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Implementation of Reverse Engineering and Re-Engineering in the Development of Pin Valve for the Nozzle of Man Diesel Trucks

B. Kareem[1], O. O. Agboola [1,2*] P. P. Ikubanni [2] and F. I. Akhator [1]

[1]Department of Mechanical Engineering, Federal University of Technology Akure, Ondo State, Nigeria.
[2]Department of Mechanical Engineering, Landmark University Omu-Aran, Kwara State, Nigeria.

ORCIDs: O. O Agboola: 0000-0002-8979-7778 (Corresponding Author).
P. P Ikubanni: 0000-0002-2710-1130

Abstract

This study focuses on the modification and re-engineering of the existing nozzles of MAN DIESEL TRUCK TGA-30+ using the reverse engineering principles. Due to corrosion and accumulation of debris at the tip of the steel pin valve, there was an incessant breakdown of Trucks. Three alternative materials for the manufacturing of pin valve were considered; such as Teflon, Fibre and Brass. The results obtained showed that brass performed optimally among the three. Through the usage of brass for the manufacturing of pin valve, forty (40) trucks of KAKATAR Company were revived. Therefore, the use of brass is recommended as a substitute for steel for the production of pin valve.

Keywords: Design; Diagnosis; Implementation; Nozzle; Pin valve; Repair; Reverse engineering and Trucks.

INTRODUCTION

One of the main applications of Reverse Engineering (RE) could be found in the generation of 3D models of various broken or worn-out mechanical components. Some of the spoilt or broken components might not be readily available for replacement due to scarcity or lack of design data to reproduce them [1]. Reverse engineering, also called back-ward engineering, is the process of extracting knowledge or design information from any man-made products and re-producing it based on the extracted information [2 - 4]. The process often involves disassembling (mechanical devices, electronic components, computer programs, or biological, chemical, or organic matters) and analyzing its components and workings in detail. Reverse engineering is also beneficial in crime prevention, where suspected malware is reverse engineered to understand what it does, and how to detect and remove it, and to allow computers and devices to work together ("interoperate") and to allow saved files on obsolete systems to be used in newer systems.

Reverse engineering is a kind of engineering which takes advantage of an already created object. The final purpose is to be able to create another object similar to the existing object. The three (3) main steps of reverse engineering are sensing the geometry of the existing object; creating a 3D model; and manufacturing through the use of appropriate CAD/CAM system [5 - 8].

Extensive literature survey reveals that a lot of studies have been done on reverse engineering, especially in the design of rotor blade but no work has been done in the design and development of nozzle's pin valve using RE. Some researches dealt with the enhancement and improvement of the accuracy of the scanned surfaces of the turbine blades [9 - 12]. Other studies focused on obtaining and using the results of reverse engineering for certain applications such as the static structural analysis for different materials at various centrifugal loads for a rotor blade [13] or describing of the manufacturing process for wide chord fan blades and improving the die sets used for their manufacture [14]. Other previous works on RE include the simulation or reconstruction of small turbine runners, either radial [15 - 16] or axial [17] have been carried out.

Recently in manufacturing sector, Vijaya *et al* [18] implemented RE for the manufacturing of crankshaft using CATIA and ANSYS as a computer modeling software and dynamic analysis respectively. They came out with the feasibility of using another materials that could bring about weight reduction; thereby reducing the cost of production. Also, Matej *et al* [19] manufactured car's volume control button using additive manufacturing technique. In spite of complicated and complex geometry of the button, similar buttons of the same qualities and properties were manufactured. This study aims at producing nozzle's pin valve from three materials: teflon, fibre and brass that can substitute the imported nozzle for MAN Diesel Trucks using Reverse Engineering.

Implementation of RE was done at the workshop of KAKATAR Group Limited. This company has a fleet of MAN Diesel trucks used in their operations. Majority of these trucks were not always available for use due to incessant damage or blockage of nozzle which leads to breaking down of the trucks. Therefore, this study is undertaken to source for alternative material that can serve the purpose of nozzles with mirror internal surface in the afore-mentioned trucks with low cost. This eliminates down time and enhances productivity of the operators.

METHODOLOGY

Whenever a component is faulty or malfunctioning, appropriate sequential steps must be taken to diagnose it to ensure that the fault is located within a possible shortest time [20 - 21]. Having realized that the main reason why the trucks

broke down was due to faulty nozzle, efforts were made to decouple some of the nozzles and it was discovered that there were blockages on the nozzles. These blockages emanated from accumulated foreign bodies that could not pass out through the orifice under high pressure. Each nozzle unit has wide diameter of 5mm fuel passage which has constriction orifice of about 0.01mm diameter; and the fuel chamber is highly tapered down. This sticking of foreign bodies to the surface of fuel passage is due to corrosive element present in the fuel. Two techniques were adopted in this study to obtain a functional nozzle:

a. Installation of micro-sized filter and water separator along the suction line to remove the traces of water, mist and other foreign bodies that can cause corrosion as shown in Figure 1.

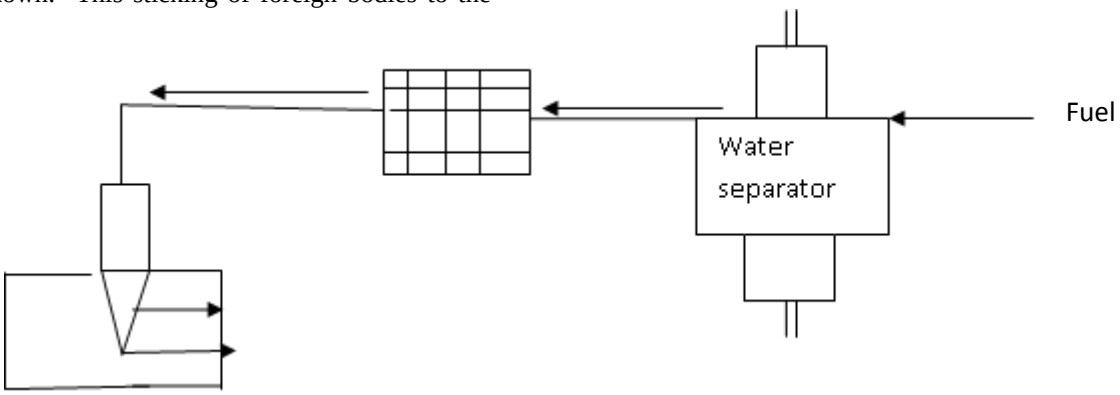

Figure 1. Water separator installation on fuel supply line

b Fabrication of nozzles (having the same configuration as its foreign counterpart) using reverse engineering.

The schematic drawing of M.A.N Diesel nozzle (M.A.N. - Diesel TGA-30) understudy is given in Figure 2. It consists majorly of nozzle (through where fuel is injected into the combustion system, pin valve (that control the flow of fuel into the combustion chamber), spindle/pressure spring (for valve and pressure control) and lubrication passage (which serves as a passage for pressurized oil for nozzle system lubrication.

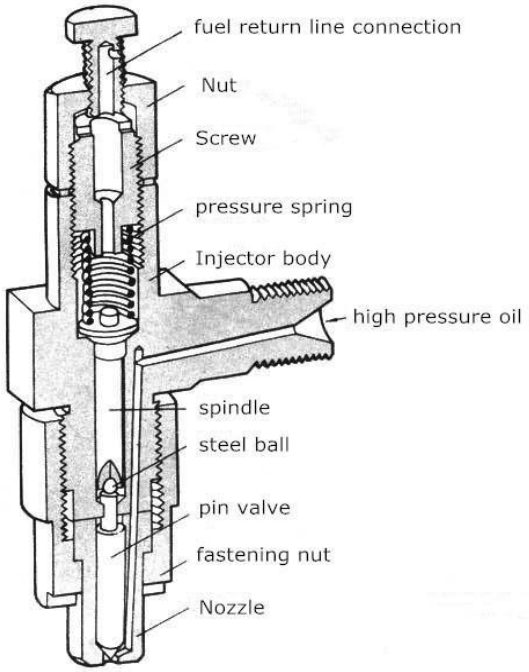

Figure 2. Sectional/Schematic drawing of the M.A.N diesel nozzle

From the experts' opinions and the observation made, the major fault of the MAN DIESEL nozzle was detected to be the pin valve. More than 100 pieces of nozzles' pin valve failures were reported from 172 fleet of MAN DIESEL trucks by a leading construction company. The nozzles' pin valves are very scarce to obtain locally. Unavailability of the component had made about 100 trucks malfunction for more than 10 years. The only option left is to order them from the original manufacturers, at exorbitant prices abroad, where it will be specially produced for the vehicular model, which is majorly being displaced by advanced technology. This challenge informed finding alternative method of producing nozzles' pin valve locally to be made affordable and reliable using locally sourced materials. Purposeful study entails; finding the root causes of nozzles' pin valve failure, finding the candidate material locally to be upgraded to fit the production and finding the technique of producing similar one from the locally sourced material having the same configuration of the original nozzle (reverse engineering).

Nozzle Manufacturing Process and Material Used

The original geometry of the steel pin valve of the defective nozzle was measured and the 3D model of it was generated on AUTOCAD 2017. Three readily available materials such as teflon, fibre and brass were then machined on a Lathe machine to conform to the geometrical shape and dimension of the original steel pin. The required shape of the pin valve is as shown in Figure 3.

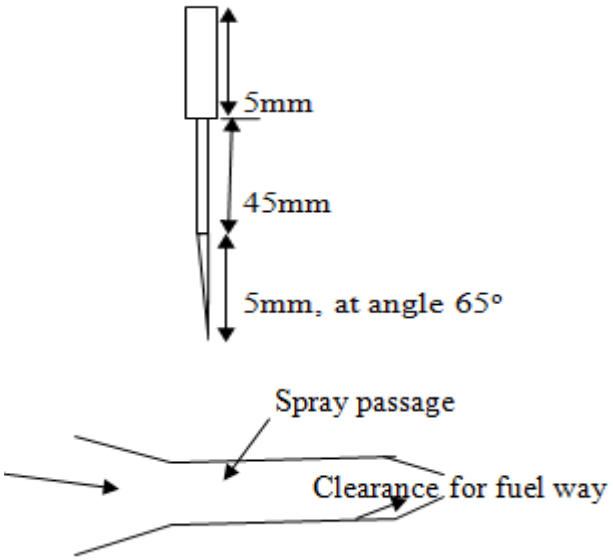

Figure 3. Pin valve and fuel way of the MAN DIESEL Nozzle

Teflon is considered as one of the materials for the manufacturing of pin valve because of the following desirable properties. Teflon is not very reactive to chemical agents because of the stability of fluorine to carbon bonds; has easy clean surface; Teflon has non-sticky surface; has high temperature resistant of 3270C; is hydrophobic – water heating, water alcohols; and has electro negativity of the fluorine atoms .

Fibre has the following properties: good strength-to-weight ratio; good abrasion resistance; keeps strength when wet; and moderate elongation.

Brass is also considered based on the following desirable properties. Brass has a higher malleability than either bronze or zinc; resists corrosion, including galvanic corrosion from salt water; is easy to cast; and is not ferromagnetic. Among other things, this makes it easier to separate from other metals for recycling.

The machined pin valves made from teflon, fibre and brass were then installed into different nozzles to replace the faulty steel pin valves.

RESULTS AND DISCUSSION

Having replaced the steel pin valve with the Teflon, Fibre and Brass pin valves in the nozzle, the reading in the odometer were compared and tabulated as shown in Table 1

Using the nozzle re-engineered with the teflon pin valve, it was tested for 4 days. After the installation of the nozzle re-engineered with a Teflon pin valve and test-runned for 4 days, with full load of asphalt, the nozzle was decoupled and found the pin valve to have depression on the steel ball and more smoke was observed from the truck with little reduction in speed. For fibre pin valve re-engineered nozzle, there was no smoke but there was a significant difference between the values of torque when using steel pin (150 Nm) and when using fibre pin (135 Nm). Also there was reduction in speed to the tune of 38 km/hr as shown in Table 1.

Table 1. Comparison table between Steel pin valve, Teflon pin valve, Fibre pin valve and Brass pin valve

	Steel pin valve	Teflon pin valve	Fibre pin valve	Brass pin valve
Torque (Nm)	150	100	135	148
Drag Force (Nm/s)	12	17	14	12
Speed (km/hr)	180	120	142	175

When using brass as a pin valve there was no accumulation of debris accumulative at the conical surface which normally leads to clogging of nozzle. Table 1 also revealed that there was no significant difference between steel pin valve and brass pin valve re-engineered nozzle based on three parameters considered: Torque; Drag force; and Speed.

CONCLUSION

Among the three materials considered for the manufacturing of pin valve, brass is found to perform optimally and the result was much closed to that of steel. This work of nozzle modification has been tested and found to perform satisfactorily. All trucks with this new modification are performing well and none of the trucks had stop working. This modification has revived about forty trucks that broke down due to nozzle's problem and the company agreed to invest more on further research to boost the performance of their trucks.

REFERENCES

[1] Adrian C, Sergiu N, Corina B. Reverse engineering for the rotor blades of a horizontal axis micro-hydrokinetic turbine. In proceeding of Sustainable Solutions for Energy and Environment EENVIRO Bucharest, Romania, Energy Procedia. 2017: 112: 35 – 42.

[2] Bagci E. Reverse engineering applications for recovery of broken or worn parts and re-manufacturing: Three case studies. Advances in Engineering Software. 2009: 40: 407–418.

[3] Yuan X, Zhenrong X, Haibin W. Research on integrated reverse engineering technology for forming sheet metal with a freeform surface. Journal of Material Process Technology. 2001; 112: 153–156.

[4] Kovács I, Várady T, and Salvi P. Applying geometric constraints for perfecting CAD models in reverse engineer-ing. Graphical Models. 2015; 1–14.

[5] Srdjan Z, Luka C, Julija K, Vidosav M, Davonin K. Reverse Engineering of Turbine Blades Kaplan's type for Small Hydroelectric Power Station. In Proceeding of 15th CIRP Conference on Computer Aided Tolerancing – CIRP CAT. 2018: 75: 379–384

[6] Gameros A, De Chiffre L, Siller HR, Hiller J Genta GA. Reverse engineering methodology for nickel alloy turbine blades with internal features. CIRP J Manuf Sci Technol. 2015: 9: 16–124

[7] Gopinath C, Prasad G. Optimum material evaluation for gas turbine blade using Reverse Engineering (RE) and FEA. In proceeding of 12th Global Congress on Manufacturing and Management, GCMM 2014: 1332-1340

[8] Anwer N, Mathieu L. From reverse engineering to shape engineering in mechanical design. J CIRP Ann. 2016: 65: 165–168

[9] Dúbravcík M, Kender S. Application of reverse engineering techniques in mechanic system services. Procedia Engineering. 2012: 48: 96–104.

[10] Chen LC, Lin GCI. Reverse engineering in the design of turbine blades – a case study in applying the MAMDP. Robot Cim-Int Manuf. 2000: 16(2-3): 61–167.

[11] Mohaghegh K, Sadeghi MH, Abdullah A. Reverse engineering of turbine blades based on design intent. Int J Adv Manuf Technol. 2007: 31: 1009–1020

[12] Li Y, Ni J. Constraints Based Non rigid Registration for 2D Blade Profile Reconstruction in Reverse Engineering. J. Comput. Inf. Sci. Eng., 2009: 9(3): 157-162.

[13] Gopinath C, Prasad G. Optimum material evaluation for gas turbine blade using Reverse Engineering (RE) and FEA. In: 12th proceeding of GLOBALCONGRESS ON MANUFACTURING AND MANAGEMENT, GCMM 2014, Procedia Engineering, 97, 1332 – 1340.

[14] Mavromihales M, Mason J, & Weston W. A case of reverse engineering for the manufacture of wide chord fan blades (WCFB) used in Rolls Royce aero engines. Journal of Materials Processing Technology. 2003: 134(3): 279-286

[15] Garcia MJR, Boulanger P, Barbosa JP, Betancur MJ. Application of the reverse engineering in the modeling of a Francis turbine in a hydroelectric minipower station. In: 23rd Proceeding of ISPE International Conference on CAD/CAM Robotics and Factories of the Future, Universidad Militar Nueva Granada Bogota D.C. Colombia, August 2007: 16-18

[16] Kaplan A, Cetinturk H, Celebioglu K, Aradag S. Reverse Engineering Design of a Hydraulic Turbine Runner. In: proceedings of the World Congress on Engineering, July 1 – 3, 2015

[17] Tiaple Y, Ridluan A, Sritrakul N, Nontakeaw U, Chamamahattana P. Reverse Engineering for Developing Small Hydro Turbine Using CFD Simulation. In: 19th proceeding of the Conference of Mechanical Engineering Network of Thailand, October 19-21, 2005

[18] Vijaya Ramnath, Elanchezhian C, Jeykrishnan, Ragavendar R, Rakesh PK, Sujay Dhamodar J, Danasekar A. Implementation of Reverse Engineering for Crankshaft Manufacturing Industry. In: Proceeding of Materials today, 5, 994-999, 2018

[19] Matej P, Tomaz I, Joze B, Franc C, Andrej C, Tomaz B, Igor D. Reverse Engineering of Parts with Optical Scanning and Additive Manufacturing. In: 24th Proceeding of DAAAM International Symposium on Intelligent Manufacturing and Automation, Procedia Engineering. 2014: 69, 795 – 803.

[20] Agboola OO, Kareem B, Akinnuli BO. Development of a diagnostic schedule for a defective LC-195V5 CNC milling machine using PERT. Leonardo Electronic Journal of Practices and Technologies, 2016: 28: 107-118.

[21] Agboola OO, Ikubanni PP, Ogunsemi BT, Ibikunle RA, Adediran AA, Kareem B, Akinnuli BO, Osueke CO. Dataset for the development of a diagnostic schedule for a defective LC-195V5 CNC milling machine at FUTA central workshop. Data in Brief. 2018: 21: 1496-1503.