ALNÁISIS DEL RENDIMIENTO DEL TREN DE POTENCIA PARA EL SERVICIO DE TAXIS URBANOS DE LA CIUDAD DE IBARRA.

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Abstract - *The present work of degree has as objective to realize an Analysis of the performance of the power train for the service of urban taxis of the city of Ibarra, due to causes like; selection of a vehicle by taxi drivers' tradition without having technical knowledge, high fuel consumption due to inadequate cylinders, high cost of maintenance of parts or parts due to oversizing, among others. Given this fact, the need arises to provide technical guidelines and minimum compliance requirements to the regulations of the organic law of land transport, traffic and road safety CNTTTSV. In addition to showing the technical selection of each powertrain element, as well as the factors considered for the analysis of performance such as: start capacity and climb capacity on slopes, this enables training of members of taxi cooperatives in the selection of vehicles and the appropriate power train to achieve optimum mechanical and energy performance, which is adapted to the geographical conditions of operation of the vehicles on the highways of the city of Ibarra.*

Keywords: *power train, gradeability, startability, characteristic curves, tires, power train calculation*

INTRODUCTION

The selection of vehicles destined for taxis in the city of Ibarra is usually done in an indiscriminate manner, without taking into account the urban and suburban geography of the city, specifically regarding components of the powertrain. Given this, there is a need to provide guidelines to help current taxi owners who wish to renew their units and future members of the different taxi cooperatives in the city, to select their vehicle observing technical parameters to achieve better mechanical performance and energetic.

In order to carry out this project, a documentary study of the units that make up the taxi park of the city of Ibarra should be carried out first. With this universe, a statistical study can be carried out which is expected to obtain as a result, the most frequently used units. One of these units will be taken and the most frequent routes and the most unfavorable routes for the units will be analyzed. Finally, with this data set, it will be possible to study the reliability of the power train available in these units

Geographical context of the city of Ibarra

Ibarra is the capital of the province of Imbabura, is located in the sierra region to the north of Ecuador, in a valley of temperate climate, its average geographic altitude is 2220 m s.n.m. since 1945 m s.n.m. in the lower part and 2347 m s.n.m. in the highest part of the urban area, with wide variations in the area of rural influence reaching around 3000 m s.n.m. in the surrounding areas that are found on reliefs formed by the Imbabura Volcano, the Floral Massif, the Campiña Ibarreña and the Caranqui Plain. Covers a surface of

12,329

Taxi service in the city of Ibarra

This study makes it possible to quantify the car park of taxis in the city of Ibarra. With this universe, it was possible to carry out a statistical study from which the most frequently used units were obtained as a result, thanks to the information of the Public Mobility Company of the North in Working together with the guild of taxi drivers of the city of Ibarra. Where Ibarra's Taxi car park currently consists of 46 conventional taxi cooperatives and 14 executive taxi cooperatives, with a total number of 1253 units'. *Tren de potencies of the car*

The powertrain of a vehicle is the set of systems and elements that allow to transform the internal energy of the fuel that is introduced in the engine into work and movement of the vehicle, through a series of thermochemical transformations of the energy provided by the fuel

Table of vehicles considered as taxis in the city of Ibarra.
In the table you can see the most used brands in the city of Ibarra providing the taxi service as you can see the brand that most demand is Chevrolet then we have Nissan that are the brands with more demand with their traditional vehicles such as the sentra B1 and the Aveo family.

Marca	Unidades	Porcentaje %
Chevrolet	425	33,97
Nissan	289	23,10
Kia	241	19,26
Hyundai	196	15,67
Renault	39	3,12
Great wall	25	2,00
Skoda	8	0,96
Toyota	4	0,64
Volkswagen	4	0,32
Citroen	2	0,32
Ford	2	0,16
Lifan	2	0,16
Daewoo	1	0,16
Peugeot	1	0,08

Then we have the calculation of slopes

Arcángel	2360	13,11
	2373	
Atahualpa	2240	4,00
	2244	
Azaya	2248	20,41
	2268	
Caranquí	2290	10,05
	2300	
Imbaya	2065	8,03
	2073	

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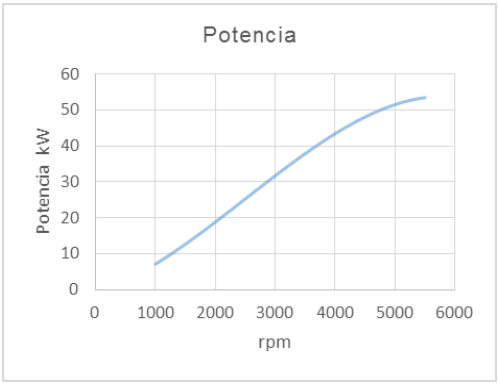
El retorno – Plaza de Toros "La Candelaria"	2293	11,07

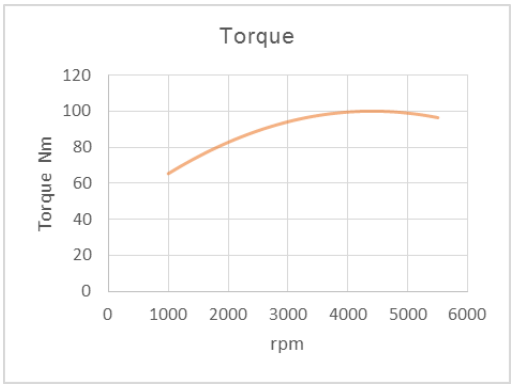
For slope calculation it is necessary to know point 1 and point 2 in meters above sea level, with the help of a GPS, the points are separated by a distance "a" of 100 meters, the difference of heights between the point 2 minus point 1 results in the distance "c", through the Pythagoras equation is the value of "b". Finally, the slope value is established with the following equation:

$$\text{Pendiente} = \frac{c}{b} * 100\%$$

Calculated curves of the vehicle Kia Rio 1.4

For the Rio 1.4, a maximum power of 53kW was obtained at 5500rpm and a maximum torque value of 100Nm at 4400rpm. We used the same methodology framed by the trend line of the values





THE MATH

To calculate the gear ratios in a box with independent differential:

$$Rt = \frac{Z1}{Z2}$$

For the selection of the engine is considered as the first approximation the power required to move the unit and to overcome the aerodynamic drag of the front area of the vehicle

$$Pe = 12.03\,A + 2.033\,PBV$$

It is necessary to find a relationship with which the vehicle reaches the maximum allowed speed within the specific fuel consumption area.

$$Pd = \frac{60\,Cll*(Rcm + 200)}{1000\,Pu\,Vr}$$

The starting capacity is expressed in percentage, must be between 20% and 30% depending on the geographical conditions of the terrain. If this criterion is not met, the torque required to perform it is calculated and another cycle is started.

$$S = \frac{T * Pd * P1 * Rll}{10.7 * PBV}$$

It is the ability to overcome roads that are in slopes with the vehicle at full load.

$$G = \frac{37{,}5 * Pr}{PBV * 10^{-3} * Va}$$

This formula sums up all external conditions and subtracts the nominal power

$$Pr = P - (Prr + Pra + Pri)$$

It is the power that the engine must generate in order to overcome the bearing resistance

$$Prr = Va \cdot (7.69 \cdot Va)\left(\frac{PBV * 10^{-3}}{375}\right)$$

This factor constitutes the necessary power that the engine must generate to overcome the forces due to the friction between the air molecules and the vehicle body.

$$Pra = [\,0.002 * Va^3 * (h - 0.75)(w)]\left(\frac{fa}{375}\right)$$

Geographic altitude is the distance between the point of geo-location and the level of the sea.

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$$fa = \left(-2464.71\ x\ 10^{-8} \cdot \frac{msnm}{0.3048}\right) + 9810^{-4}73.53x$$

This factor constitutes the necessary power that the motor must generate to overcome the inertia of the rest.

$$Pri = (nM \cdot PBV) + nB$$

It is the linear velocity of displacement in the wheel.

$$Va = \frac{D \cdot rpm}{Pd \cdot Pt1 \cdot 336}$$

It constitutes the radius of the wheel, measured from the center of the rolling axis, to the outermost edge of the tire

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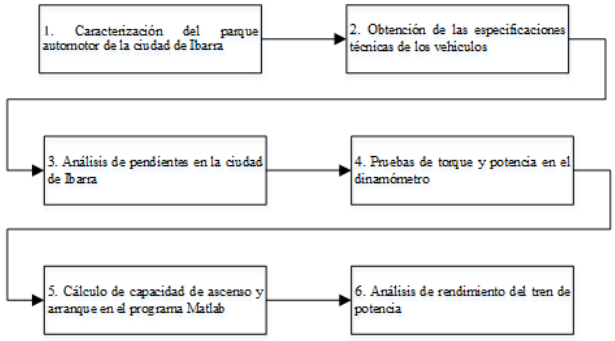
$$\text{Rdin} = \frac{\text{rin}}{2} + \frac{\text{ar.hr}}{100} + \text{tolrin}$$

THE UNITS

MAGNITUD	UNIDADES
Pe	[Kw]
A	[cm2]
PBV	[kg]
Pd	[s/u]
Cll	[plg]
Rcm	[rpm]
Vr	[km/h]
S	[%]
T	[Nm]
Pl	[s/u]
G	[%]
Va	[km/h]
P	[kW]
Pr	[kW]
Prr	[kW]
Pra	[kW]
Pri	[kW]

DEVELOPMENT OF THE PROPOSAL

This table will explain the main steps, which we carried out in the development of power train analysis for urban taxis in the city of Ibarra.



Technical specifications KIA - Rio 1.4

The Kia Rio 1.4 is a vehicle of Korean origin, like the Aveo, has a four-door sedan body, has a four-star safety rating of five possible according to Euro NCAP, which qualifies the safety of vehicles before a simulated frontal impact test. It is powered by a double-camshaft twin-camshaft engine, each with two inlet valves and two exhaust valves.

Motor	
Desplazamiento [cm³]	1339
No. de Cilindros	4
No. de Válvulas	16
Potencia [kW@ rpm]	72.33 @ 6000rpm.
Torque [Nm @ rpm]	119.3 @ 4256 rpm
Relación compresión	9.4:1
Diámetro x carrera [mm]	75,5X78,1
Transmisión	
Tipo	Mecánica 5 vel.
Relaciones	
1.°	3.615
2.°	2.053
3.°	1.370
4.°	1.031
5.°	0.837
Reversa	3.583

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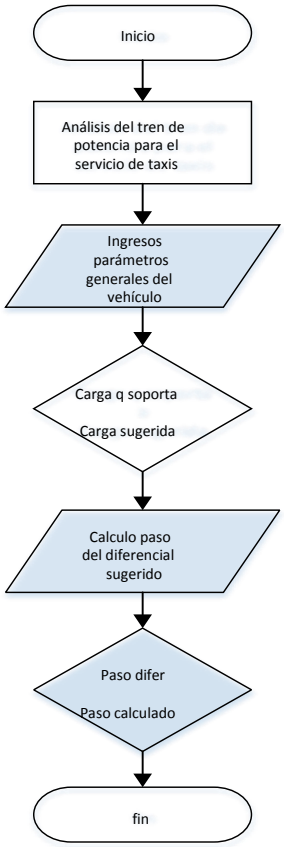
Axis final ratio	4.056
Number of teeth cone	16
Number of crown teeth	70
Tires	185/60 R15

to define their context.

Pesos y Capacidades	
Peso vacío [kg]	890
Peso bruto vehicular [kg]	1390
Capacidad de carga [kg]	500
Volumen en área de [l]	382
Tanque de combustible [l]	45.5
Capacidad de pasajeros	5

Flujograma de procesos para el código de programación

Para facilitar la comprensión de los procesos que se realizan en el **código**, se puede escribirlos en forma de diagrama de flujo, indicando los pasos a seguir durante cada etapa del proceso. A pesar de ser uno solo, se lo ha separado en partes



MATLAB ANALYSIS PROOF AND EXECUTION OF THE PROGRAM OF POWER TRAIN PERFORMANCE

For the operation of the powertrain program, the software is entered and the file "Powertrain Analysis Programming" is executed, the "Editor" screen is displayed, where the programming lines are displayed and we select the values obtained in the technical specifications of the Z

```
"INGRESE LOS DATOS DEL NEUMÁTICO"
- La carga mínima sugerida que debe soportar el neumático es: 374.5[Kg]
- Carga que soporta la rueda[kg]: 450
- Diametro interior [pulg]: 14
- Ancho de la rueda[mm]: 185
- Alto de la rueda[%]: 60
- Tolerancia radio dinámico(sugerido +10%)[%]: 0
```

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then we ingrate the parameters of the vehicle where we ask the gross vehicle weight the width, height, number of wheels and height above sea level where the study is being done.

```
"INGRESE LOS PARÁMETROS GENERALES DEL VEHÍCULO"
- Peso Bruto Vehicular PBV [kg]: 1498
- Ancho del vehículo[m]: 1.495
- Altura del vehículo [m]: 1.670
- Número de ruedas del vehículo: 4
- Altitud sobre el nivel del mar de Ibarra[m]: 2220
- Velocidad reglamentaria de circulación ANT [km/h]: 50
- Pendiente máxima del terreno(sugerido 30%)[%]: 23.4
```

Then the tire data is entered based on the manufacturer's specifications and the load index preference by the guild of the taxi drivers:

```
"INGRESE LOS DATOS DEL NEUMÁTICO"
- La carga mínima sugerida que debe soportar el neumático es: 374.5[Kg]
- Carga que soporta la rueda[kg]: 450
- Diametro interior [pulg]: 14
- Ancho de la rueda[mm]: 185
- Alto de la rueda[%]: 60
- Tolerancia radio dinámico(sugerido +10%)[%]: 0
```

An average of the minimum load index to support the gross vehicle weight PVB, is load IC 80, according to tire specifications the indicated load index supports up to 450 kg, data according to wheel measurements, width and height of profile, additionally the dynamic radius is considered a value of zero, due to the low regulated speed of circulation.

Then enter the gearbox values as indicated by the manufacturer's specifications:

```
"INGRESE LOS DATOS DE CAJA DE CAMBIOS"
- La capacidad de carga de la caja debe ser mayor a: 1498[Kg]
- Capacidad Carga Maxima[kg]: 1498
- Relación de 1ra marcha: 3.545
- Relación de última marcha: 0.763
- Capacidad Torsional[N.m.]: 127.4
- Número de marchas: 5
```

Then the differential data is entered based on the manufacturer's specifications:

```
"INGRESE LAS RELACIONES DEL SISTEMA DIFERENCIAL"
- La relación del diferencial sugerida es: 7.7054
- Relación del diferencial: 4.25
- La capacidad mínima de carga sugerida para el diferencial es: 1498[Kg]
- Capacidad de carga del diferencial[kg]: 1498
```

Considerado los parámetros calculados se procede a la validación de los mismos como se indica en la siguiente figura.

```
===== VERIFICACIÓN DE RESULTADOS ======
- Las ruedas soportan el peso del vehiculo: SI
- La caja soporta la carga generada por el peso del vehiculo: SI
- La Potencia del Motor es mayor o igual a la Potencia sugerida: SI
- La caja de cambios soporta el Torque del Motor: SI
- El diferencial soporta la carga generada por el peso del vehiculo: SI
- El Paso diferencial es menor o igual al Paso sugerido: SI
- La Velocidad máxima del vehículo es mayor que Velocidad permitida+15km/h: SI
- La Capacidad de Arranque(Startability) es mayor o igual a 23.4%: SI
- La Potencia de Reserva es mayor a 0: SI
- La capacidad de Ascenso(Gradeability) es mayor o igual a 28.4%: SI
```

After verification of results and read whether it meets or does not meet the selection of powertrain components, the program gives the option to continue the analysis. When continuing with the analysis, the program provides the option of entering parameters and values to generate the graphs that normally provides the manufacturer or that in our case study was obtained in a specialized dynamometer with respect to curves of power, torque, these come given from 2000 RPM, the data entered with respect to final maximum power RPM is given by the manufacture

```
Desea seguir el análisis del tren?(y/n): y

Ingrese el intervalo de RPMs para la grafica(múltiplos de 100)
La RPM inicial(sugerido 800 RPM): 1000
La RPM final(sugerido RPM Pot max): 5000
El intervalo de RPM(sugerido 100 RPM): 100
```

When following the analysis, it is essential to enter the gear ratios of the gearboxes, in order to establish the speed curves, in our case the vehicles analyzed are all 5 gears, where the values entered are those provided

```
Ingrese los datos de la CAJA DE CAMBIOS
Relación de 2da marcha: 1.952
Relación de 3ra marcha: 1.276
Relación de 4ta marcha: 0.971
Relación de 5ta marcha: 0.763
```

The program then requests the necessary data to be able to make the graph corresponding to torque or motor torque, according to the parameters and values already established previously. The program then displays the power, torque and consumption curves according to RPM.

Analysis of data obtained from powertrain

Rise is 27.92% above the outstanding value that can be found in the city Ibarra and its surroundings.

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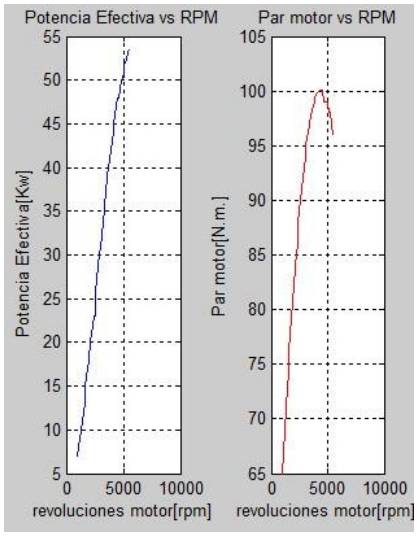
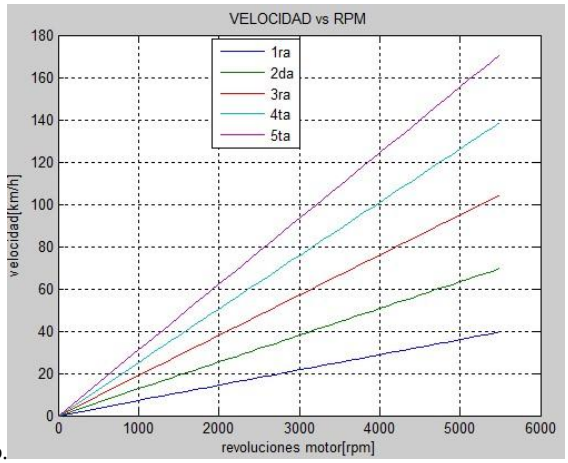
Calculated parameters	Rio 1.4
Maximum speed [km/h]	170.9446
Boot capacity [%]	50.103
Velocidad Aparente [km/h]	31.6638
Power to overcome bearing resistance [kW]	1.2924
Altitude Factor	0.80784
Power to overcome aerodynamic drag [kW]	0.55595
Power to overcome resistance by inertia [kW]	3.2103
Power reserve [kW]	38.5044
Climbing Capacity [%]	27.9195



VEHICLE LINEAR SPEED VS KIA RIVER MOTOR ROTATION SPEED 1.4

IN THE LINEAR SPEED OF THE VEHICLE VS. SPEED OF ROTATION OF THE ENGINE OF THE KIA RIO 1.4, VALUES CAN BE READ THAT REACHES SPEEDS OF 158 KM / H IN ZERO SLOPE TO 5000 RPM IN ITS LAST MARCH, WHICH MEANS THAT IT EXCEEDS REGULATORY SPEED IN THE SECTOR URBAN, PERIMETER AND



ROAD.

KIA RIO 1.4 POWER, PAR AND CONSUMPTION CURVES

THE POWER CURVE DELIVERED BY THE DYNAMOMETER SHOWS A MORE ACUTE BEHAVIOR, STARTING AT 1000 RPM UP TO 5500 RPM, WHERE THE ANALYSIS IS CUT OFF. THE MAXIMUM VALUES ARE BORDERING THE 53 KW FOR POWER AND 100 NM IN TORQUE WITH AN ANGULAR SPEED OF THE ENGINE OF 4300 RPM.

LINEAR SPEED ANALYSIS BY MARCHING FOR THE KIA RIO 1.4

THE FIRST GEAR IS IN BLUE COLOR, WHICH IS OPERATIVE IN THE RANGE OF 0 TO 40 KM / H; GREEN IS OBSERVED AT THE SECOND GEAR, WHICH IS OPERATIVE BETWEEN 15 TO 65 KM / H. THE THIRD GEAR FROM 20 TO 110 km/h, de color cian está la cuarta marcha desde 25 a 145 km/h y de color purpura la quinta entre 35 a 170 km/h.

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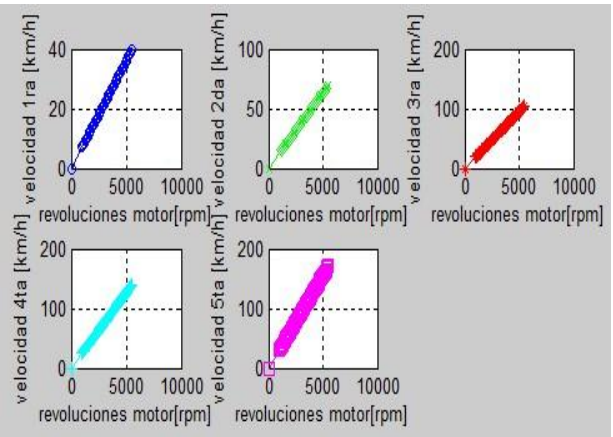
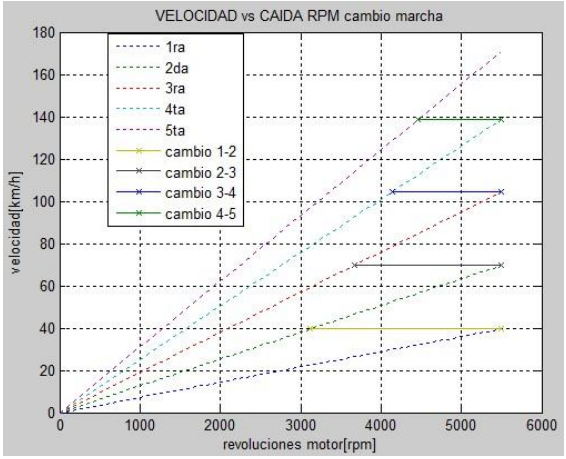


I. SPEEDS AGAINST THE FALL OF REVOLUTIONS OF THE KIA RIO 1.4

IT IS SEEN THAT IN THE CHANGE OF FIRST TO SECOND GEAR THERE IS A FALL FROM 5500 TO 3100 RPM, WHEN REACHING THE MAXIMUM SPEED OF 40 KM / H. IN THE SECOND TO THIRD GEAR SHIFT, IT DROPS FROM 5500 TO 3600 RPM WHEN IT REACHES THE TOP SPEED OF 65 KM / H, IN THE 3RD TO 4TH GEAR SHIFT, IT DROPS FROM 5500 TO 4100 RPM WITH A SPEED OF 110 KM / H AND IN THE GEAR SHIFT FROM FOURTH TO FIFTH, FALLS FROM 5500 TO 4400 RPM, WITH A TOP SPEED OF 140 KM / H.



APACITY OF RISE AGAINST SPEED OF THE KIA RIVER MOTOR 1.4C

For the Kia Rio 1.4 it can be indicated that a stronger gear is needed when the slope of the slope increases and the speed decreases. The maximum Gradeability of the Kia Rio
1.4 is 28% in first gear. In spite of its low cylinder exceeds with 5% more the value of the maximum slope of the city of Ibarra.

ANALYSIS OF PERFORMANCE IN THE MAXIMUM PERFORMANCE.

The following table shows the performance of the cars in analysis, taking as reference the highest slope of the city of Ibarra, which corresponds to the one located in the sector of Azaya, the value of this slope is 20.41%.

Model	Chap. of ascent mx. m %	Pending in Azaya 20%	March in the that is ascent	About dimensioning m%
Sentra B13	37%	Meets	1ra y 2da March	17%
Aveo Chevytaxi	45%	Meets	1ra y 2da March	25%
Rio 1.4	28%	Meets	1ra March	5%
Aveo active	35%	Meets	1ra y 2da March	15%
Accent 1.6	65%	Meets	2da y 3ra March	45%

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ANALYSIS OF VEHICLE POWER TRAIN RESULTS * 1

The following table shows fuel efficiency and CO2 emission. Where we can appreciate

* ***Information taken from www.ecovehiculos.gob.mx.***

that the highest fuel efficiency is for the Kia Rio 1.4 with a value of 15.7 (km / L) and low CO2 emissions with a value of 114 (g / km).

This information has been taken from the website Eco vehicles that represents a Mexican government research entity to estimate the consumption data and pollutant emissions of vehicles sold in that country.

This information has been chosen because it is aimed at vehicles that circulate in urban areas and roads in combination, but the conditions of the study are not specified as geographical height or other details.

Quantity	Brand	Model	performance City (km/l)*	Issue CO_2 (g/km)*	CO2 emission by num. of vehicles in eight hours (Ton)
837	Kia	Rio 1.4	15,7	114	22,90

Eco vehicles is a project of the Mexican government that seeks to qualify the range of emissions and energy efficiency of vehicles produced for the domestic market in the country. The information provided by this web portal is obtained from reliable sources such as the Federal Office of Environmental Protection (PROFEPA), which collects the information provided by the automotive manufacturers.

Conclusions

- Based on the geography of the city of Ibarra, it is established that the minimum starting capacity of a vehicle for urban taxi service is 20%.
- Based on the capacity to start and fuel consumption, it is established that the ideal model to drive in the city of Ibarra providing the taxi service is the Kia Rio 1.4
- According to the quantitative analysis carried out with the program, it is verified that all vehicles exceed the minimum requirements established to be able to circulate in complicated geographies such as our ciudad.
- It is estimated that if all the taxi units were replaced, vehicles with a minimum displacement such as the Kia Rio 1.4 would obtain a fuel consumption of 3380 gallons in eight hours, generating an emission of 22.9 tons of CO2, in counter position to the 31.75 tons are estimated to be generated currently, resulting in a reduction of 27.87% in pollution.
- The most suitable gearbox and differential ratios for vehicles used in the taxi service of the city of Ibarra are those considered by the manufacturer Kia, for its model Rio 1.4. Transmission ratios for different cylinder sizes to 1.4 liters are not analyzed

Recommendations

- The National Transit Agency should update regulations for the taxi service based on hybrid electric vehicle technology. Taking as normative foreign references as is the case of Holland, in order to take care of the environment.
- It is recommended that based on the geography where the automotive will work, a displacement and a gearbox are chosen that allow to circulate at a normalized speed in flat and inclined surfaces, with an efficient consumption of fuel, to do this of collective form will diminish in something the impact on the environment and individual owners will reduce economic costs in automotive maintenance.
- The technical university of the north should have technological equipment as a dynamometer necessary for the analysis and obtaining of curves of real power, torque and fuel consumption in order to homologate with the values of power and torque that the manufacturer delivers in the specifications.
- As new uncertainties arise regarding the behavior of the vehicle at different gear ratios, a powertrain selection study is recommended by varying the behavior of these relationships in order to determine a substantial

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improvement in the capacity of promotion, saving of fuel among others.

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ALNÁISIS DEL RENDIMIENTO DEL TREN DE POTENCIA PARA EL SERVICIO DE TAXIS URBANOS DE LA CIUDAD DE IBARRA.

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