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Design review of an Innovated Single Piston Diesel engine in Uganda*

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Abstract
Engineering designs are important in engine production. This research aimed at incorporating engineering principles and practices into the developed single piston diesel engine at Kevoton. Tests on the already innovated engine were carried out to evaluate the performance of the existing engines in terms of power, torque, rpm and exhaust temperature. Designs of the major components were generated together with material selection, which helped in determining whether the used material was appropriate for engine production. Results showed that the engine runs at a speed of 1800 rpm, a torque of 5 Nm, and a power of 10 HP with 2.4 liters per hour of fuel. The major components of the engine include the engine piston, the crankshaft, connecting rod, cylinder head and the camshaft. The power obtained after carrying out the new design was 13 HP, with a 5 Nm torque as well as 1 liter of fuel consumed per hour. It was realized that some components were not meeting the design specifications and the design was below the minimum required power of 13 HP. Power produced was less than 13 HP that was required to handle the purpose of engine manufacture, the engine was designed to be a prime mover to do most of the local. It was identified that the need of the engine should be considered as a primary requirement when coming up with the designs, the choice of injectors affect the amount of exhaust and engine testing requires consideration while designing an engine.

Keywords Diesel Engine, Performance, Innovation, Material Selection

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1. Introduction
An engine works on either internal or external combustion. In this study, efforts have been put on analyzing an internal combustion engine (ICE) running on diesel, locally innovated and produced in Uganda. ICEs employ compression of air-fuel mixture in a cylinder to generate the required power (Naik et al. 2019), while for the external combustion engine, a separate combustor is used to burn the fuel (Radoslav 2011). ICEs may either be diesel or gasoline fueled and are known to be reciprocating (Ken et al. 2015). They are a widely used technology for both transportation and stationary applications (Ken et al. 2015). Diesel engines are commonly used for power generation due to their higher efficiency (Breeze 2018). But these engines are accompanied with flaws like high temperature required to combust the fuel and high percentages of emissions (Shams 2019). For that matter, spark ignition engines burning natural gas have become increasingly popular for power generation in industrialized nations. Stirling engine which is also a piston engine is being developed for specialized power generation applications though it is an external combustion engine (Breeze 2018). The diesel engine was invented in 1892, by Rudolf Diesel of Munich (Michaelis 2013). Diesel engines possess a number of efficiency advantages over gasoline (petrol) engines. These arise due to the way diesel engines operate. The deceit engines do not use a throttle to control airflow into the engine or a spark plug to ignite the fuel as gasoline does. Instead the load is controlled by the amount of fuel injected. The timing of fuel injection controls combustion timing as the fuel ignites almost immediately after being injected into the hot compressed gas within the cylinder. As a result, diesels eliminate the significant pumping losses that come from forcing air past the throttle in gasoline engines (Aaron Isenstadt 2017). Uganda is among the countries that have taken up the diesel technology for their applications. The country is gifted with natural resources and a salubrious climate with low industrialization and value addition. The country faces the challenge of poverty alleviation, a high human population

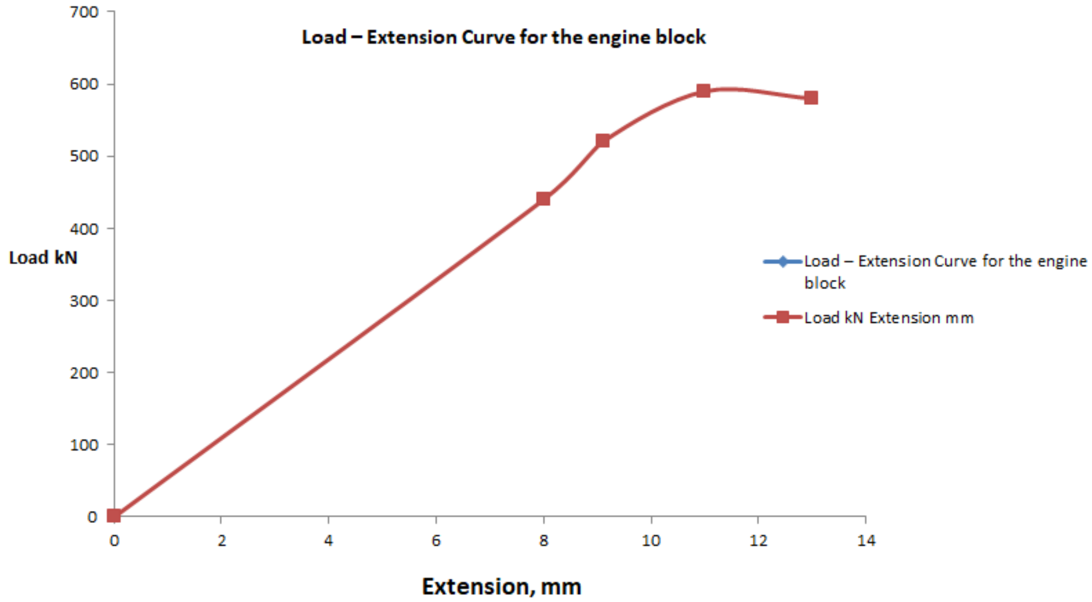

Figure 10: Load – Extension Curve for the engine block

4.4 Composition of the materials for the engine block, piston, cylinder head and the crankshaft

The compositions for the materials of the engine parts were determined as highlighted in section (2.2).

Specimen	Si	Mn	Zn	Pb	Cr	Mg	Ni	Fe	Cu	others	Al
Engine block	8.63	0.252	0.5	0.02	0.030	0.950	0.201	0.53	0.265	0.119	Bal.
Engine piston	7.34	0.55	0.07	0.52	0.005	0.980	0.415	0.15	0.112	0.211	Bal.
Cylinder head	6.93	0.0348	0.25	0.325	0.025	0.890	0.310	0.06	0.073	0.320	Bal.
Crankshaft	9.23	1.70	-	-	-	-	-	Bal.	-	1.82	-

Table 26: Chemical Composition of the Engine Material

Comparisons are made to the various results obtained by different authors; a similarity in the results that were obtained on the tests carried out on the materials of the single piston diesel engine to those obtained by various authors is witnessed. Yadav et al., (2017) carried out tests on Al 6061/ 15wt. % MoS2, Scari et al., (2014) conducted tests on AA6082-T6 Aluminum at room temperature, Heysler et al., (2001) conducted tests on AlSiMgCuNiFe, Ahamed et al.,(2019) performed tests on Al-6061 metal matrix composite, Anilchandra et al., (2017) tested the composition of AlSi9Cu3(Fe) and all these authors made deductions as per the results in Table 27.

Specimen	Si	Mn	Zn	Pb	Cr	Mg	Ni	Fe	Cu	others	Al
Al 6061/ 15wt. % MoS_2	3.47	0.325	0.445	0.096	-	0.023	0.082	0.85	0.62	0.119	Bal.
AA6082-T6	7.34	0.46	0.002	0.001	0.0005	0.24	-	0.21	0.017	0.023	Bal.
AlSiMgCuNiFe	7.21	0.50	0.139	-	-	0.41	0.51	0.43	0.37	0.056	Bal.
Al-6061 metal matrix	0.65	0.03	0.08	-	0.14	0.88	-	0.24	0.23	0.1	Bal.
$AlSi_9Cu_3$(Fe)	8.23	0.261	0.895	0.083	0.083	0.252	0.081	0.799	2.825	0.426	Bal.
$ASi_7Mg_{0.3}$	6.5	0.007	0.006		-	0.3	0.003	0.1	0.002	0.1	Bal.

Table 27: Chemical Tests Carried Out On the Various Aluminum Alloys For Engine Construction

5. Conclusion and Recommendations

This study focussed at reviewing the designs of the engine prroduuced at KML so as to come up with a reproducable design for future developments. Based on the results obtained from the tests carried out on this engine, it was realized that the choice of the injectors matters in the exhaust fumes produced by any engine as well as the combustion pressure, the purpose of the engine should be considered as well since it helps customizing the design to avoid it requiring modifications to have it perform the purpose, the engine should be built with the ability to be coupled for testing.

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