (in order to prevent slipping). Thus, due to these two points, the efficiency of a CVT is 10% to -20% lower than an automatic transmission by planetary. (Dias, Joao. 2011, page 2).

Furthermore, there is a general consensus that a CVT transmission, when compared to automatic planetary transmissions, presents an advantage in relation to fuel consumption. This is due to the fact that CVT has a “continuous” gear shift, making it possible to keep the engine working in “optimal” regions of torque and power (Ji, J., He, B., and Yuan, L., 2017, pag . 1).

It is important to note that, in a continuously variable transmission (CVT), the ratio continuously changes between its maximum and minimum values (Span), a characteristic that disassociates the engine's speed (rotation) from the vehicle's speed. This feature allows an additional degree of freedom to accompany the ideal engine operation line (OOL- Optimal Operation Line) and thus operate in a region of greater efficiency. However, for automatic transmission by planetary gears, which have defined gears (“gear sets”), gear changes can only contribute to the operation of the engine in areas “close” to its ideal region.

This difference between them allows an improvement of 5% to 15% in fuel economy for a vehicle with CVT transmission, when compared to a vehicle with automatic transmission for planetary (stepped gears). Especially when the maximum speed of the vehicle is relatively low, it can be seen that the improvement in fuel economy is more significant.

In addition, as the number of gears ("gear sets") of an automatic planetary transmission increases and the interval decreases, such as an 8/9 or 10-speed transmission, the influence of the types of "gear changes" (planetary staggered and continuously variable) in the efficiency of the engine operation is reduced. In addition, the improved fuel economy of CVT vehicles is not very clear, as the efficiency of the planetary transmission is greater due to less hydraulic loss. (Ji, J., He, B. and Yuan, L., 2017, page 1).

Thus, the intention of this study was to compare CVT automatic transmissions with planetary automatic transmissions, in vehicles sold in Brazil, where E27 and E100 fuels are applied, using INMETRO's homologation data for consumption and emissions, and to analyze the best correlation methodology.

To exemplify, in the graphic of the “sawtooth diagram”, the scaling of a manual transmission (planetary transmissions behave in a similar way) can be compared with the curve of a CVT transmission.

Image taken from magazine “Autoentusiastas”, of September 30, 2018, and modified by the author of this project.

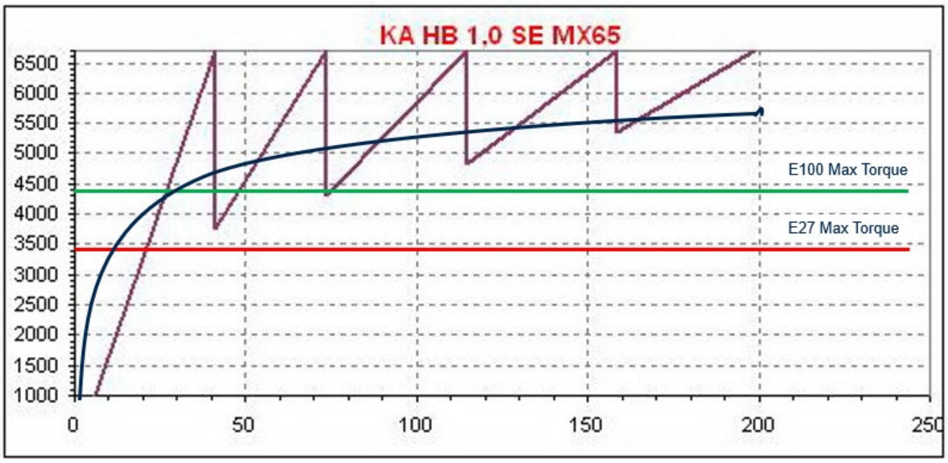


Gráfico dente de serra do novo câmbio manual MX65 do Ford Ka

2. METHODOLOGY

• Initially, a bibliographic search was carried out in order to identify results of studies where they were evaluated: fuel consumption as a reason for choosing CVT transmission to equip vehicles; comparisons of types of automatic transmissions regarding fuel consumption and atmospheric emissions and efficiency studies of CVT transmissions.

• Obtaining consumption and emissions data will be extracted from back 2011 the annual publication of vehicle homologation issued by INMETRO (National Institute of Metrology, Quality and Technology – “Instituto Nacional de Metrologia, Qualidade e Tecnologia”);

• The choice of the "Fuel consumption / energy efficiency table for automotive vehicles", applied by INMETRO for vehicles sold in Brazil, is due to the standardization of data from various sources (automakers), such as same test procedures. Results are shown in km / l (kilometers per liter) taken under same standard laboratory conditions (NBR7024) and adjusted for the most common simulated conditions of use (applications).

• The research was consisted in four parts: (i) collecting information through the INMETRO website: http: //www.inmetro.gov.br/consumidor/pbe/veiculos_leves_(back to 2011); (ii) summarize in a data file; (iii) selection of vehicles with automatic transmission; and (iv) separation by type of automatic transmission and type of fuel (CVT and planetary automatic transmissions).

www.inmetro.gov.br e www.conpet.gov.br

Marca	Modelo	Versão	Motor	Transmissão Velocidades (nº) Manual (M) Automática (A) Automática Dupla Embreagem (DCT) Automatizada (MTA) Contínua (CVT)	Ar Cond. Sim (S) Não (N)	Direção Assistida Hidráulica (H) Mecânica (M) Elétrica (E) Eletro-hidráulica (E-H)	Combustível Etanol (E) Gasolina (G) Flex (F) Diesel (D)	Emissões no Escapamento – Poluentes NMHC (g/km)	Poluentes CO (g/km)	Poluentes NOx (g/km)	Poluentes Redução Relativa ao Limite	Gás Efeito Estufa – Etanol CO_2 fóssil (g/km)	Gás Efeito Estufa – Gasolina ou Diesel CO_2 fóssil (g/km)	Quilometragem por Litro – Etanol Cidade (km/l)	Etanol Estrada (km/l)	Gasolina ou Diesel Cidade (km/l)	Gasolina ou Diesel Estrada (km/l)	Consumo Energético (MJ/km)
Mercedes-Benz	A250		2.0 - 16V	DCT 7	S	E	G	0,017	0,136	0,009	A	\	112	\	\	10,5	14,6	1,81
Mercedes-Benz	AMG CLA 45 4MATIC		2.0 - 16V	DCT 7	S	E	G	0,008	0,598	0,010	A	\	142	\	\	8,4	11,6	2,31
Mercedes-Benz	CLA200 FF		1.6 - 16V	DCT 7	S	E	F	0,026	0,120	0,008	B	0	119	7,1	9,0	10,3	13,2	1,92
Mercedes-Benz	CLA250 4MATIC		2.0 - 16V	DCT 7	S	E	G	0,014	0,113	0,010	A	\	127	\	\	9,2	13,5	2,05
Mercedes-Benz	CLA180		1.6 - 16V	DCT 7	S	E	G	0,016	0,101	0,011	A	\	110	\	\	11,2	13,7	1,78
Mercedes-Benz	AMG GLA 45 4M		2.0 - 16V	DCT 7	S	E	G	0,014	0,287	0,017	B	\	146	\	\	8,2	11,2	2,36
Mercedes-Benz	GLA200 FF		1.6 - 16V	DCT 7	S	E	F	0,025	0,146	0,010	B	0	122	6,9	8,8	10,0	12,7	1,98
Mercedes-Benz	GLA200 FF	STYLE	1.6 - 16V	DCT 7	S	E	F	0,025	0,146	0,010	B	0	122	6,9	8,8	10,0	12,7	1,98
Mercedes-Benz	GLA250		2.0 - 16V	DCT 7	S	E	G	0,014	0,098	0,010	A	\	129	\	\	9,3	12,4	2,10

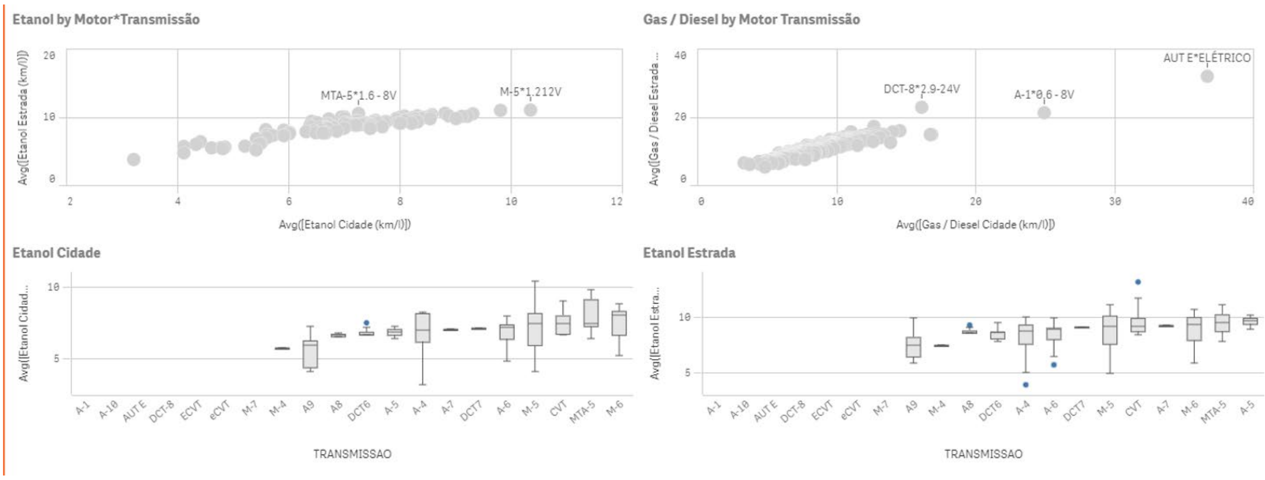
Example extract from “Fuel consumption / energy efficiency table for automotive vehicles", applied by INMETRO

• The vehicles selected in the search was classified by type of fuel and engine: Ethanol, Gasoline and engine capacity.

• Developmental of a model, using a cluster system (based on Qlik Sense Software) in order to understand the collective behavior of each type of transmission studied here (planetary and Continuously Variable).

3. RESULTS AND DISCUSSION

Per a dispersion graphics, we were able to plot a regressive equation for fuel economy (average, highway and city) combined for ethanol and gasoline, also vehicles efficiency and emissions gases. (Below Application plotted).



4. CONCLUSION

Through the development of the research was expected:

1) Understand, through a diverse sampling (based on Brazilian market), if the CVT advantage regarding fuel consumption would be confirmed;

2) Identify the possibility of extending to a second study, focusing on advantage in emissions figures, a better match engine x application x CVT (ie: hybrid or a more efficient Flex/Ethanol fuel engines

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