Lecture 20
3rd Semester M Tech. Mechanical Systems Design
Mechanical Engineering Department
Subject: Advanced Engine Design
I/C Prof M Marouf Wani

Lecture 20 – Alternative Fuels In CI Engines
Topic: Biodiesel – 02-11-2020

Alternative Fuels For CI Engines

Vegetable Oils.

- The Most Popular Types Of Crops From Which Vegetable oils Can Be Extracted Include Soybeans , Sunflowers , Peanuts , Rapeseed And Chinese Tallow Trees.
- Initially , It Was Believed That Vegetable Oils Could Be Used Directly With Minimal Processing And Preparation. However , Extensive Engine Testing Proved That While Diesel Engines Operated Satisfactorily On " Raw" Vegetable Oils , Combustion Residues And Deposits Would Quickly Cause Problems With Fuel Injectors , Piston Rings , And Oil Stability.
- By Reacting The Raw Vegetable Oils With Methanol Or Ethanol , Esters Are Formed Which Have Much Improved Characteristics As Fuels. These Esterified Versions Of Vegetable Oils Have Been Given The Generic Label Of "Biodiesel".

Biodiesel

- Manufacturers Of Biodiesel Have Been Targeting Transit Bus Fleets To Use A Blend Typically Containing 20% Biodiesel With Diesel Fuel , Known Also As "B20".
- The Favorable Emissions Properties Of Biodiesel Reduce Smoke , Particulates , And Gaseous Emissions When Used In Typical Transit Bus.
- The Major Impediment To Use Of Such Blends Of Biodiesel And Diesel Fuel Is The Cost Of Biodiesel Compared To Some Other Alternative Fuels That Could Be Used , And With Emission Control Hardware For Older Transit Bus Engines. Biodiesel Is Not The Only Alternative Fuel Facing Unfavorable Economics Relative To Petroleum Fuels; However , It Remains A Viable Contender As An Alternative Fuel For Diesel Transportation Engines.

Vehicle Performance And Emissions Characteristics.

- Straight Biodiesel (Soy Methyl Ester) Has A Cetane Rating Significantly Higher Than Diesel Fuel , Slightly Lower Heating Value ,Slightly Higher Viscosity , And Contains Approximately 10 Mass Percent Oxygen.
- The Lower Heating Value Will Cause A Small Loss In Maximum Power If The Engine Fuel System Is Not Recalibrated.
- In A Pre-chamber Diesel Engine Using A Transient Eight-Mode Test , Straight Soy Methyl Ester Showed A Significant Reduction In Hydrocarbon Emissions , No Significant Change In Carbon Monoxide Emissions , A Slight Reduction In Oxides Of Nitrogen Emissions , Reduced Particulate Emissions. These Results May Be Less Favorable If The Engine Were Recalibrated To The Same Maximum Power Output As When Using Diesel Fuel.
- Additional Benefits Of Using Soy Methyl Ester Include Reduced Toxic Emissions , Very Low Sulfate Emissions , And A Much More Pleasant Exhaust Odor.
- These Beneficial Emissions Effects Were Attributed To The High Cetane Value Of Soy Methyl Ester That Caused Reduced Ignition Delay , Earlier Energy Release , And Probably Reduced Peak Flame Temperatures.

Vehicle Emission Characteristics.

- When Biodiesel Is Blended With Diesel Fuel , The Emissions Results Change Somewhat. A Significant Decrease In Hydrocarbon And Carbon Monoxide Emissions Is Typical , No Change Or Small Change In Oxides Of Nitrogen Emissions , And Significant Reduction In Particulate Emissions. Emissions Of Toxins Would Also Decrease According To The Percentage Substitution Of Diesel Fuel.
- Biodiesel Has Inherently Low Sulfur Content That Makes It Well-Suited To Diesel Engines Equipped With Catalysts For Emission Control. Biodiesel Is Competitive With “Clean Diesel” Without Any Additional Modifications.

Vehicle Performance Characteristics.

- On A Mass Basis , Neat Biodiesel Has Approximately 13% Less Energy Than Typical Diesel Fuel. This Loss In Energy Is Caused By The Oxygen Content Of Biodiesel Of Approximately 10%.
- Biodiesel's Higher Specific Gravity Of Approximately 0.88 Compared To Approximately 0.82 For Diesel Fuel Regains Some Of The Loss In Energy On A Mass Basis For An Overall Impact Of Approximately 7% Loss In Energy Per Unit Volume. Thus , An Engine Adjusted For Diesel Fuel Should Experience A Loss Of Power Approximately 7% When Using Neat Biodiesel (Blends Should Experience Power Losses Proportionate To The Blend Level).
- Engines Readjusted To Increase Fuel Injection Quantities At Full Power Should Not Experience Any Loss In Power.
- Because Of The Lower Energy Per Unit Volume , Vehicles Using Neat Biodiesel Should Experience A Loss In Fuel Economy Of About 7% On Average.
- Biodiesel Has Higher Viscosity And Higher Pour Points Compared To Typical Diesel Fuel, Which Could Affect Operation In Very Cold Temperatures. Like Diesel Fuels , Pour Point Additives Are Effective At Decreasing Pour Point.
- Engine Oil Dilution Is A Potential Problem With Biodiesel Since It Is More Prone To Oxidation And Polymerization Than Diesel Fuel. The Presence Of Biodiesel In Engine Oil Cause Thick Sludge To Occur With The Consequence That The Oil Becomes Too Thick To Pump.
- Special Formulations Of Engine Oil Are Being Developed To Minimize The Effects Of Dilution With Biodiesel.

Materials Compatibility

- There Has Been No Indication That Any Of The Metals Currently Used In The Distribution , Storage , Dispensing , Or Onboard Fuel Systems For Diesel Fuel Would Not Be Compatible With Vegetable Oil Fuels. However There Are Reports Of Some Signs Of Incompatibilities With Fuel Transfer Hoses , And Nitrile And Butadiene Elastomers With Methyl Esters. More Testing Is Needed To Fully Define The Elastomers That Are Best For Use With Vegetable Oils.

Comparison Of Physical and Chemical Properties Of Soy Methyl Ester Biodiesel and Diesel.

Fuel Property	Source - Soybean Soy Methyl Ester Biodiesel	Petroleum Diesel
Formula	C_{18} To C_{19}	C_{8} To C_{25}
Molecular Weight	300	200
Composition Weight % Carbon Hydrogen Oxygen	 78 11 11	 84-87 13-16 0
Density , Kg/L	0.87	0.81-0.89
Viscosity MPa-S	3-6	2.6-4.1
Lower Heating Value , MJ/L	32	35-37
Stoichiometric Air-Fuel Ratio	12.8	14.5
Cetane Number	52	40-55

Dated: 02-11-2020

Prof M Marouf Wani

I/C Advanced Engine Design
Mechanical Engineering Department
National Institute Of Technology
Srinagar, J&K
India – 190006

Text Book:

Alternative Fuels Guide Book
Author - Richard Bechtold
Published By: SAE International USA