EXECUTIVE SUMMARY

Depletion of fossil fuels and increase of emissions have alarmed the researchers to think seriously on alternative fuels in order to maintain and provide sustainable development. Vegetable oils have long been considered as attractive alternative fuels to the conventional diesel fuel. Use of vegetable oils provides almost same power output with higher fuel consumption resulting into lower brake thermal efficiency when compared to conventional diesel. Some of such alternative fuels are Cottonseed, Jatropa, Linseed, Rapeseed Sesame etc..,that are available, out of which, the heating value of Jatropa vegetable oil is nearer to conventional diesel. Hence, Jatropa based straight vegetable oil (SVO) is considered as pilot fuel for this experimental work. But the viscous and dense nature of SVO, makes coarser injection causing poor atomization and later vaporization resulted in deterioration of its combustion process. As literature suggested, use of pre-heated straight vegetable oil at 90^{o}C will have lower viscosity as prescribed in ASTM limits for CI fuels, hence this temperature is considered to continue with pre-heated straight vegetable oil at 90^{o} C (PHSVO 90) as a pilot fuel.

With PHSVO 90, the performance got deteriorated and emissions were increased when compared to the conventional diesel fuel due to deteriorated combustion. In order to enhance the combustion and reduce of emissions of PHSVO 90, gaseous hydrogen (GH_2), which has high flame speed, wide flammability, low ignition energy, high burning velocity supplemented with PHSVO 90, in the range 0.3 to 1.0 gm/min at manufacturer's recommended injection timing 20^{o} bTDC and injection pressure of 175 bar. From the selected supplemented range, the band of 0.4 gm/min to 0.7 gm/min with PHSVO 90 at 80% load showed improvement in combustion of pilot fuel. However, 0.5 gm/min GH_2 dosage, gave a very good response out of identified 0.4 to 0.7 gm/min to the engine. But, at the same time, it was identified that, complete combustion of inducted GH_2 did not takes place because the heat liberated by pilot fuel is not sufficient to increase the self-ignition temperature of the GH_2 at manufacturer's recommended injection timing. Further, being a viscous vegetable oil, it needs more time to get interacted with air to become a combustible mixture. Hence, injection timing was advanced from 20^{o} bTDC to 26^{o} bTDC with an increment of 2^{o} bTDC. With advanced injection timing, brake thermal efficiency got increased,

smoke, CO were decreased, and NO_x was considerably increased along with a slight increase in HC. With the advanced injection timing, as more fuel got accumulated resulted in increased ignition delay. Increased ignition delay, allowed the fuel to get interacted with available air for longer time leading to overmixing. This overmixing resulted in increase of HC emissions. Accumulated fuel during ignition delay burns nearer to TDC, which allows nitrogen to get react with oxygen at this high temperature resulting in increase in NO_x emissions. The brake thermal efficiency got increased with advancing the injection timing in the range of 20^o bTDC to 26^o bTDC. However, significant improvement in brake thermal efficiency was observed at 22^o bTDC and 175 bar injection pressure with 0.5 gm/min GH_2 supplementation with PHSVO 90 as compared to pure PHSVO 90 and conventional diesel at 80% load. Hence, this injection timing was optimized.

Further, with optimized injection timing (22^o bTDC) at optimized 0.5 gm/min GH_2 supplementation with PHSVO 90; injection pressure was varied in the range of 175 bar to 265 bar at optimized load 80%. As the injection pressure increased, shorter injection duration was observed for the injection quantity that enhances the atomization of fuel resulting in formation of better combustible mixture. Further, supplemented GH_2 enhanced the mixture combustion, by which pilot quantity of fuel got reduced leading to increased thermal efficiency. The results indicated that, up to 235 bar injection pressure brake thermal efficiency got increased and later slightly decreased due to impingement of fuel sprays on the walls i.e., spray over penetration leads to bulk quenching of combustion chamber temperature, thereby deteriorating the combustion reactions. Further, with respect to exhaust emissions indicated that, due to faster combustion of the mixture nearer to TDC, made favorable situation for formation of higher NO_x. Smoke and CO were reduced as mixture became leaner with advanced injection timing.

With optimized injection advancement 22^o bTDC, injection pressure 235 bar, GH_2 of 0.5 gm/min supplementation with PHSVO 90 and optimized load at 80%, brake thermal efficiency was increased to 31.76%, which is 3.3% more than pure PHSVO 90 and 1.34% more than the conventional diesel. Smoke was reduced to 27.4 HSU, which is 39.6 HSU lower than pure PHSVO 90 and 28.6 HSU lower than conventional diesel. CO was reduced to 0.05% by volume which is 0.15% lower than pure PHSVO 90 and 0.04% lower than conventional diesel. HC was reduced to 8 ppm, which is 7 ppm lower than the pure PHSVO 90 and 2 ppm lower than the conventional diesel. NO_x of 492 ppm, which is 142 ppm higher than the conventional diesel, 201 ppm higher than the pure PHSVO 90, Pmax was increased to 56.71 bar at 7^o aTDC which is 15.73 bar more than the pure PHSVO 90 and 13.1 bar more than the conventional diesel with CA advancement of 4^o and 2.5^o with pure PHSVO and conventional diesel respectively. Further, heat release rate, both pre-mixed as well as diffusion combustion peaks were improved when compared to pure PHSVO 90 and the conventional diesel. Ignition delay appreciably reduced to 13.1^o CA, which is 3.6^o CA lower than the pure PHSVO 90 and 2.91^o lower than the conventional diesel.

With these promising results, supplementation of gaseous hydrogen at lighter doses for straight vegetable oil operated indirect-injection engines enhanced the combustion there by improving the performance and reducing the emissions.