Improving Characteristics of Diesel Engine by Changing the Engine's Charging and Design Method

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Abstract

This paper represents research on improving the working characteristics of a direct injection 16.5 Hp diesel engine by changing the engine's charging and design method. With the help of SolidWorks 3D software, previous design and rendering plans were compared and evaluated visually compared to the new method. The criteria which are surveyed and evaluated are design time, flatness and smoothness of the object's surface. The intake manifold of the engine is designed and modeled using a newly developed method, which is evaluated by experiments in comparison with the old method. Operation improvement of the engine's specifications such as max power, specific fuel consumption at continuous rated power is the goal of this study.

Keywords: Intake manifold, volumetric efficiency, simulation study, output power, fuel consumption

1. Introduction

An important step towards the development of aninternal combustion engines is the optimization of the inflow through intake ports since the charge movement generated by the intake flow considerably influences the quality of mixture and combustion especially in diesel engines [1]. The characteristic of the airfield in the combustion chamber at the time of fuel injection directly affects the combustion process and is the dominant factor for the efficiency and pollution level of direct injection diesel engines. Accurately combining fuel injection parameters, piston top shape, compression ratio, and intake manifold profile are important considerations in new engine design.

Table 1. Specification of reference VIKYNO RV165-2 engine

Bore (mm)	105
Stroke (mm)	97
Displacement (cm^3)	839
Maximum output (Hp/v/ph)	16.5/2400
Maximum Torque	4.9/1800
Compression ratio	20
Specific fuel consumption (g/Hp.h)	206

The intake manifold of the engine is not only an important detail but also very difficult to design and fabricate. For the intake manifold, the profile of the details not only curves in complicated curves in three-dimensional space but also has a transition from a square profile at the inlet to a circular profile at the position where the airflow go inside the engine cylinder. This creates many difficulties in rendering to ensure smoothness in areas where there is a transition from a square profile to a circular profile. Therefore, the rendering of a complete 3D model not only take a great amount of time, from about 7-10 working days but also very dependent much on the skills of using 3D drawing software of design engineers.

Fig. 1. The intake manifold researched**.**

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In the modern world where advanced manufacturing takes place, the creating of a complete 3D drawing is the key to making a good detail. Therefore, the 3D modeling of smooth, high-quality helical intake is very significant in ensuring the continuity of the air flow when entering the engine combustion chamber.

This study presents a way to parameterize a part of the engine's intake manifold. Simultaneously modeling 3D helical intake by Solidworks software in a completely different approach based on the built-in parameters. With this method, 3D design and modeling time is much reduced, only about 2-3 working days, while ensuring smoothness at transition areas. Henceforth, opening many opportunities to improve and advance the quality of engines.

The researched object of the article is VIKYNO RV165-2 which is manufatured in Vietnam, it has a range of power used in the Vietnamese market popularly.
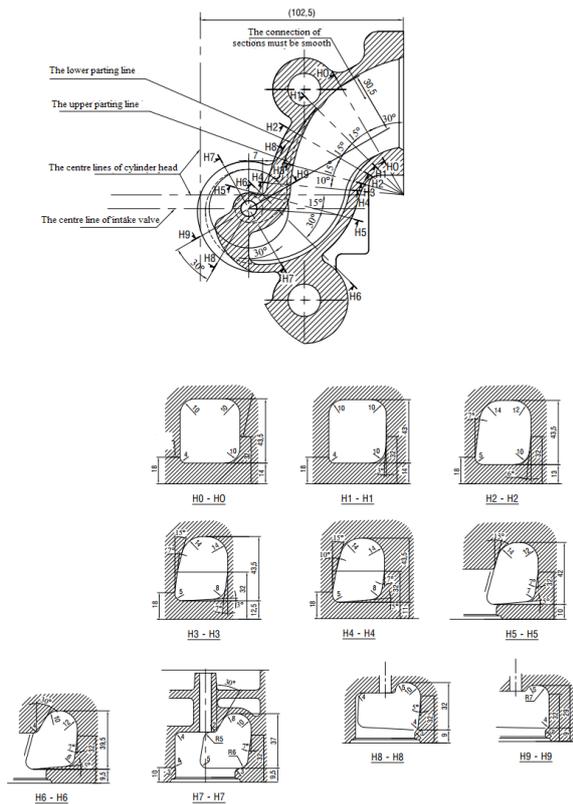
Fig. 2. Design 2D intake manifold [2].

2. Operation process

2.1. 3D modeling of intake manifold by the old method

In the old method (current method)

- 2D designing stage: Intake manifold is described by many sections at different positions and these sections are connected by curves located on the upper and lower parting plans

- 3D modeling stage with Solidworks: With 2D design as above. We only have a single 3D rendering method that uses the LOFT [3] command to join the sections together. The limitation of this rendering is heavily dependent on how the software interpolates when creating blocks of sections
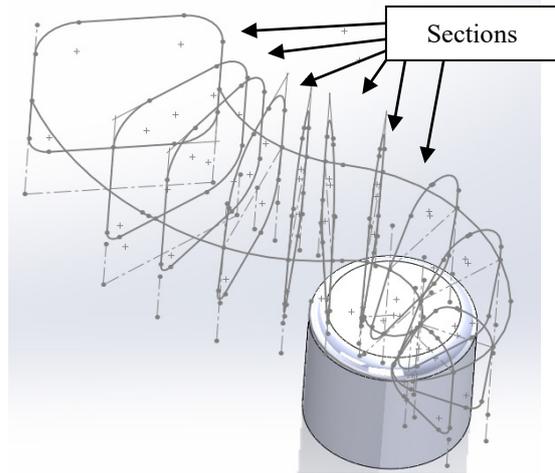
Fig. 3. Sections built in Solidworks
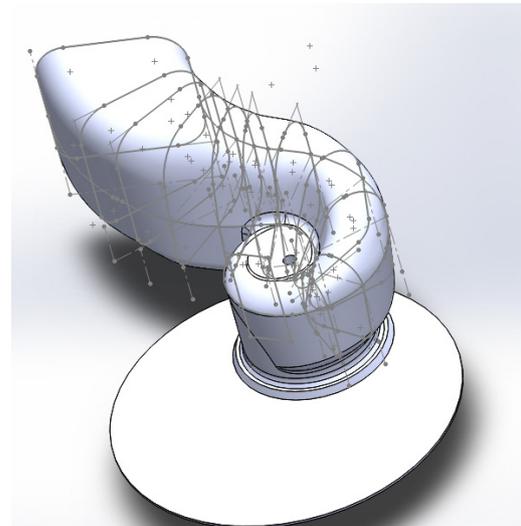
Fig. 4. Intake manifold rendered by the current method

2.2. 3D modeling of intake manifold rendered by the new method (parametric method)

2.2.1 Intake manifold parameterization

In 2D design, there are more than 100 dimensions used to represent intake manifold. From this available design basis, important dimensions are parameterized as bellows:
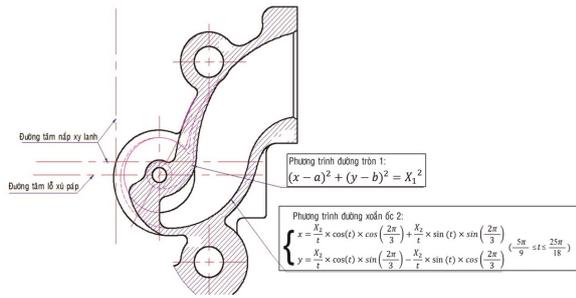
Fig. 5. The functions representing generatrices of the intake manifold
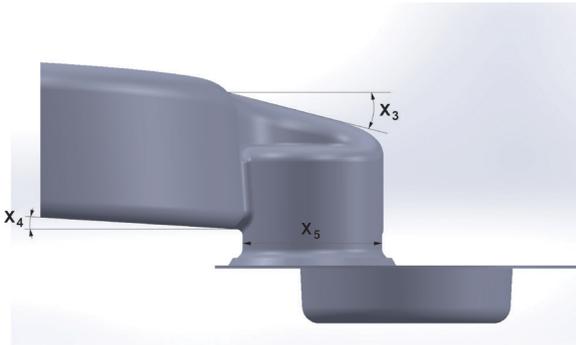
Fig. 6. The important geometric dimensions are chosen for parameterization

Table 2. Proposed intake manifold parameters

No	Parameters (designing variable)	Value	Note
1	X_1	17 (mm)	The radius of circle equation 01
2	X_2	103	The coefficient of helical equation 2
3	X_3	12,5 (độ)	Upper inclination
4	X_4	3,5 (độ)	Lower inclination
5	X_5	40 (mm)	The diameter of the intake valve

2.2.2 Rendering by a parametric method

- 2D design stage: Keep the cover dimensions unchanged and the dimensions are not parameterized. Replace the profile of the sections with parameterized variables.

- 3D design stage: The profile of the intake manifold is completely controlled by designing variables by combining the following commands: Extruded [3], Extruded – Cut [3] and VarFillet [3] in Solidworks. The Loft command use is limited that significantly reduces interpolation from software.
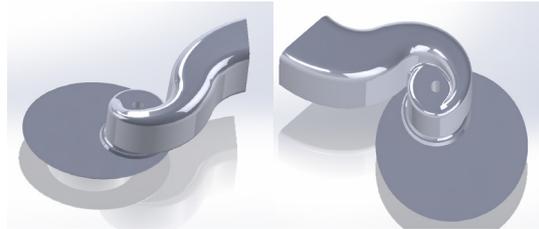
Fig. 7. Intake manifold rendered by the parametric method

2.3. Results and discussion

2.3.1 Qualitative assessment

The difference in volume of the intake manifold rendered by the parametric method is not more than 1,5% compared to the original intake manifold.
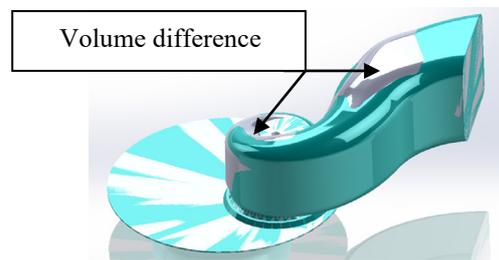
Fig. 8. 3D model comparison of two method

The intake manifold rendered by the parametric method is much smoother than the original intake manifold
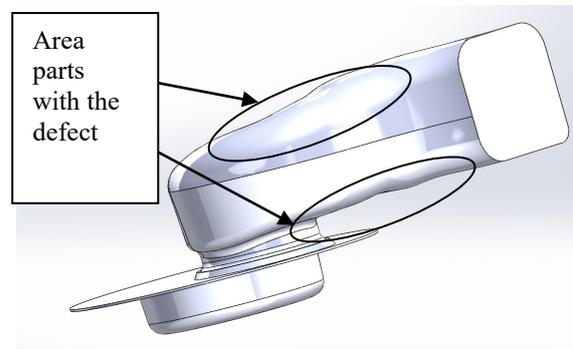
Fig. 9. The intake manifold rendered by the current method

Fig. 10. The intake manifold rendered by the advanced method

2.3.2 Quantitative assessment through the experimental process

Experimental process is carried out at SVEAM company. The equipment used in the experiment are certified by Quality assurance and testing center 3.

2.3.2.1 Diagram and principle of experimental process.

a. Principle diagram
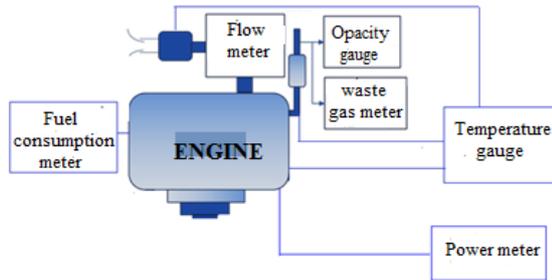
Fig. 11. Principle diagram of experimental process

b. Step by step

For every method, measurement shall be conducted respectively as follows:

- Run innon-load the engine in 15 minutes.

- Run to evaluate the characteristics:

- Pulladjusting to reach the maximum rounds 2550 rpm.

- Put load into the engine (torque) to reduce the rounds steadily to the measuring points at 2400, 2200, 2000, 1800, 1600 rpm.

- At every measuring point, record the specifications: input air temperature and pressure, atmosphere temperature and pressure, input air volume, torque.

- At each measuring point, the engine runs 3 times and the average value shall be recorded.

- Run to evaluate the norm output (Power = 14 Hp (10.29 KW) at 2200 rpm), which is recommended by the producer.

- Set up the engine operating at 2200 rpm and 44.6 N.m torque, relative power is 14Hp (10.29 KW).

- At this measuring point, the specifications of input specific fuel consumption.

- At each measuring point, the engine runs 3 times and the average value shall be recorded.

2.3.2.2 Result of of experimental process

The intake manifold designed by the parametric method is fabricated and experiment to compare with the original intake manifold achieving positive results. Actual volumetric efficiency increased by 5.98%. That is the basis for the maximum output that the engine generates more than 4% from 16.39 Hp to 17.08 Hp. This result can be explained by the smoothness of the intake manifold rendered by the new method. The smooth and non-rugged intake manifold makes the air flow in the cylinder stable, reducing the energy loss caused by the unexpected disturbance, increasing the volumetric efficiency, thereby increasing the output of the engine.
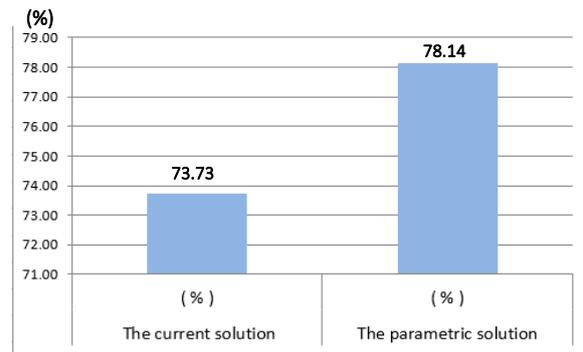
Fig. 12. Actual volumetric efficiency
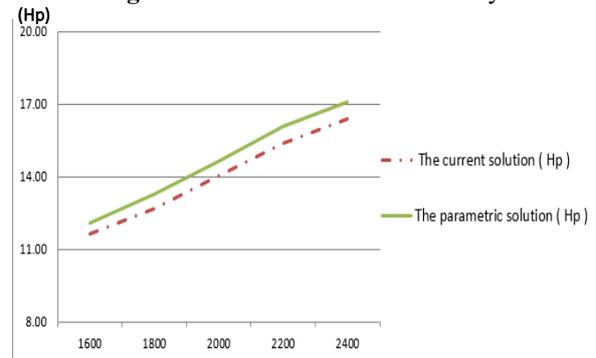
Fig. 13. Output characteristic
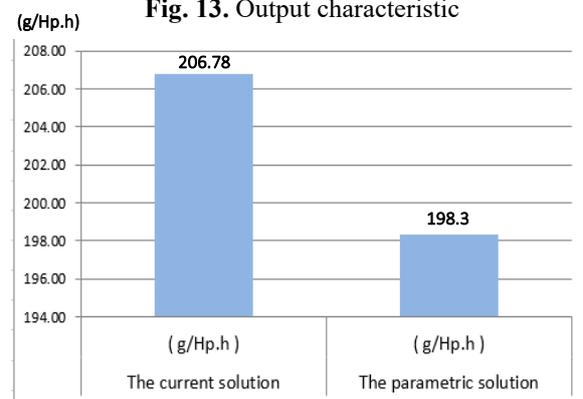
Fig. 14. Specific fuel consumption at continuous rated power

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Besides, the specific fuel consumption at continuous rated power (Power = 14 Hp at 2200 rpm) decreased by nearly 5%. This means that if the engine operates 8 hours a day and continuously for a year, the fuel consumption will be reduced to 403 liters, saving more than 6 million VND if the diesel oil price is 15,000 VND / 01 liter (occupy nearly 40% of the engine value used for research).

3. Conclusion

The engine's intake manifold designed and rendered by the parametric method actually brings certain efficiency. The designing time is reduced because the model has been parameterized simply. Therefore, it is easy to change and control these parameters (designing variables), so the designing change process for improvement purposes can be continuous and easier.

The 3D model of the intake manifold rendered by the new method is much smoother than the old method. This is the basis of bringing efficiencies in the working process of the engine. Specifically, the maximum output and the specific fuel consumption at the norm output all changed in a positive direction.

The parameterization of the intake manifold model of the 16.5 Hp engine with mathematical functions and designing variables not only improves the working characteristics of the engine but also the first preparation step for the designing optimization process of this detail.

Acknowledgement

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