The Open University

DESIGN BEHIND THE BIKE

WHEELS

INTRODUCTION V.O.

Far from being a simple, round, spinning object, the component parts of a wheel combine to affect weight, aerodynamics and the overall performance of a bike. Over time, changes in technology, materials and testing have meant that science and those at the forefront of bicycle manufacturing have never stopped reinventing the wheel.

1. THE COMPONENTS OF A WHEEL

BRIEUC CRETOUX, RESEARCH ENGINEER, MAVIC

The wheel is the key element between the bike and the ground and especially the tyre.

BEN SPURRIER, HEAD OF DESIGN, CONDOR

The component parts of a wheel are the rim, the spoke nipples, the spokes and at the centre the hub. In their separate parts they're not strong at all. Once they are laced into the pattern of a bicycle wheel is when they become a truly strong, cohesive unit.

2. HISTORY OF WHEELS

MICHEL LETHENET, GLOBAL PR MANAGER, MAVIC

The first wheels were in wood. The second generation of wheels were in steel, but super heavy. The next step was the integration of aluminium. But the aluminium has characteristics that can be interesting for making hubs but for example it took us years to achieve aluminium spokes.

V.O.

The evolution of the spokes from the struts of the wooden and iron wheels to the spokes under tension in later wheels was also a significant development. Frenchman Eugene Meyer invented the wire-spoke tension wheel in 1869 for use in the high wheeler bicycle. Wheels using such spokes under tension were lighter and gave greater comfort to the rider.

ROGER HAMMOND, FORMER PROFESSIONAL CYCLIST

Wheels have changed immeasurably. I mean OK they're still round. That's about it. When I first started they were pretty much what we used to call a box section aluminium rim with 32 spokes generally. Then carbon fibre hit the market, initially in the frames and once they'd developed it enough it was introduced to the wheel technology.

BEN SPURRIER, HEAD OF DESIGN, CONDOR
Carbon fibre is the lightest material that you can build a rim from whilst maintaining all the requisite strength.

MICHEL LETHENET, GLOBAL PR MANAGER, MAVIC
All those materials brought evolution, brought interesting aspects but each one of them has good side and bad side in terms of characteristics, they can be used for some parts but not all the parts to make a complete wheelset.

V.O.
With regard to characteristics, early steels were strong but prohibitively heavy. Aluminium was lighter and a good material for making hubs but was technically more challenging when used to make spokes as it would crack when bent. Carbon fibre is light and can be used to make very developed shapes but is expensive and a compromise in terms of durability.

Understanding the role each wheel plays individually and collectively on the bike and the forces involved in performance, has been crucial in the evolution of wheels.

BEN SPURRIER, HEAD OF DESIGN, CONDOR
The front and rear wheels of a bicycle are very often constructed in different ways because they have different jobs to do.

BRIEUC CRETOUX, RESEARCH ENGINEER, MAVIC
If you improve the performance of the front wheel you will improve the performance of the complete bike.

BEN SPURRIER, HEAD OF DESIGN, CONDOR
The rear wheel is concerned with driving the bicycle forward and that has a rotational force generated from the hub obviously where the chain goes around the cogs. So you're generating a twisting movement from the centre of the wheel at the same time as the rear wheel bears the brunt of the weight of the rider so it has to be stronger in different ways. The front wheel of the bicycle has to deal with different twisting forces under steering and braking but it doesn't have to bear so much of the weight of the bike so it can be lighter.

V.O.
Reducing the weight to create lighter wheels became the focus of wheel component production and overall design. In time, this focus would lead to the introduction of vital new materials adapted for use from other industries.

BEN SPURRIER, HEAD OF DESIGN, CONDOR

When you reduce the weight of rotating mass, it is something in the region of 4 times as effective as reducing the weight of static mass. A lighter weight rim will accelerate faster than a heavier rim, so you need lightweight components to make up that rim. The only down side of that is a compromise to strength.

MICHEL LETHENET, GLOBAL PR MANAGER, MAVIC

You have two weights in a wheel. The wheel itself, the mass, and the rotating mass. You maybe wont feel the weight because the inertia of the wheel will be low. You can have also super light wheelset that will be very interesting to ride when you go up hill but when you're on the level surface you will need to push on the pedals very regularly to keep the momentum because there's no inertia.

BEN SPURRIER, HEAD OF DESIGN, CONDOR

If you lace together a wheel in what is referred to as a radial pattern so they fan out like the fingers on my hand, no two spokes cross over each other, you will ultimately create a stiffer and lighter wheel. A lot of wheels are laced together in such a way that we have spokes effectively criss-crossing each other. One spoke will be under compression while the other is under tension and that will help to distribute the forces evenly throughout the wheel.

MICHEL LETHENET, GLOBAL PR MANAGER, MAVIC

All this has to be considered and in the end also the wheel's got to be affordable and serviceable.

4. DESIGN EVOLUTION

V.O.

The introduction of lightweight carbon fibre into bicycle design along with new testing and scientific knowledge revolutionised the sport. Aerodynamics became of paramount importance in the design of the wheel.

MICHEL LETHENET, GLOBAL PR MANAGER, MAVIC

Aerodynamics was already in our mind for a long time. It has accelerated in the past fifteen years.

ROGER HAMMOND, FORMER PROFESSIONAL CYCLIST

The first thing that cuts the air is your front wheel so of course it's hugely important for aerodynamics.

BRIEUC CRETOUX, RESEARCH ENGINEER, MAVIC

The drag is the force of the air to the rider and to have a good aerodynamic system the drag must be as low as possible.

MICHEL LETHENET, GLOBAL PR MANAGER, MAVIC
You count the drag in grams and sometimes its 2,3 grams and you've got to improve this step by step and it takes a long time. A lot of means, a lot knowledge, a lot of studies.

BRIEUC CRETOUX, RESEARCH ENGINEER, MAVIC
You have two different ways to work on aerodynamics, you have the CFD so this is the computering (computational) fluid dynamics so you are working on a computer. The other way is the wind tunnel and for us this is the easiest way because in the wind tunnel you put a prototype and you can measure precisely the, you can measure the drag.

MICHEL LETHENET, GLOBAL PR MANAGER, MAVIC
So we can pre-study a wheelset to define how many spokes we need to absorb this distortion, this stress and what is the thickness of the rim walls and how many holes we're going to put in and which angle.

BRIEUC CRETOUX, RESEARCH ENGINEER, MAVIC
To reduce the drag we are working on the shape of the rim, so this shape has been optimised to reduce the drag and we have also integrated the tyre with a structure on the tyre, and this structure is very important to reduce the drag and the last element is the blade, you can see here, this is a link between the rim and the tyre, so when the airflow is coming like this you have a very smooth surface, very continuous.

MICHEL LETHENET, GLOBAL PR MANAGER, MAVIC
We can stay up to 400 hours during the year in the wind tunnel to validate things and to change the prototypes to reach what we want to reach. We give also those prototypes when the basic safety issues are solved to end users. So from the very beginning from and idea to the final product on your bike you can have from one year and a half to up to three, four years. Depends how much innovation you have included in the wheelset.

BEN SPURRIER, HEAD OF DESIGN, CONDOR
One technological advance, which has been made and developed in recent years is surface texture in the same way that a golf ball has dimples on its surface in order to catch pockets of air, bicycle wheels have now started to integrate that technology. If you look at some wheels they'll have very shallow dimples across the surface. There is nothing more aerodynamic or slippery than air against air.

V.O.

With both weight and aerodynamics factoring into the design of a wheel, ultimately the defining criteria will depend on the end user and the event in which the wheel will be used.

MICHEL LETHENET, GLOBAL PR MANAGER, MAVIC

We define the criteria we need. If the first priority is the weight or the aerodynamics or the cost.

ROGER HAMMOND, FORMER PROFESSIONAL CYCLIST

You have to look at the event, you have to look at the weather conditions and you have to ask the rider what sort of feel they like and that's what gives you your ultimate choice of wheel.

5. FUTURE DEVELOPMENTS

V.O.

So what does the future hold for bicycle wheel technology and design?

ROGER HAMMOND, FORMER PROFESSIONAL CYCLIST

Now we're actually going back full circle on wheel aerodynamics again to saying slightly increase the width of the rim but have a very small profile of the rim is more aerodynamic in real world situations than actually the original deep section rims that came out 10 years ago.

BRIEUC CRETOUX, RESEARCH ENGINEER, MAVIC

We can still reduce the drag of the bikes, of the wheels and of the other components. So I think that in the future we will see the improvement of tyres and the integration between the tyres and the wheels.

MICHEL LETHENET, GLOBAL PR MANAGER, MAVIC

The next generation of wheels, or bike components will be maybe in finding in new materials. But the wheels will stay round and you will still have to push on the pedals to go fast.