Case Study: Volkswagen & Additive Industries

Additive Industries

Additive
Industries b.v.
Achtseweg Zuid 155,
5651 GW Eindhoven,
The Netherlands
T: +31 (0)40 2180660

www.additiveindustries.com
team@additiveindustries.com

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Case Study
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Volkswagen realises performance improvement & cost saving on Tiguan production tooling using the MetalFab in combination with M789 tool steel

Abstract

Through manufacturing their Tiguan production tooling on the Additive Industries MetalFab system, VW has achieved a significant cost reduction, along with a reduction in lead time and the ability to quickly iterate designs with improved performance.

Volkswagen Group Overview

The Volkswagen Group with its headquarters in Wolfsburg is one of the world's leading automobile manufacturers and the largest carmaker in Europe. The Group is made up of twelve brands from seven European countries.

Introduction

As an innovative car manufacturer, Volkswagen Group invests in advanced manufacturing technologies such as Metal AM. Each working day, 43,000 vehicles are produced by around 630,000 employees who are involved in vehicle-related services, or work in the other fields of business. The Volkswagen Group sells its vehicles in 153 countries. Volkswagen produces many parts with AM from tooling, prototypes and small series, and to support this have invested in two MetalFab systems at their Wolfsburg factory. This case study showcases a specific tooling nozzle, used in the mass production process of the VW Tiguan. The main impacts of this application are as follows:

- A major cost reduction for a consumable part used in high volume vehicle assembly
- A significant reduction in lead time for the supply of spare parts
- Added flexibility to quickly iterate designs with improved performance

This is a very significant achievement for Metal AM, which has been traditionally linked to Racing or Luxury car applications. With this case study, we demonstrate that by selecting the correct application in combination with smart design and the quality and productivity achievable with the Additive Industries MetalFab system, Metal AM is now ready to be competitive and cost-effective as a production method in the automotive industry.

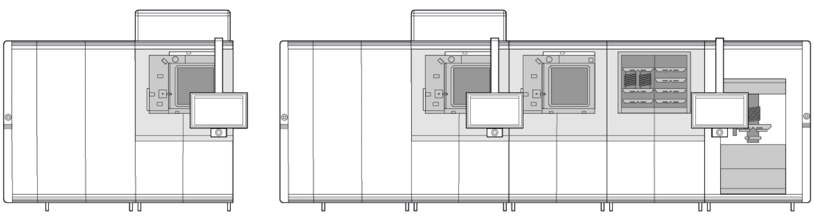

Fig.1 VW MetalFab installation, Wolfsburg

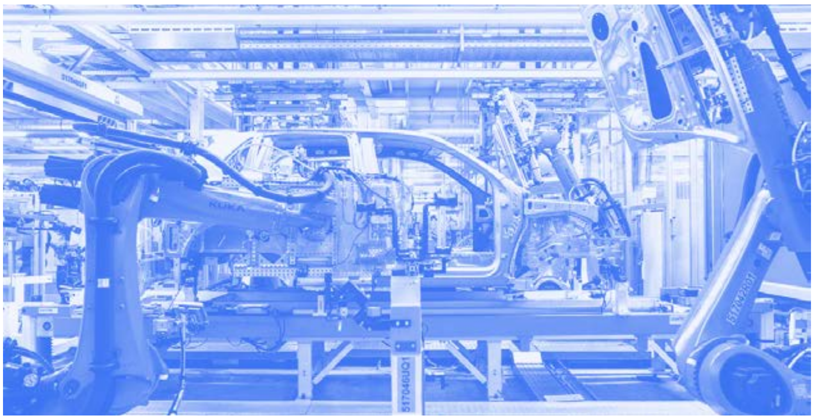

Figure 1. VW vehicle assembly line

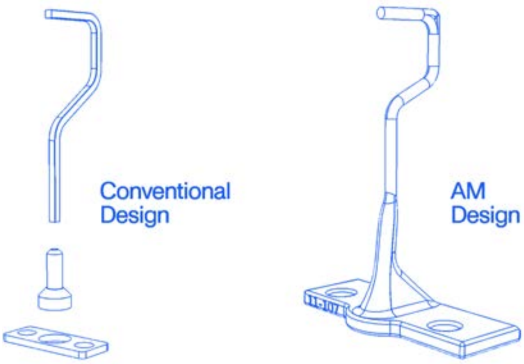

Figure 2. Tooling nozzle design integration

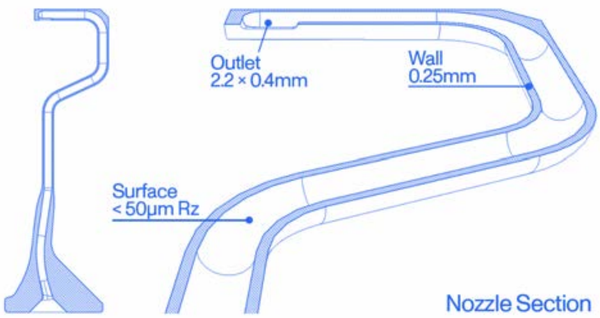

Figure 3. Nozzle key features

Application Overview

The tooling nozzle is a component used during the VW vehicle's assembly process. Each car model has its own unique nozzle and this case study is focused on the design used during the assembly of the VW Tiguan. During the car assembly process, the tooling nozzle is attached to a robot arm which sprays a liquid PVC rope at the flanges of the front and rear doors of the car. The rope is applied to protect the door against water-induced corrosion. Conventionally, the nozzles are made of three titanium parts, that are welded together (see Fig. 1). Many different manufacturing and post-processing steps are required in its manufacture.

From a technical perspective, the accuracy of the nozzle outlet is a critical requirement to ensure the quality of the PVC deposited rope. More than 1000 nozzles per year are required for the VW Tiguan car production in Wolfsburg. Previously, VW outsourced the manufacture of these nozzles, which impacted both the cost and lead time of production. The challenge for the AM part is to achieve a tolerance of +/-0.01mm for the nozzle outlet, whilst also achieving a density of >99.7% for walls of 0.25mm with a surface roughness <50µm Rz.

Furher to this, VW were aiming to increase the life of each nozzle and therefore decided to move to a high strength steel alloy which also possessed high corrosion resistance - M789 tool steel. Since this alloy is more commonly used for large, bulky tools in the die casting industry a set of process parameters would need some careful optimisation to ensure the requirements of the application were met, with a part specifc approach leading to custom settings being employed in production.

Parameter Development

Due to the small size of the parts and tight requirements around surface roughness, wall thickness and outlet accuracy, a high resolution parameter set was developed utilising a 30µm layer thickness. This approach will lead to a more controlled process allowing the thin wall density and surface roughness to be achieved, and can be more easily tuned to meet the specific nozzle profile and dimensional accuracy requirements. To achieve this a standard 3 step process was followed:

- Definition of baseline parameters
- Optimisation/fine tuning of parameters specific to nozzle
- Production build validation & sign off

The baseline parameter set is developed using a standard Design of Experiments (DoE) process, first on small scale density cubes which are analysed optically, and then validated with full build arrays of tensile test specimens and density cubes using all 4 lasers. This parameter

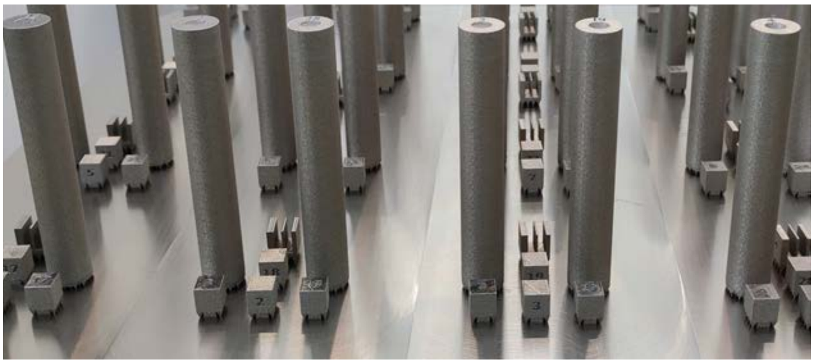

Figure 4. Baseline parameter validation builds

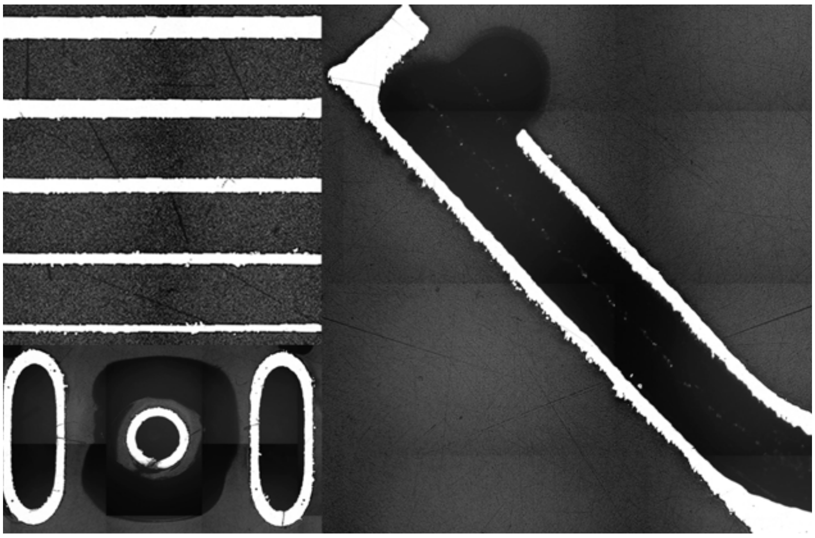

Figure 5. Mounted microscope images of various representative features

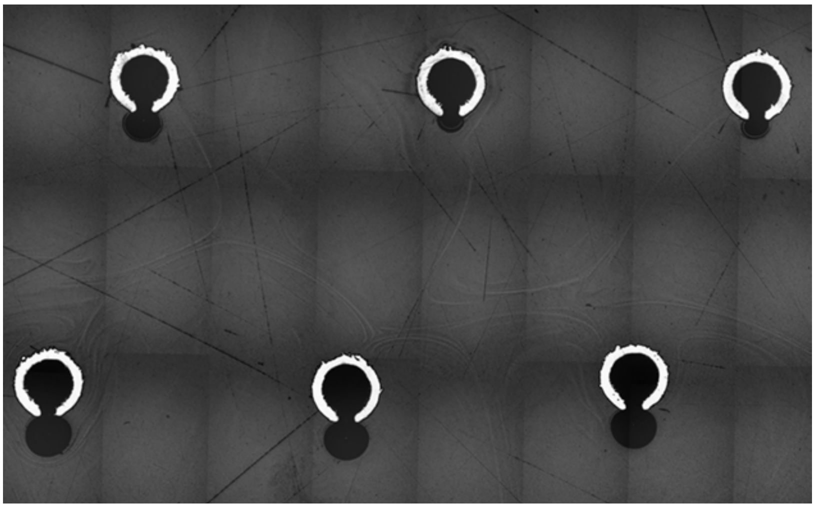

Figure 6. Nozzle outlet optimisation specimens

set forms the start point of the part specific parameter optimisation process, and was shown to achieve excellent mechancial properties and material density >99.9%.

To optimise this baseline a series of experiments are carried out to fine tune various aspects of the parameter set, optimising the energy density, spacing and offsets of the range of vector types which influence surface roughness, dimensional accuracy and thin wall density. The first step was to carry out a DoE to optimise the borders which includes the energy density, number of borders, spacing and interaction with hatching areas. Through this DoE it was possible to achieve acceptable density and surface roughness on vertical wall thicknesses down to 0.2mm.

Some further optimisation is then carried out to ensure that both density and surface roughness are meeting the requirements on angled features, with the infuential parameters here being Upskin and Dowskin borders and hatches. To achieve a good result, some representative test samples were designed - essentially small sections of the final nozzle design - which could easily be mounted and polished to allow optical microscopy to be carried out, along with clamping for surface roughness measurements. During a further DoE study, an optimal set of parameters are created to also meet the roughness and density requirements of the 0.25mm nozzle walls at angles down to 45 degrees, with good results demonstrated on sample level.

With the fundamental parameters now in place, the final step is to optimise the dimensional accuracy of the nozzle outlet, with a very tight tolerance required across the 2.2 x 0.4mm slot of +/-0.01mm. To realise this accuracy the beam compensation is fine tuned, once again using a representative sample built in the production orientation of this feature - 45 degree upfacing. A range of specimens are produced with various beam compensation settings, mounted, polished and measured using optical microscopy. The optimal setting, which achieves the required tolerance is added to the new parameter set.

With the part specific parameter set now complete, the final test is to ensure that these settings work effectively with all 4 lasers, in all positions of the base plate since the MetalFab has full field lasers. This test was carried out using the various specimens which were mounted, polished and analysed confirming their conformance with the requirements.

Using this parameter set a series of production representative builds are carried out with selected samples destructively tested.

Figure 7. The M789 tooling nozzle build manufactured with MetalFab

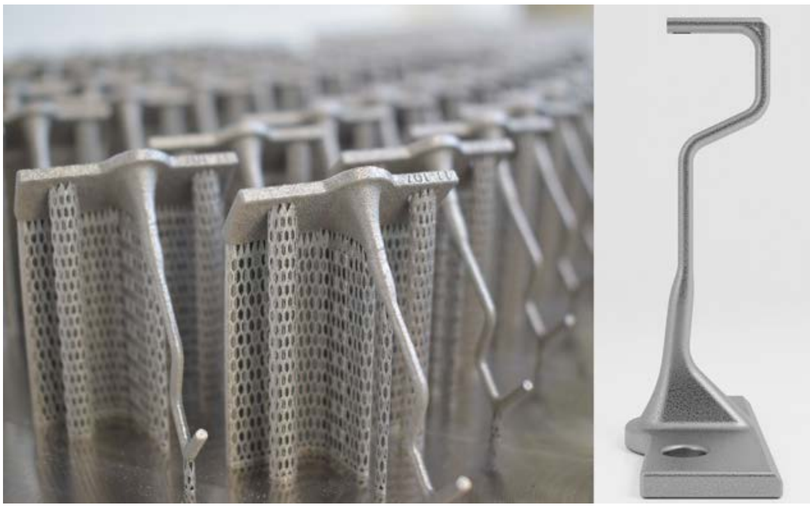

Figure 8. Nozzle parts as built in MetalFab

Part Manufacturing

The production nozzle build job is prepared with parts in the pre-defined orientation and support structures added. The geometry has been simulated and pre-distorted, to reduce any deformation of the final parts and the part specific M789 process parameters developed by Additive Industries, are assigned to the build.

The build (Fig. 7) is then printed with the MetalFab system and its automatic powder removal feature. 80 tooling nozzles fit the system build platform, and, thanks to the 4 lasers working in parallel, the printing time is only 13 hours. After printing, the nozzles are easily removed from the build platform and the support structures are manually removed. Every nozzle is then inspected visually and using a pass/fail jig, checking the fit & form of the parts, before being assembled onto the robot arms ready for use. The total lead time for this manufacturing process is 2-3 days.

This is a huge time saving when compared with the weeks needed for the conventionally manufactured components. Thanks to the design optimisation and process simulation, it has been possible to avoid any post-machining or heat treatment steps. The AM nozzle is made of M789 Tool Steel which is much cheaper than the Titanium alloy previously used as well as demonstrating improved damage tolerance and similar good corrosion resistance. The combination of material change and optimised AM design, maintains the performance required for the tooling nozzle.

Feature	Value
Material	M789 Tool Steel
Parameter set	30µm part specific
Printing time per part	9.75 minutes 80 parts on a build which takes 13 hours
Internal channel diameter	1.3mm
Minimum wall thickness	0.25mm
Area in the car	Door sealing front and rear, application of PVC rope at the flange
Vehicle range	Tiguan

Conclusion

This project, born from the collaboration between Volkswagen and Additive Industries has demonstrated the significant business case benefits, especially in terms of cost and time, that the MetalFab system can bring in the Automotive mass production sector. Being one of the first projects which have demonstrated an important cost reduction in the daily application of this sector, where Metal AM has traditionally struggled to penetrate, the AM nozzles have been shown to be an interesting business case that will inspire and create more applications in similar production environments.

At Additive Industries, our objective is the success of our customers in achieving the lowest cost per part at market leading part quality.

We pride ourselves on our flexibility to work with our MetalFAB users in achieving their industrial goals.

Contact details

Additive Industries b.v.
Achtseweg Zuid 155, 5651 GW Eindhoven,
The Netherlands P.O. Box 30160, 5600 GA Eindhoven,
The Netherlands
T: +31 (0)40 2180660

Additive Industries North America, Inc.
Process and Applicati ons Development Center
1250 Avenida Acaso, Unit H, Camarillo, CA 93012,
United States of America
T: +1 805 530 6080

marketing@additiveindustries.com