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A Predictive Model for Diesel Particulate Filter (DPF) Aftertreatment System

Introduction

Running a modern fleet, whether it's a small one with 200 vehicles or a large enterprise fleet with 10,000 vehicles, has two main goals: making operations efficient and minimizing downtime. To achieve these goals, Pitstop, a fleet maintenance software powered by predictive analytics and AI, plays a central role. Within Pitstop's fleet software, there are models that analyze and predict potential issues with a vehicle's essential parts like the battery, brakes, and engine.

One crucial part is the Diesel Particulate Filter (DPF) in the exhaust system of diesel vehicles. In a recent survey with over 200 fleet professionals, 51% of them pointed to the DPF (or DEF) as the main reason causing breakdowns in their fleets, pointing to being a significant concern in the industry. DPFs are vital for controlling emissions, but they can get clogged with soot, which can seriously hurt engine performance and fuel efficiency if not addressed.

This article takes a deep dive into the important role of predicting DPF soot buildup in keeping a fleet running smoothly. It explains why staying ahead of DPF issues is crucial for reducing maintenance costs, maintaining peak performance, and meeting environmental regulations. We'll explore how the technology works and what it means for the future of fleet management.

In a time when the transportation industry is focused on sustainability and cost-effectiveness, understanding and predicting derates using DPF soot load is a significant step in ensuring that any fleet runs smoothly.

Challenges in DPF Maintenance

Modern diesel vehicles have an aftertreatment system designed to meet emissions regulations. This system includes a critical part called the Diesel Particulate Filter (DPF), which captures soot emitted

by the engine. Over time, the DPF collects this soot, and it needs a process called "regeneration" to turn it into ash and clear the filter.

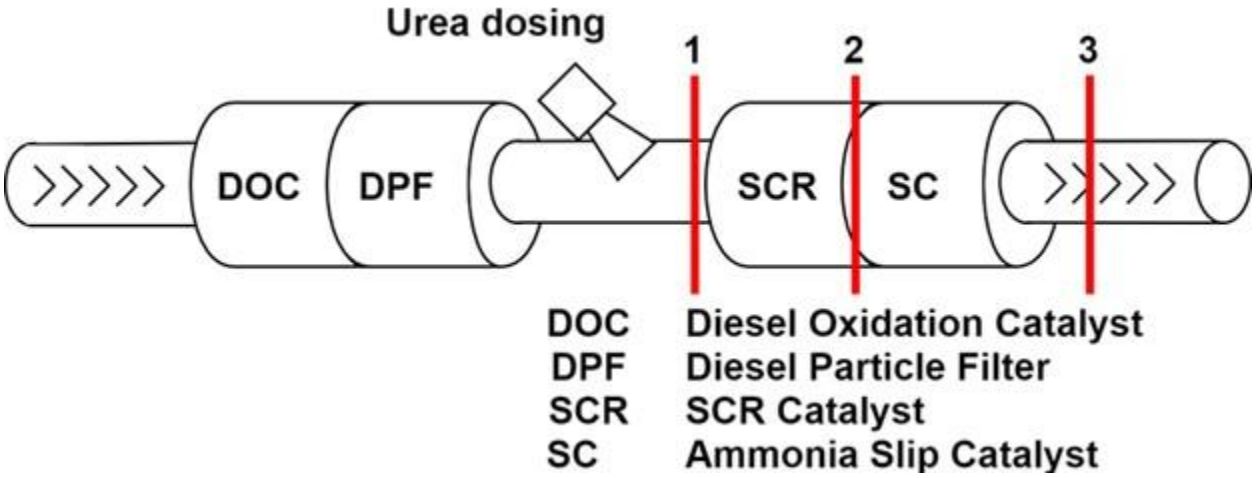

Figure 1 below illustrates the components of the aftertreatment system.

When the soot in the DPF exceeds a certain level, often set by the manufacturer, the vehicle goes into a state called "derate." During derate, the vehicle's computer intentionally limits the engine's power output to prevent further damage and excessive emissions. This limitation means less horsepower and torque, leading to reduced performance and increased fuel consumption. For fleet managers focused on efficiency, a derated vehicle can be a big problem.

The effects of derate go beyond reduced performance. Slower vehicles mean longer routes and lower productivity. The strain on the engine can also increase maintenance costs and potentially damage other engine parts. In the worst case, a derated vehicle might break down, requiring towing and increased safety concerns for the driver.

As a result, reduced efficiency and higher maintenance costs can seriously eat into profits. Managing and predicting DPF soot buildup becomes crucial for fleets looking to cut costs and maintain or improve their operations.

Our Solution: Preventing and Predicting Derate Events

Our main goal with our aftertreatment model is to prevent or predict derate events by continuously monitoring important aftertreatment sensors like DEF fluid level, DPF soot level, and regeneration

status. We also keep an eye on key events like active regenerations to provide the most accurate estimate of the aftertreatment system's condition and predict potential derates.

How It Works

To achieve this, we delve into the intricacies of DPF regeneration, which involves various modes:

- **Passive Regeneration:** Soot is continuously burned off from the DPF without ECU intervention, typically occurring at higher engine loads.
- **Active Regeneration:** When the ECU determines that exhaust temperatures are too low for passive regeneration, it actively increases exhaust temperature (500-650°C) to burn off soot.
- **Parked Regeneration:** Drivers can initiate parked regeneration by parking the vehicle and engaging a switch, causing the engine to rev up and increase exhaust temperature to burn off soot.
- **Forced Regeneration:** Technicians at a shop can perform forced regeneration by connecting to the vehicle via a laptop/diagnostic tool.

These DPF regeneration modes form the basis of our aftertreatment system tracking:

- **Active Regeneration Tracking/Prediction:** By utilizing aftertreatment sensors, we predict if a vehicle is likely to require active regeneration. We also monitor the success of completed active regenerations. Incomplete active regenerations signal a worsening state of the DPF.
- **Parked Regeneration Tracking/Prediction:** Leveraging aftertreatment sensors and the data from active regeneration tracking, we forecast the need for a parked regeneration and assess its success.
- **Forced Regeneration/Derate Prediction:** Combining aftertreatment sensors, active and parked regeneration tracking, and fault code information, we predict the likelihood of a vehicle entering derate mode and needing a forced regeneration.

Additionally, we issue alerts to fleet managers and technicians when our predictive analytics indicate an impending derate event. These alerts serve as early warnings, allowing ample time for proactive maintenance measures to be taken. Typically, the timing for these alerts falls within a 24 to 72-hour window, providing a reasonable timeframe for intervention. However, it's essential to note that the

timing of these alerts may be subject to change based on additional information we may uncover during our monitoring process.

Our approach provides fleets with the tools they need to proactively manage DPF maintenance, ultimately reducing expenses, and ensuring optimal operational efficiency.

Concluding Thoughts

In conclusion, the technology discussed in this article represents a significant step forward in fleet maintenance. Pitstop's commitment to predictive analytics and AI solutions positions us as leaders in the field, dedicated to addressing real-world challenges in the transportation industry.

As mentioned earlier, predicting DPF soot load is just one part of what we do in the Pitstop ecosystem. We believe in a holistic approach to fleet maintenance that considers the entire vehicle lifecycle, not just individual components. By doing so, we're not only improving Diesel Particulate Filters' performance; we're transforming fleet maintenance for fleets of all sizes.

Our technology benefits various stakeholders in your organization:

- **Fleet Managers:** Experience improved efficiency, fewer breakdowns, and better operational control, leading to cost-effective fleet management.
- **Technicians:** Save time on diagnostics and maintenance with our predictive analytics, allowing you to focus on targeted repairs and improvements.
- **Drivers:** Enjoy increased safety and confidence, knowing that your vehicles are well-maintained and less likely to break down unexpectedly during routes.
- **Executives/CEOs:** See a significant decrease in maintenance costs and downtime, directly impacting the bottom line and driving profitability.

At Pitstop, we're not just a solution provider; we're your partner in maintaining efficient, sustainable, and cost-effective fleets. As the transportation industry continues to evolve with a focus on sustainability and operational excellence, Pitstop's commitment to cutting-edge technology and comprehensive solutions remains steadfast. Together, we'll lead the way toward a brighter, more efficient future in fleet maintenance.

Contact us here to book a free 30-minute consultation call with our experts!