CHAPTER 7

CONCLUSIONS

An inexpensive test set-up was created to conduct "no-oil" tests on small four-stroke engines in the I.C. engine lab of Virginia Tech using a test procedure that imposed more severe conditions than that on the production line of an engine manufacturing facility. The efficacy of lubricant formulations in preventing scuffing and avoiding seizure during 1-minute "no-oil" tests was evaluated both in a high temperature pin-on-disk machine as well as on engine tests. Some lubricant formulations exhibited superlative anti-wear qualities on both the pin-on-disk and engine tests. A bold step of using the tribopolymer-formers (monomers) as lubricants / lubricant components, in pure form, was taken. A correlation between the results obtained from the pin-on-disk tests and the engine tests was made. More importantly, this "no-oil" hot test procedure has been successfully tested on the production line of an engine manufacturing facility.

A study of the variances of critical engines systems such as the lubricating system, carburetion, flywheel braking system etc. in small four-stroke engines manufactured singly by Tecumseh, has been presented. The characteristics of four-stroke engine lubricants were

studied along with an analysis of the running-in of engine components. The concept of tribopolymerization, which forms the basis for this research, was studied. Specific conclusions from this study are pointed out below:

7.1 ENGINE TESTS

1. An inexpensive experimental set-up was developed and used to carry out no-oil hot tests on small four-stroke engines at Virginia Tech.
2. A test procedure that imposed conditions at least as severe as that during 'hot tests' on the production line was developed and used for the 'No-Oil' hot tests conducted at Virginia Tech.
3. Based on the engine tests conducted in the internal combustion laboratory of Virginia Tech, lubrication of the connecting rod - crank bearing was found to be the critical factor for no-oil hot tests on Tecumseh's four-stroke engines.
4. Slight scuffing at the upper main bearing was noticed on some engines but seizure at this interface occurred only during the first test, which was conducted for 5 minutes and 40 seconds. Under the conditions for no-oil hot tests and with the lubricants employed thus far, this interface does not appear to be a cause for any concern.
5. Scuffing of the in-cylinder components i.e. piston, piston rings and the sleeve itself was found to be negligible.

6. Wear at the cam-valve lifter region was found to be almost zero on the engine tests at Virginia Tech as well as the tests on the assembly line.
7. The average amount of lubricant used for pre-treating a Tecumseh 4-stroke engine (TVS 115, LEV 115 or VLV 55 series) was found to be between 7 to 9 grams.
8. A total of twenty eight "no-oil" hot tests using "Tribolubes" formulated in the laboratory were conducted at Tecumseh's engine manufacturing facility in the presence of Drs. Furey and Kajdas and the author. Simultaneous "no-oil" tests were also conducted on similar engines, using a conventional, commercial lubricant pretreatment. While the engines that were pretreated with the "Tribolubes" completed the test cycle successfully with minimal or no scuffing, the latter showed severe scuffing at the Connecting rod - crank bearing interface and the upper main bearing and even seized before the test cycle was completed. These tests displayed the superior anti-wear properties of the tribolubes. Moreover, it is even more praiseworthy considering the fact that conventional lubricants are extensively tested mixtures of anti-wear additives, corrosion inhibitors, detergents, anti-oxidants and rust inhibitors in base oils, at their optimum level.

9. Although the lubricants used were either made up of tribopolymer-formers (100%) or contained these monomers as additives, analysis of engine deposits was not carried out to look for evidence of tribopolymerization.