CYLINDER HEAD COVER & Frame MAN D08

Armando Higa
Marcelo Wood
MAHLE METAL LEVE S.A.

Bruno de Castro Bastos Lagoeiro
VOLKSWAGEN CAMINHÕES E ÔNIBUS COMERCIO E SERVIÇOS LTDA.

ABSTRACT
The market aims at lower cost products, improving technical/legislative requirements, such as the CONAMA P8 legislation, which motivated the development of Cylinder Head Covers for D08 MAN engines. The objective of this work is to demonstrate the gains of the Cylinder Head Covers project with the integration of 19 (nineteen) components, especially the oil separator, harnesses, and integration of the engine cooling system, which made the project viable. In order to maintain the functional conditions, engineering polymers were used, resistance tests were carried out on the coolant composed of ethylene glycol, virtual calculations (CFD and structural), sealings, mechanical resistance tests and tests on functional prototypes were carried out without the need for "soft tools". The development of components for combustion engines starts with virtual simulations and mechanical integration studies, carried out by the project team. Next, the physical installation architecture for mechanical/electrical integration is defined. Subsequently, the new functionalities were tested in a vehicle, obtaining comparative results, both in relation to fuel consumption and energy recovery, as well as the possible advantages related to adapting vehicles to the new regulations.

INTRODUCTION

The automotive industry is one of the organizations that has the most skills to apply and influence innovations aimed at market strategies, compliance with legislation, application of solutions, among others.

This brings continuous development challenges throughout the production chain, from vehicle assemblers to component development and supply systems, in addition to the logistics system.

The challenge of designing the Cylinder Head Cover & Frame for application in MAN's D08 engine included several challenges for MAHLE.

CONAMA P8 LEGISLATION

CONAMA (*Conselho Nacional do Meio Ambiente*) is the Brazilian government organization that regulates the Environmental Policy in Brazil and through PROCONVE (*Programa de Controle de poluição de Ar por Veículos Automotores*) legislates on pollutant emissions generated by vehicles.

The Cylinder Head Cover project started with the objective of complying with the P8 legislation, which had its beginning established for January 2023

The previous condition was to use a Cylinder Head Cover without integration of an engine Oil Mist Separation system. The previous Oil Mist Separation system was a remote component, that is, not integrated into the engine, interconnected by hoses that captured the blow-by flow, partially separating the oil that was returned to the engine through another hose.

Blow-by Gas: Gas formed from engine compression system leaks that flows into the crankcase system through gaps in internal engine components.

The development of a new project in order to guarantee the CONAMA P8 emission level objective consisted of integrating the Oil Mist Separation system in the Cylinder Head Cover so that the oil returned from the upper part of the engine to the crankcase region through oil drains, without the need to include hoses and assembly items.

The Oil Mist Separation system is carried out by a two-stage system. In the first stage, the separation of oil with larger particle sizes is carried out using deflectors. In the second stage, the separation of smaller particles is carried out through the system called IMPACTOR, which consists of a reduction in the passage of the blow-by flow through calibrated holes, which causes the fluid velocity to increase and subsequently impact against a wall of material called fleece (non-woven) that binds smaller particles, transforming them into larger particles that precipitate into the drain system, returning the oil to the crankcase. The "clean" air then flows into the engine air supply system. Oil Mist Separator Strategy flow in Figure 1

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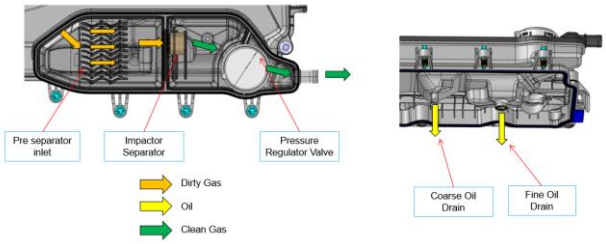

Figure 1: Oil Mist Separator Strategy flow

The project's solution contributed to the certification of the Engine for the condition of CONAMA P8 legislation. Oil emission test for engine certification in Figure 2

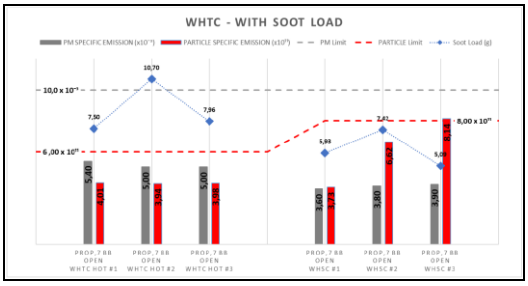

Figure 2: Oil emission test for engine certification

INTEGRATION OF COMPONENTS

Projects where they replace existing components – Running Change Projects – have the complexity of obtaining a business case, as it means an investment in new tools, R&D costs and monitoring of the PDP (Process Development Plan) for the customer. The way found to make the project viable from a technical and economic point of view was the integration of several components of the Valve Cover Project.

In the previous condition, the customer needed to acquire and control 19 (nineteen) Part Numbers to have the same functional solution as the project. In the current condition, the customer needs to acquire 2 (two) Part Numbers. A reduction beyond the added cost of the parts, reduced the work of acquisition, control, logistics and assembly of the components. Design previous condition in Figure 4.

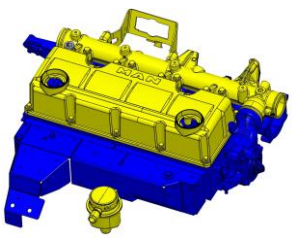

Figure 4: Design previous condition

The 2 (two) Part Numbers consist of a Valve Cover and a Frame. The valve cover, in addition to covering the engine's internal system, has an integrated oil separation system, an engine pressure control valve (PRV), incorporated fixing screws, an integrated gasket, the client's company logo, and of visual concept called Style. Design current condition in Figure 5.

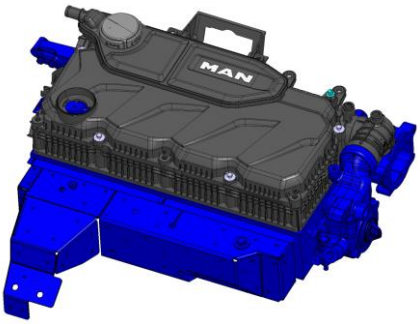

Figure 5: Design current condition

The Frame is a spacer between the Valve Cover and the Engine Head. which integrated Metal Bracket for Wire Harness Connector, Incorporated Fixing Screws, Integrated Sealing Gasket, Connectors and, in special, Integration of Cooler Manifold which was the reason for FRAME generation. Cover and Frame in Figure 6.

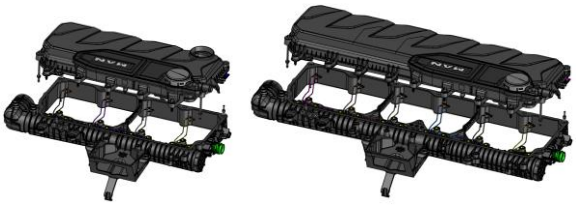

Figure 6: Cover and Frame

The creation of the FRAME was necessary, due to the integration of the Cooling Manifold, it was not possible to disassembly the Cylinder head Cover, since the Cooling Manifold is part of the cooling circuit of the engine system. With the inclusion of the Frame it became possible to disassemble the Cylinder Head Cover for engine tuning and maintenance services.

COOLER MANIFOLD – the Cooling Manifold Integration consists of the replacement of an aluminum part to Engineering Plastic Part: Polyamide >PA66-GF35<. Cooling Manifold in previous and current design in Figure 7.

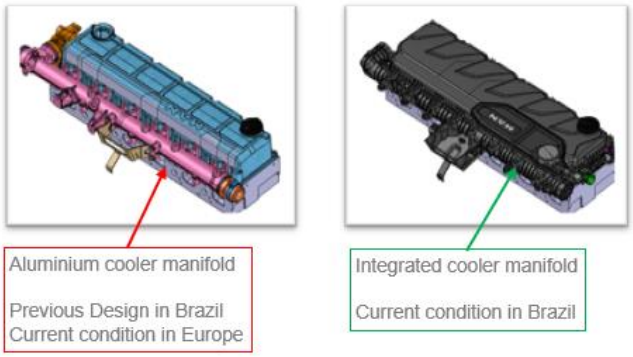

Figure 7: Cooling Manifold in previous and current design

Cooling Manifold is part of the engine cooling circuit - ethylene glycol. The substitution of aluminum for polyamide required proof of the material's resistance to the chemical attack of ethylene glycol, including the resistance of the plastic welding process that closes the circuit. For this, specimens were produced, which were injected into the material designated for production to be subjected to tightness and burst / pulsation tests after thermal cycling even before the release of the product design phase.

The tests carried out were approved with rupture in pressure pulsation above 14bar. Target 2 bar. Ethelene glycol resistance concept test in Figure 8.

Figure 8: Ethelene glycol resistance concept test

WEIGHT REDUCTION – The replacement of the previous Cylinder Head Cover for the component integration concept reduced the weight by 2.64kg in the D0834 application (4 cylinders) which means a mass reduction of 38% where the most representative item is the Aluminum Cooling Manifold.

DESIGN WITHOUT PROTOTYPES TOOLINGS – The standard condition of product development, in special, products considered complex as this case, demand project validation through the construction of tooling prototypes. This phase called DV (Design Validation) has the function of solving and achieving the project goals for all the functions required by the project. Adjustments and/or design changes can be made at this stage with reduced impact on quality, time and costs.

However, due to the criticality of time to reach the goal of CONAMA P8 legislation in January 2023 and the reduction of investments in the costs of prototype tooling. MAHLE and MAN decided together to carry out the project in a single step, that is, without building prototype tools. The basis for the decision consisted of carrying out representative virtual simulations, tests with prototypes called Rapid Prototypes, detailed DFMEA and development of the product in CAD together with the customer. The concept was defined so that only small design changes could be made, such as occasional changes in wall thickness and/or inclusion of ribs or small shapes that would not compromise the structure or shape of mass production tooling.

DESIGN SIMULATION – CFD and FEA Calculation were carried out with the objective of representatively anticipating the real conditions of the application.

CFD calculations were able to assess the real condition of head loss and movement of the coolant flow inside the Cooling Manifold, demonstrating that even in a plastic tube that, due to the injection process, is designed with draft angles that vary the fluid passage section, it does not compromise the result in relation to the machined aluminum tube with constant cross-section. CFD calculation also gave a great support in the oil separation flow calculations providing a basis for defining the disposal and flow strategy in a regime closer to the laminar condition. CFD Calculation in Figure 9.

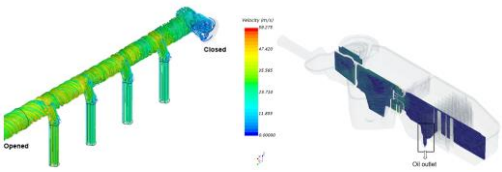

Figure 9: CFD calculation

Modflow calculation evaluated the conditions of projects and processes for the injection operation of plastic components. For a better condition from the structural point of view of the part, it was essential to analyze and apply injection sequencing through valves that ensure that the flow allows for the best alignment of glass fibers, which are materials that make up the granules of the polymeric material. Moldflow also made it possible to define early countermeasures for the construction of tooling for the conditions of warping of parts, among other benefits. Moldflow calculation in Figure 10.

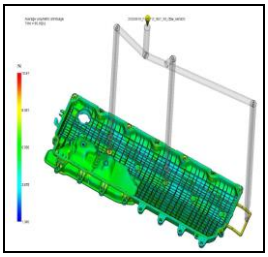

Figure 10: Moldflow calculation

FEA calculations were able to assess the structural conditions of the panels forming parts, Impacts, punctual efforts, sealing conditions, among others.

The calculation considered the boundary conditions of the project such as Pressure, Temperature, Efforts of peripheral components, fastening system, Elastomeric materials, etc. who guided in design countermeasures still in the design phase of the project in an assertive and relevant way. FEA calculation in Figure 11.

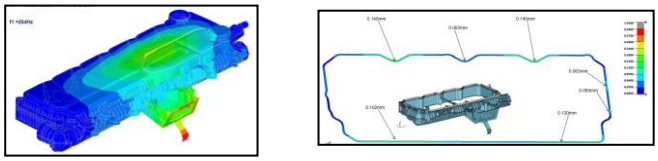

Figure 11: FEA calculation

RAPID PROTOTYPE – Following the agreement not to make tooling prototypes, but with the need to validate product, engine and vehicle functions, the decision was to manufacture prototype parts as representative as possible.

The process for the Rapid prototype chosen was the Process called PA Casting – parts injected in Polyamide mold and in material >PA6-GF30<. The samples provided that functional tests were carried out in advance during the finalization of the product design

With these prototypes, it was possible to evaluate the initial conditions of oil emission from the blow-by system, assembly, vehicle testing, among others.

The use of Rapid Prototypes in PA Casting allowed the development of the client's project without jeopardizing the development program, since this is a Running Change project, where most of the components were already defined, this item became the most representative of the project.

STYLE DESIGN

The valve cover is often the first part to be seen on the engine. The customer requested the condition of a style piece that led to the condition of development in partnership to define the final style, keeping the customer's Logo highlighted and the definition of texturing on the Valve Cover. Style Development in Figure 12.

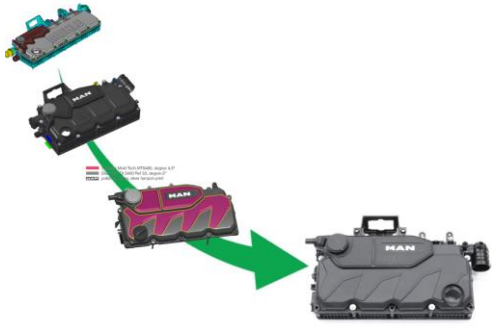

Figure 12: Style Development

CONCLUSION

The vision of a project conception is not limited to just one item under development. The search for systems integration projects as well as the application of innovations bring challenges with great economic, technical, and legislative benefits. The best use of resources, available or not, can be the key to consolidate a project in a very competitive field such as the automotive segment.

Working in partnership with the customer and supplier allows for more assertive projects with gains in performance and costs when thinking about systems and not isolated components.