Four steps to improve operational efficiency on Bus & Coach applications

Reducing emissions and operational costs
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December 12, 2015 a historic agreement was signed by 188 countries to limit earth global warming during COP21 Conference in Paris. Amongst the agreements, countries plan to reduce their emission of greenhouse gases. Some countries have committed to ambitious zero emission target for inner city, creating Low Emission Zones, particularly for public transport and service vehicles, providing a cleaner and greener environment.

To achieve these targets, vehicle manufacturers have to re-think the methods that create vehicle movement to reduce emissions by improving efficiencies. Changing the dependency on the Internal Combustion Engine (ICE) by replacing Hydraulic variable displacement pump and compressor drives for example with more efficient electrically driven devices, enables ICE downsizing and emission reduction to begin with.

 Improvements starting with Hybrid vehicles leading to fully Electric vehicles with Zero emissions are possible, and both can benefit from inclusion of electro-hydraulic steering particularly within bus & coach.

In the following paper we review the different steps of steering efficiency improvement up until the latest of today’s solutions.

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Working in the high efficiency electric motor area for more than 25 years respectively in production, design, industrialisation, quality and marketing. He is now in charge of developing the electric technology for Hybrid and Electric Vehicles in Europe for Parker Hannifin.
The first power steering system was originally designed with a variable displacement hydraulic pump driven by a belt connected to the Internal Combustion Engine (ICE). The variable displacement pump is necessary to be able to assist the steering even when the ICE is idling; a hydraulic load sensing valve is used to provide the correct fluid displacement, which produces inefficiency in the form of a pressure drop of between 20 and 30 bars in the system.

In fact even the best belt system has a 98% efficiency and therefore also adds to the losses in the system. Having the pump located near to the ICE at the rear of the bus and the steering device at the front, the hydraulic circuit and its multiple connections create a potential for a further pressure drop of approximately 10 Bar due to the circuit complexity associated with length of the pipes and potential leakages. With the hydraulic pump being installed alongside the ICE, should there be any oil leakage there is always a risk of fire. Euro 6 engines are known to run at higher temperatures than previous designs thus also increasing the potential fire risk. Originally the ICE was sized to provide the power for traction and to develop additional auxiliary power for hydraulic and pneumatic functions on the bus. However new technological improvements can lead to ICE downsizing, resulting in the reduction of emissions and fuel consumption by lowering the dependency to drive multiple functions other than traction.
Standard assisted steering

Hydraulic pump driven by a PTO

The second power steering system was almost identical to the first apart from the fact that the variable displacement pump was no longer driven by a belt, but by a Power Take Off (PTO) drive from the ICE. The introduction of the PTO drive provided a reduction in losses and maintenance operations linked to the belt in comparison to the previous system and therefore the interest to implement the change without complicated engineering modification was easily adopted.

But again, having the pump located near to the ICE at the rear of the bus and the steering device at the front, the hydraulic circuit and its multiple connections create a potential for a further pressure drop of approximately 10 Bar due to the circuit complexity associated with length of the pipes and potential leakages.
Assisted steering system

The third power steering system brings us in to the Hybrid or Electric age, however at present it cannot be considered as a standard system, but is a strong improvement compared with the previous two options.

In this case as there is an electric energy storage system (battery) that is recharged by a generator driven by the ICE, there is no longer a need to consider the maximum steering power in the ICE selection, but only the average one. This allows OEMs to downsize the ICE and to reduce the associated emissions and fuel consumption.

When it comes to Hybrid or Electric buses there will always be a high voltage / power battery for traction. This energy source can be used to electrically drive the hydraulic pump and remove its direct connection to the ICE.

Due to the energy storage contained in the battery, the speed of the electrical motor can be varied to provide a variable output flow and therefore allow the use of a lower cost fixed displacement pump in place of a variable displacement one and its load sensing valve. As a result the Hydraulic circuitry is simplified and the associated losses are reduced.

The simplest way to introduce an electric motor was to use an induction variant that was quite common and cost effective. However induction technology leads to large motors that had often to be installed at the back of the bus, close to the ICE in an extreme temperature environment creating electric motor cooling issues.

Even if fire risk is far lower, with the motor + pump + hydraulic connections remote from the ICE, the hydraulic connections from the rear to the front steering box still produce a pressure drop of around 10 bar.
Assisted steering system

The fourth power steering system is still part of the Hybrid or Electric domain.

A new range of Permanent Magnets AC motors (PMAC) dedicated to Mobile applications have been recently developed. These bring several advantages when compared to the previous solution.

Due to PMAC’s efficiency level and the physical motor size reduction, it allows it to be installed at the front of the bus, improving the system efficiency (Reduced Pressure losses) due to the shorter hydraulic connections from pump to the steering box.

With the low losses associated with PMAC motor technology it enables us to utilize a low voltage steering Electro Hydraulic Pumps with a high protection level (IP6K9K) developed for mobile applications.
Two different pump technologies can be implemented in the system depending on the customer main interest. A vane pump technology for a better hydraulic efficiency or an helical gear pump technology for a lower noise level.

A DC/DC converter is required to convert from HV to LV (typically 24 VDC), the low voltage drive is far cheaper and better suited to this application than the high voltage version. It also delivers a higher safety level in case of high voltage energy storage failure.

This provides the benefit to connect the electrical drive onto the standard 24 VDC battery used for all the bus auxiliaries for safe emergency recovery service.

In trolley bus applications, when passing over the crossroads (due to the lack of high voltage energy availability), there are 2 ways to ensure steering function remains operational.

- Switch hydraulic steering fluid via a diverting valve with supply provided by High Voltage or Low Voltage Electro Hydraulic Pump (EHP) depending on the available voltage. In this case 2 EHP’s and a hydraulic diverting valve are needed

- Utilize Single low voltage EHP with a primary low voltage system converted from the High Voltage supply that can be switched to the low voltage auxiliary battery supply to maintain steering operation on crossroads.

Currently this fourth solution is the most efficient one that can be implemented within standard Hybrid or Electric bus / trolley bus applications. It typically allows the driver different steering assistance levels depending on the area the bus is moving within.

Electric Generator driven by the Internal Combustion Engine plus an Electro Hydraulic Pump for steering function
Steering system in Bus & Coaches

Future trends and Drivers

Today, 54 per cent of the world’s population lives in urban areas, a proportion that is expected to increase to 66 per cent by 2050, bringing with it the challenges of sustainable urban mobility within the mass public transport system to support economic growth and with improved transport modes come the environmental challenges. Electrification of light vehicles such as vans, trucks and buses, will help EU Member States to meet greenhouse gas emission reduction targets for 2030. Moreover, emissions in urban centres could be halved by 2050 and zero-emission urban logistics could be attained by 2030 with a shift to electro-mobility beginning with e-steering solutions.

E-Steering will develop through the various stages as vehicles move towards modes with full electrical drive as discussed. Future improvements for the OEM would be a more ergonomic electrically controlled system providing the hydraulic power for steering.

In the longer term we could envisage the removal the steering box system with the introduction of a four-quadrant pump, which provides hydraulic flow only when required. Therefore, either a very small amount or no power would be required for steering when driving on straight roads such as motorways, providing improved system efficiency.

The Electro-Hydraulic Pump introduction in bus & coach steering is a first step in the vehicle hybridisation process that will lead to its complete electrification helping EU Member States to meet greenhouse gas emission reduction targets for 2030.

About Parker

Parker designs and manufactures a broad array of hybrid and electric vehicle drivetrain motors with maximum power density, highest efficiency, and broad scalability.

At Parker we understand that each vehicle electrification application brings with it unique requirements and demands. We can support your vehicle development goals by delivering high performance solutions in the areas of electro-hydrostatic systems, electric and hybrid electric drivetrain systems and auxiliary vehicle systems, such as pumps and compressors.

For more information http://solutions.parker.com/mobile