KTM Technologies GmbH

Reduction of Moving Masses – Streamlined Design for Improved Engine Performance

To further improve engine performance regarding the available rpm range it is important to reduce the mass inertias of the moving masses to a minimum while meeting the component's stiffness targets. In this way, the rpm can be maximized without leading to higher forces on the component. Keeping the loadings on a low level also ensures that the part will show the needed durability performance. In a project at KTM Technologies GmbH, a division of PIERER Mobility AG, engineers were tasked with redesigning a rocker arm to improve inertia and reduce its mass while at least keeping deformation and stiffness on the same level.

Claim for best performance

Having their main competences in the field of automotive, sports, general machinery, medical, and smart consumer applications, KTM Technologies focuses on concept and product development in lightweight design, composites and electrics and electronics. KTM Technologies' simulation division employs static and dynamic structure simulation, computational fluid dynamics (CFD), manufacturing simulation, e-motor, and operating range simulation along with optimization. As part of the simulation division, the structure and optimization group is primarily focused on structural optimization of parts for various manufacturing methods (such as composite, forging or casting components), durability analysis, and multi-scale modeling of additively manufactured lattice structures.

For the KTM 450 Factory Edition, a motorcycle currently available in the U.S., the structure and optimization group was challenged with improving the engine performance by redesigning the existing rocker arm to reach higher rpm values. As an Altair customer since 2014, KTM Technologies used Altair HyperWorks™ to structurally optimize the design while taking manufacturing constraints into account. Specifically, they used Altair HyperMesh™ for preprocessing tasks, Altair OptiStruct™ for topology optimization and nonlinear finite element analysis, and Altair HyperView™ for postprocessing tasks.

Industry
Motorcycle, Automotive

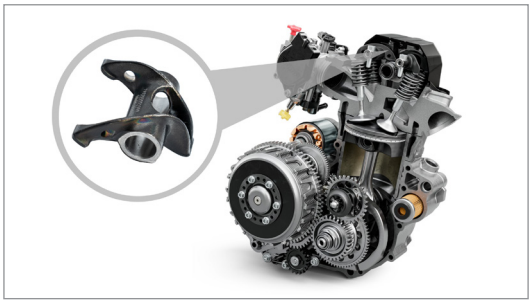
Challenge
To expand the rpm range of a motorcycle engine a new type of rocker arm with lower inertia was needed while maintaining or improving stiffness and deformation level.

Altair Solution
Altair HyperWorks™ for nonlinear topology optimization and nonlinear structural analysis.

Benefits
- Reduced component inertia by 15 percent
- Reduced component mass by 21 percent
- Improved stiffness by 14 percent
- Extended rotational speed by 150-200 rpm

Topology optimization accounts for manufacturing method

To reduce the mass inertia of the existing rocker arm while keeping the overall stiffness, the team first defined the design space for the new geometry, applied forces on the component and included other boundary conditions. They also added manufacturing constraints for forging to the model. Having all the information in place, the team used OptiStruct to conduct a topology optimization to define the ideal geometry of the redesigned part. Subsequently, the engineers evaluated the deformation, contact pressure, static stress, durability, and the new mass in comparison to the existing design.

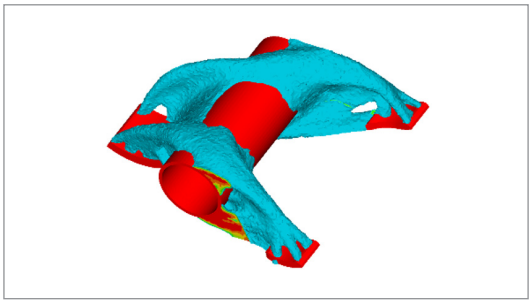


Single cylinder engine of KTM 450 Factory Edition

Boosting motor performance

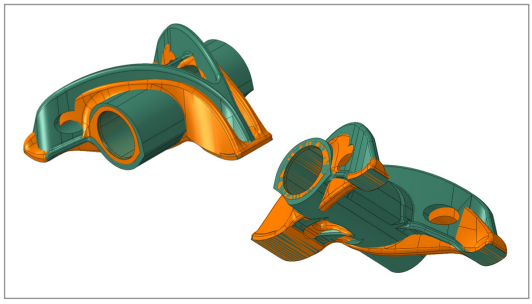
The newly defined optimized geometry of the component led to a much more compact and more mass centering design, where the lower section became stronger. On the camshaft side of the rocker arm, the new version now had two arms instead of only one as in the previous design, enabling a more homogeneous contact pressure distribution, leading to less abrasion and a longer lifetime of the rocker arm.

The new rocker arm design exceeded all set goals. It was possible to reduce the mass inertia by 15 percent and the mass by 21 percent, to increase the stiffness by 14 percent (leading to less deformation), and the component shows a much better durability safety factor. All made improvements contribute to a higher rpm range, the basic intent of the redesign. For the engine used in the KTM 450 Factory Edition, this means an additional rotational speed reserve of 150-200 rpm.



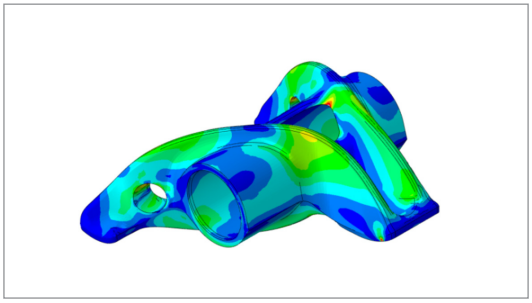
Element density plot of a topology optimization was the base of the new rocker arm design.

> "In combination with knowledge from the engine experts of KTM and our engineers of KTM Technologies, the Altair solutions enable us to accurately optimize various components and reach a new level in lightweight design."
>
> David Marschall
> Group Leader Structure & Optimization, Department Simulation.



Geometry comparison of the old (green) and the new (orange) rocker design.

"Altair HyperWorks provides us with comprehensive tools for structural optimization," said David Marschall, Group Leader Structure & Optimization, Department Simulation. "The structural optimization with OptiStruct is fully integrated into our development process for engines and chassis and allows us to exactly adjust both, the optimization goals and the boundary conditions. In combination with our engineers' know-how, the Altair simulation tools enable us to accurately optimize various components and reach a new level in lightweight design."



FEM simulation

Looking ahead

Using the Altair tools in combination with KTM Technologies expert knowledge in structural mechanics, the engineers can now reach a new level in lightweight design and enable KTM and other third party customers to deliver high-end reliable products that meet all customer requirements.

While rocker arms are basic components of 4-stroke engines and have been subject to various optimizations in the past, the use of OptiStruct in this project marked a significant step towards efficiency and an improved performance of the engine.