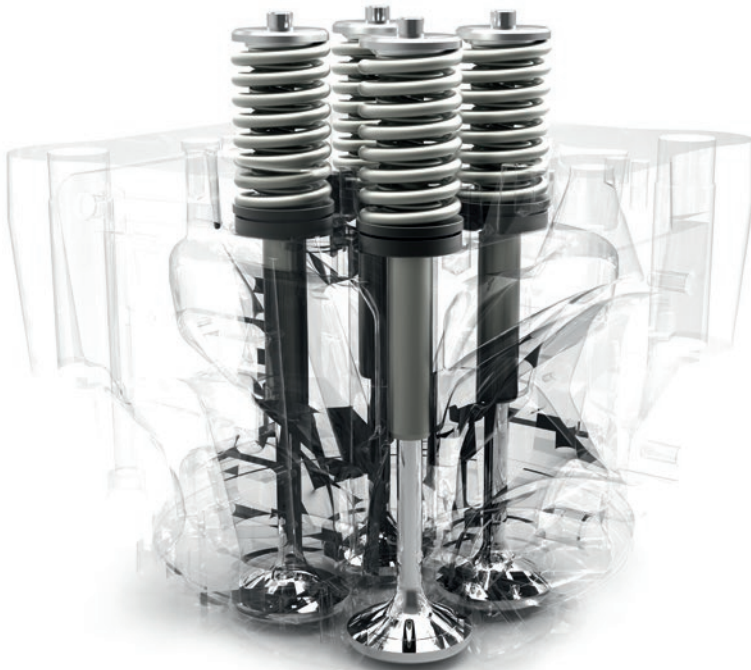


Performance



MÄRKISCHES WERK
Your Engine. Our Ingenuity.®

Where limits are only temporary: Welcome to Märkisches Werk



Ship engines, locomotives, power plants and racing: At Märkisches Werk, Halver (MWH), we develop, manufacture and recondition cylinder head components for many kinds of large bore and high speed engines. But if you ask anybody who works with MWH about what defines us, they will probably come up with answers that are a bit less technical: Our customers can always rely on us to keep our promises. Our products are just as reliable as we are. And every day at MWH, we challenge ourselves to enhance the performance of our clients' engines.

This does not only show in the quality of our manufactured engine components. It can also be seen in how we approach the individual challenges our customers confront us with on a daily basis. Ever since our modest beginnings as a small smithery in 1859, there has been a spirit of inventiveness, a passion everybody at MWH shares, to make things perform better. And if that means coming up with a solution beyond what has been deemed possible so far by others, then that's just what we will do.



"Going beyond what others deem possible, in manufacturing, development and reconditioning – that's what makes MWH so unique."

Pushing the limits of performance

What gives us a significant advantage in tackling customer challenges is that we are at the same time a company of engineers and of manufacturing specialists. This means we can make use of a particularly wide range of skillsets at once. Combining cutting-edge solutions from the areas of manufacturing engineering, material research and component design, we are able to create exciting new solutions that seriously push the boundaries of engine performance.

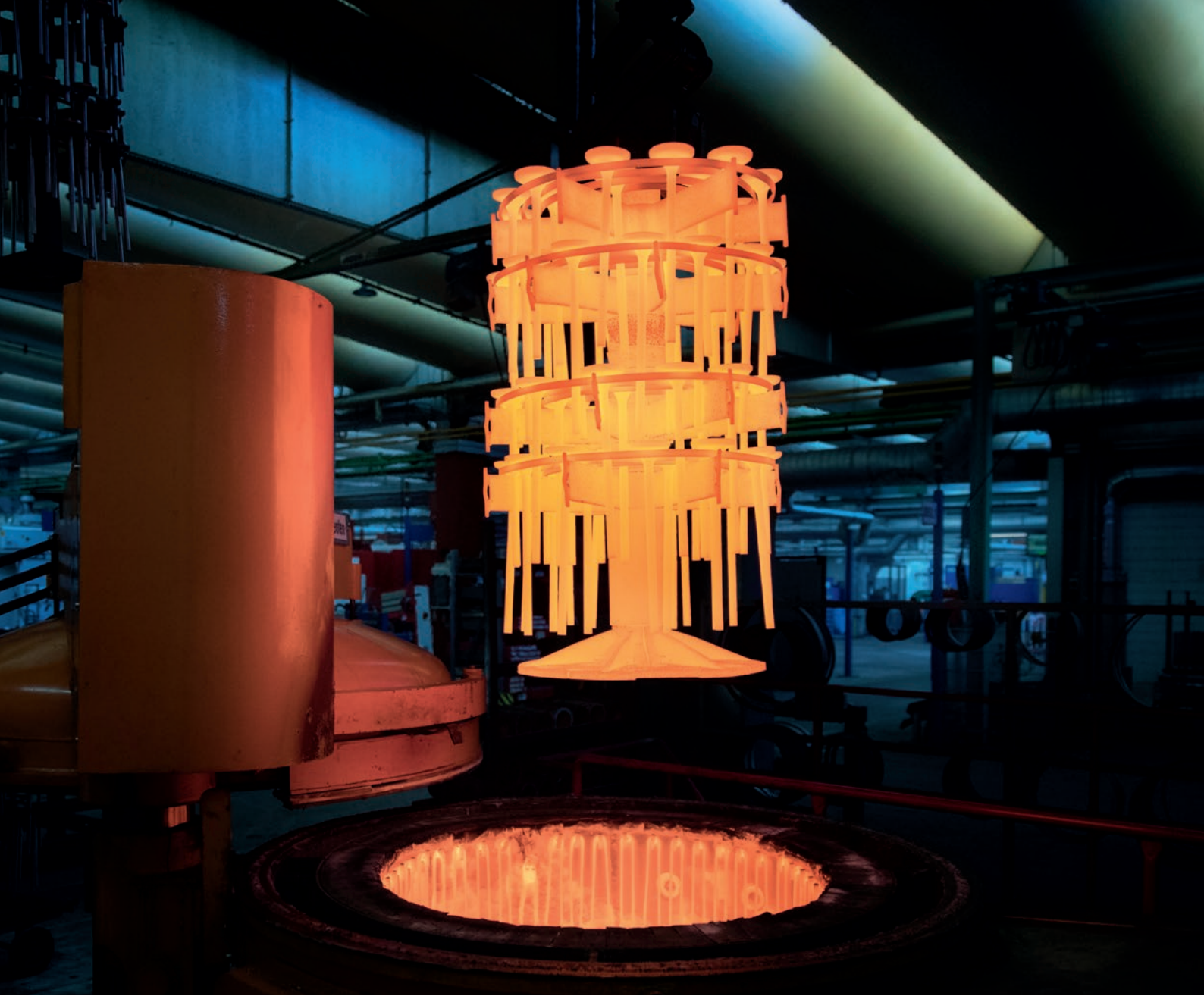
Exceeding customer expectations

Over the years, we have continued to set new standards in high-performance components. Which is why we have become a leading provider of cylinder head components and a development partner for the majority of large bore engine builders around the world.

But size isn't everything: What truly sets us apart is our clear focus on maximum performance. Which is why our MW Racing department applies our engine knowledge to precision valves used for example in Formula 1 and MotoGP high-speed engines by many leading racing teams.

Your Engine. Our Ingenuity.®

Ever since we have started creating engine components in the late 1940s, we have been solving the tasks our customers consulted us about, using pioneering science, in-depth engineering knowledge and decades of experience – plus the ability to truly listen to you, our customers. Because eventually it is all about your engine – and what our ingenuity can add to it.



The answer to current engine challenges: Performance

Experience and cutting edge science

From precision hollow head valves for Formula 1 engines to robust cylinder head systems for large bore ship engines, from engines that need to run long and reliably even in the most adverse conditions to the sprint-like high-speed performance of perfectly tuned racing engines: At MWH you will always get exactly the kind of high-performance component you need.

For decades, we have perfected valves and other critical cylinder head components – and we are still not done. As customers ask us to assist them with greater and greater technical challenges, we constantly evolve and innovate as a component manufacturer, development partner and leading edge problem solver for our clients.

Our own research as well as our collaboration with renowned research institutes ensures that we are always at the forefront of engineering, material research and manufacturing science. By uniting this scientific approach with our many years of knowledge and experience in engine components design, engineering and maintenance, we can uniquely offer our customers a complete package as we tackle the tasks they share with us.

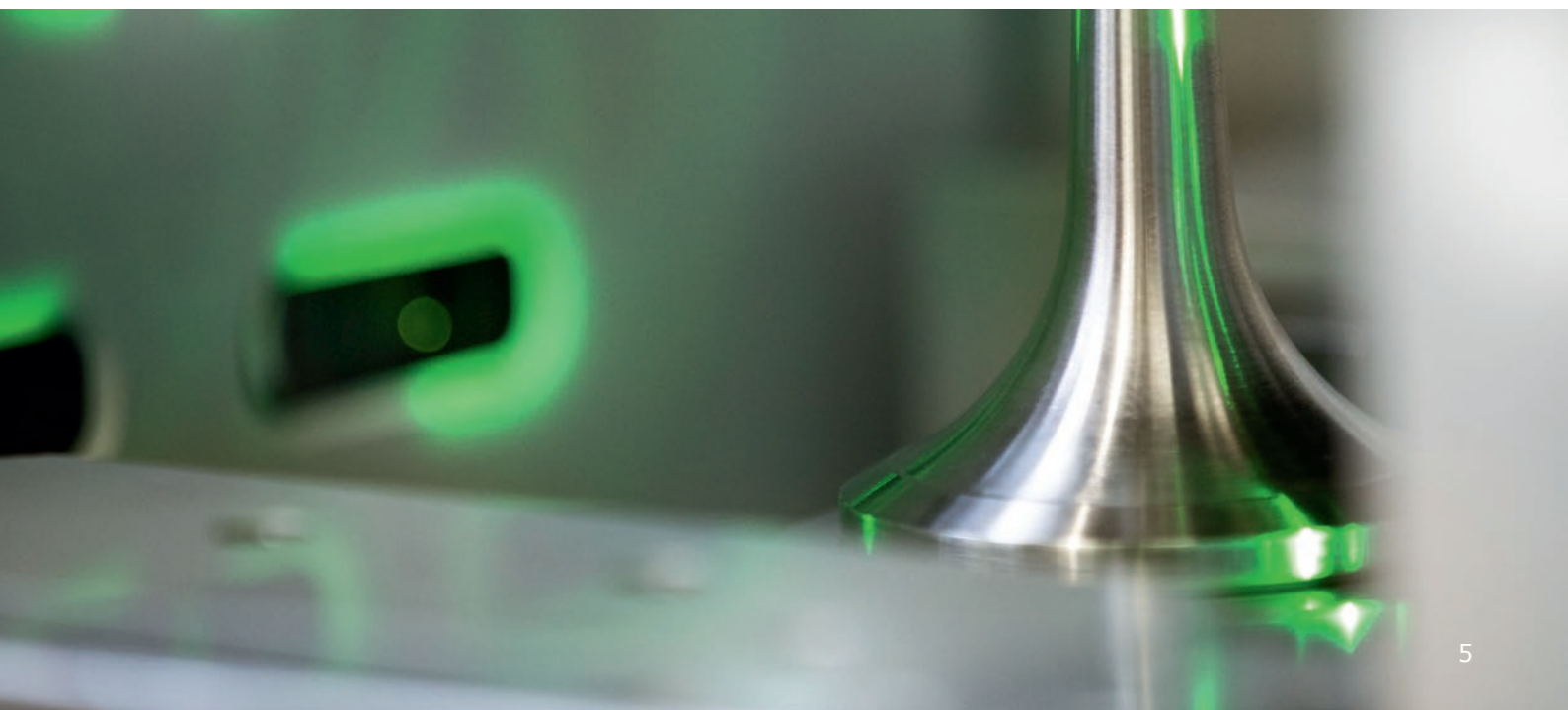
Meeting today's engine challenges

Engine builders as well as operators today are facing a wide range of increasingly hard-to-meet requirements. On the one hand, their engines need to perform better and better, which in itself puts more strain on systems and materials. On the other hand, operational costs need to be cut to a level of competitiveness that keeps them in business: Downtime has to be minimized, time between overhaul extended, and, lastly, fuel costs must be reduced.

On top of it all, increasingly strict emission standards worldwide are cracking down on levels of CO₂, sulfur oxides and NO_x. Innovative types of fuels, from gas to synthetics, are one way to cater to these demands, but they also render an engine's operating conditions much more difficult. New types of engine wear and tear have to be considered.

One-stop shop for cylinder head systems

The more strain on components, the more beneficial it is to have perfectly optimized component systems. This is where MWH as a one-stop shop for cylinder head systems comes in. Because our components are made to work together as smoothly as possible and are also designed to withstand the strains of being used with a particular type of fuel, you will reap the benefits both short- and long-term. After all, the better components are tuned to each other and to their operating conditions, the less you will have to worry about wear and tear. An optimized system will help maximize engine performance, it will reduce planned and unplanned downtime and it will considerably extend the engine's total lifespan.



A wide range of things we can do for you



Beyond manufacturing

As a problem solver for all things related to cylinder head systems, we go far beyond component design and manufacturing in what we can do for our customers. It is for this reason that engine builders from around the globe consult us whenever they want to create uncompromisingly high performance – or need to solve a particularly tricky engine problem.

Identifying the problem – and solving it

Our engineers are also in demand when it comes to diagnosing systems that don't work as planned. The MWH diagnostics team will get to the root cause of your engine issues, detecting the reasons for perpetual engine failure, for insufficient performance or unexpectedly excessive wear and tear even when others can't.

Our diagnostics experts will measure and examine your malfunctioning system on-site, including a thorough look at operating conditions. They will then take the data gathered back to MWH, where we will develop a custom solution for the problem. Once this solution is installed, our engineers are also able to train your staff to service and maintain the system in the best possible

way. This is often a crucial factor, which can contribute to a more favorable system lifespan as much as the system improvement itself.

Sustainable and cost-efficient: Reconditioning

Reconditioning is another area of MWH problem solving expertise. MWH offers this service both for single components and entire cylinder heads.

Having components or systems reconditioned isn't just sustainable – it massively improves total cost of ownership, without compromising on performance. Rather, when we receive your cylinder head for reconditioning, we will give it a thorough inspection, and if we find that it could perform significantly better, we will offer you ways to improve it. Eventually, you might end up with a reconditioned system that works better than it did originally – for a significantly lower price.

Components like cylinder heads, valves, seat rings and valve cages can be reconditioned twice without any loss in performance quality or life span. This will save you up to 50% compared to new components.



The MWH performance investigators: Getting a power plant back up and running

While operating a power plant that several hundred thousand households depend upon for electricity, reliability is critical. So, when only a few years after starting operations, this particular South American power plant began to experience problems which lead to unplanned engine stoppages, it was clear that this was a serious issue. After all, the power plant was no longer able to reliably dispatch electricity to the grid. This not only led to blackouts, but also to lost revenues and fines from clients.

Time and money were invested in multiple attempts to diagnose and solve the problem – to no avail. Finally, after having been contacted by MWH, the power plant operator revealed that they had been experiencing heavy valve wear in their engines. Valuable power output was being lost due to constant engine stoppages in order to measure valve lash.

Systematic analysis and documentation

Possible next steps were discussed with the customer. Different scenarios and options were considered, particularly in terms of costs and efficiency. Eventually it was decided that MWH should take on the challenge to find a viable solution for the problem. Our engineers began to investigate.

And investigate they did: Nothing was left to chance. Step by step, they inspected materials, examined maintenance procedures, probed the quality of fuels and lubricants. They thoroughly analyzed the engine's Otto cycle and even the current component designs – all while bearing in mind that solutions should not affect operational costs and must be designed to limit component cost inflation while minimizing part specification changes.





"We identify the problem, and then we solve it – all while keeping in mind the customer's budget and needs."

A better system with better components

The engineers' verdict was clear: After analyzing the data and running R&D simulations, it was obvious that the engines were suffering from a lack of tribofilm from lean-burn operations and post-combustion residual deposits on the valve train components. To make the engines run efficiently, a different geometry and possibly a material upgrade for both valves and seat rings for the exhaust side were needed. All improvements implemented during the overhaul processes were documented in detail, to ensure correct installation in the cylinder heads.

Once the solution was installed, wear was observed and measured during the initial operating break-in with an additional inspection once a third of the target hours had been reached. Keeping an eye on the operating conditions allowed for further process improvements. The scheduled inspections brought good news: The geometry change along with the upgraded materials had yielded the desired results. The client finally was able to reach proper engine time between overhaul.

A passion to always make things better

While happy with this first result, our engineers weren't quite done yet: To further improve conditions at the power plant, they developed a method to measure valve lash without having to stop the engine. Using our strategic partnerships in condition-based maintenance and combustion know-how, MWH employed ultra-sound technology to determine the exact moment of opening and closing of the exhaust valves and pilot injection valves – all without having to stop the engine. This solution will further reduce engine downtime for valve lash calibration in the future.

Needless to say, the customer was delighted with how MWH not only identified but sustainably solved the problem and our engineers are already thinking about how to optimize the system even further.

Built-in expertise: MWH systems and components

90% of the large engine builders around the world rely on MWH for cylinder head components that deliver the highest level of performance. We develop, manufacture and recondition components for a wide range of applications and fuel types, such as diesel, MDO, heavy fuel, natural gas or propane. All of our expertise plus decades of experience and research go into the products and services we offer. This also means that, if you are in need of a solution we don't have in our portfolio yet, it still pays to talk to our engineers.

No matter whether you are looking for high-speed racing engine components or components for large bore combustion engines, we continue to set new benchmarks for efficiency, lower running costs, dependability and last but not least: Excellent performance.

High performance by MWH

Components and systems for large bore combustion engines and high-performance racing engines, developed, manufactured and delivered by MWH:

- Valves
- Valve guides
- Seat rings
- Springs
- Pre-chamber nozzles
- Valve rotators (TMA, BSR)
- Clamping cones
- Valve cages and assemblies
- Piston pins
- Reconditioned components
 - Valves (4-stroke, 2-stroke)
 - Cylinder heads
 - Valve cages

Valve reconditioning: Excellent quality, excellent TCO

Freight locomotives are expected to work in the toughest conditions: Each pulls up to 60 freight cars carrying a wide variety of goods from soy beans to oil to iron ore to shipping containers. They cover transcontinental distances such as from the port of Long Beach, CA to New York, NY, crossing the Rocky Mountains and the Great Plains, in the coldest of winters and the hottest of summers.

No matter the conditions, operational availability, lowest cost per ton per mile and fuel efficiency are key. Intake and exhaust valves are critical not only for performance and reliability of engines, but also for emissions.

Regular valve replacement

To ensure an operational availability of at least 95%, our client, a major global manufacturer of freight locomotives with 12- to 16-cylinder diesel engines and up to 4,000 horse power, set up a service program for engines in collaboration with MWH. This program includes replacement of critical components after certain periods. Exhaust and inlet valves, for example, are replaced after seven years, as part of an extensive engine rebuild.

A common goal of both the engine builder and MWH is the reduction of life cycle cost of valves while re-using highly valuable material. During engine overhauls, used valves are taken out of the engine and returned to the nearest MWH facility. The components are returned to MWH reusing boxes and trays which originally contained new or reconditioned valves.

Like new – for 50% of the cost

The remanufacturing process at MWH has been developed to ensure the same quality level and life-time as a new valve. Upon arrival at MWH, every valve is cleaned and then submitted to our rule-based inspection (RUBI). It then undergoes our specifically designed remanufacturing process. This is done on the same machines where our new parts are manufactured, and with the same rigorous quality control. The final result is a remanufactured valve with the same life expectancy as a new valve at 50% of the cost. A significant contribution to a competitive total cost of ownership in the rail business.

"Everything we do is about quality and durability. Oh and it doesn't hurt that our reconditioning process saves our customers a lot of money, too."





"We know that other people rely on our components to perform. Be it for power generation, Grand Prix racing or out at sea. That is what drives quality at MWH every day."





Unique possibilities, unique solutions

Ingenuity at its best

At MWH, you will find experts both for component design and manufacturing. This gives us a unique advantage as we can simultaneously work with all these factors to achieve the best possible outcome. By orchestrating design, material know-how and manufacturing engineering, we create, improve and enhance certain desirable properties in the system and minimize or eliminate unwanted ones. Again and again, this holistic approach to creating components enables us to redefine the limits of what can be done – and it is certainly one of the main reasons why we are in demand as an innovative system provider around the globe.

Better materials, better methods

MWH engineers are always developing new methods and materials to make engines work well under real-world conditions. Meticulously examining operating conditions often leads us to choose special materials – or to develop new ones that sport the qualities needed.

To reduce acidic cold corrosion, for example, we developed the Cold Corrosion Coat MW-C³. This coating considerably extends the life-cycle of seat rings. Our MW-C² coating is an innovative thermal barrier coating, which protects valves as well as piston crowns whenever heat and corrosion are an issue, for example if an engine is to be operated with HFO (Heavy Fuel Oil).

Better engines, better performance

For high-performance Formula 1 and MotoGP engines, we have developed our diamond-like coating DLC, which minimizes friction, allowing for a higher engine speed and thus higher performance. To further improve performance in racing engines, we introduced a material known and used in aerospace engineering to racing valves: Titanium aluminide guarantees both high stiffness and particularly low weight. For an additional 15% of fatigue strength, our Formula 1 valves are created by means of extrusion.



A formula for success: New materials for better racing engines

Season after season, racing teams search for new and better solutions. After all, when it comes to winning, even the tiniest details matter: a slightly stronger material, a slightly lighter component, a slightly smarter solution – all these small bits can add up to making or breaking the season.

As racing team engineers work on increasing power by maximizing the volume of air and fuel that moves through the engine, they have to increase rpms, which in turn creates friction losses. Worst case, this can lead to uncontrolled valve motion and, eventually, valve failures. Reducing valve mass while maintaining – or better yet, increasing – valve strength and stiffness would solve the issue.

Introducing titanium aluminide

MW Racing with all of the MWH valve expertise is just the right partner to resolve these issues. In close cooperation with renowned international racing teams, we for example developed and manufactured inlet and exhaust valves made from titanium aluminide which come with roughly 10% lower density and 15% higher stiffness than titanium – valves truly ready for high performance.

To achieve these specifications we didn't just rely on cutting edge materials previously unused in valves. We also optimized our manufacturing process to the limit, for example by maximizing material properties further through extrusion, but also through surface superpolishing and special thin-film coatings.

Always trying to get better

At MW Racing, we have a lot in common with our customers. Just like them, we are all about performance. And just like them, we are always trying to get even better. Several generations of TiAl valves have been in use by racing teams in the last decade or so – and we like to imagine that now and then, they just may have been that slightly better detail that made all the difference.



"The difference between an engine and a high-performance engine is that the latter consists of high-performance components."



Extraordinary engines
demand extraordinary
engineering

Your partner in development

Whenever you plan on a new engine to perform on the verge of what is currently deemed possible, we at MWH are there for you with all our expertise. In fact, the earlier you involve our engineers in your design process, the better we can support you in developing an extraordinary engine.

Be it for a large bore engine or for a high-performance racing engine, as a manufacturer or engine designer, it makes sense to take advantage of our components expertise. This is especially true if you plan to go beyond current performance standards with your specifications. We can design and manufacture components for you that meet even your highest demands – and that you will not find anywhere else.

An unmatched treasure trove of know-how

Our specialists draw on the most advanced science as well as decades of hands-on experience and practical know-how. We know what will work in an engine and what won't, we know why things might fail, we can anticipate technical difficulties and predict probable pitfalls. In addition to that, we have unmatched knowledge about how environmental factors and operating conditions might impact your new engine. In short: You will end up with tried and tested components that are custom-made to your specifications.

Validated components

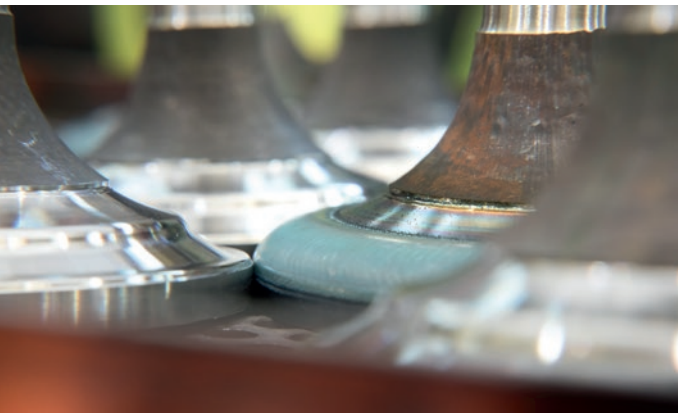
One of the most important reasons for engine builders to involve us in their design process is that we can deliver validated components. Getting for example a validated subsystem with a fine-tuned valve and seat ring makes for one less thing to worry about during the engine design process. After all, we are not only able to calculate the perfect geometry for your purpose and simulate wear and tear – we will also validate individual components and materials using high-end test rigs, either at our own labs or at one of the renowned research institutes we collaborate with. Either way, the result is the same: By working with MWH, engine builders save both time and money.

"By designing your engine with MWH, you will be able to skip quite a few unpleasant surprises."





The devil is in the detail – and so is the solution



As a development partner for engine builders, we at MWH combine material science and cutting edge engineering in order to go beyond what is currently deemed possible. Maximizing desired material properties and joining different metallic materials and alloys for improved performance.

When one of our clients contacted us about a brand-new engine they had developed which was showing unexpected valve wear and tear in the field, we were immediately sure it was a job for our engineers – the amount of wear found on the valves after less than 1,000 operating hours seemed excessive and called for thorough investigation by our experts.

"With us, you can think beyond what is possible. And then go there."

After inspection of the damage and extensive FEM simulation, our engineers came to the conclusion, that the problem could be solved by an upgrade of the materials used: Buffered hardfacing would make the valves more wear-resistant and thus gives the engine and its valves a more reasonable running life. Of course, at MWH, with our combination of research and manufacturing capacities, the step from theory to practice could be taken quickly. And soon enough, the new valves could be installed.

The improved engines performed as planned and the operating hours with the new valves rose to a trouble-free 15,000 – enough for the engine builder to confidently proceed on to mass-producing, marketing and, last but not least, sell their new engine.



We are there for you, wherever you need us

Your engines power ships across the seven seas, drive trains on every continent, generate electricity throughout the developing and developed world and push natural gas and oil through a network of pipeline spanning the globe – they are the heartbeat of the modern world. These global applications require a global network of experts, support and logistics, which is why you will find our engineers wherever MWH expertise is needed. Together with our regional hubs, we cover the globe and we will happily be there for you, wherever you are and whatever your specific component needs are. Contact us, you'll be surprised at how much we can do for you!

*"We cover the globe
and we will happily be there
for you."*





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