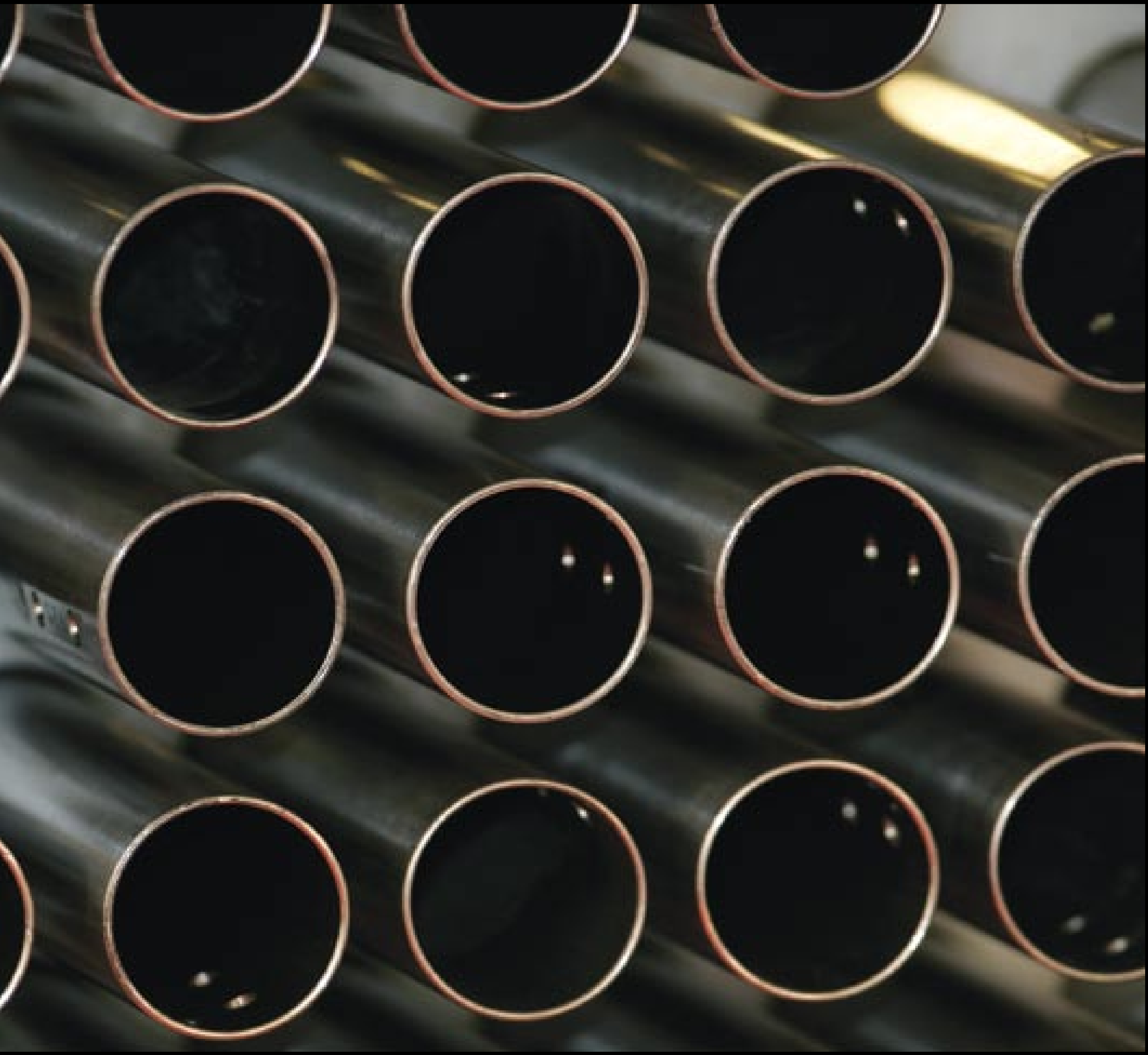
As you know, the axle is a mechanical component that allows the exchange of forces and moments between the "chassis/engine structure and the rear wheels/ ground structure. Despite the fact that it's a simple tubular section bar, its function is important for keeping the tyre correctly positioned on the ground, so as to guarantee best adherence during braking, accelerations and round corners – and to reduce oscillation caused by uneven ground surface. Therefore, depending on circuit or drive style, the chassis and engine correspond to different component behaviour, which could require changing the mechanical characteristics, and not only but also the chemical and microstructural characteristics may need changing too.

The chemistry of axles

They all seem to be the same, but if you look closely they're quite different... 'you can't judge a book by looking at the cover'



***By** University team Uniracer.it **- Report** A.Mattei **- Drawings** D.Marcelletti*

Chemistry

From a chemical point of view, iron and carbon are the main elements used for making the metal alloy used for making axles. Then there is a smaller percentage of chromo, molybdenum, magnesium and silicon added. Iron-carbon alloys, known as Fe35 and Fe45, are used to make more flexible axles. This is commonly known as soft steel. These alloys contain a percentage of carbon that varies from 0.10% to 0.20%, manganese from 0.40% to 0.50% and silicon 0.10%. Soft steel can be easily machined and can be welded easily too, therefore it is also used for making axles that are made from a sheet wrapped in a circular section and then longitudinally welded.

Stiffer axles are made with a type of steel commonly known as 25CrMo4, which contains the alloy with 0.25% carbon, 1.00% chrome, 0.20% molybdenum, 0.60% magnesium and 0.35% silicon.

The alloy has been made with the aim of integrating the mechanical property of the iron, as if using just iron it wouldn't be able to compensate for the special needs of a racing kart. Besides, it would be easily damaged by the environmental conditions, in other words it would be soon attacked by rust.

In order to understand why alloys are made with all these elements, you should know some basic chemical-physics notions about "iron". It is found in nature under form of cubical crystals where the atoms are located in precise configurations. When the temperature changes, these atoms could – or have to

The axle is a mechanica
moments between chas

The main elements used for making the metal alloy, with which axles are made, are iron and carbon, plus smaller percentages of chrome, molybdenum, magnesium and silicon

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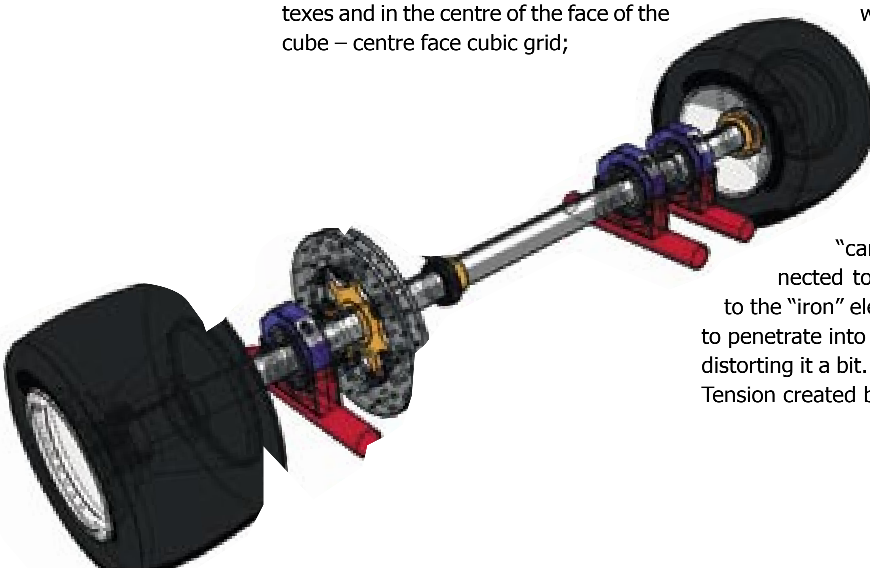
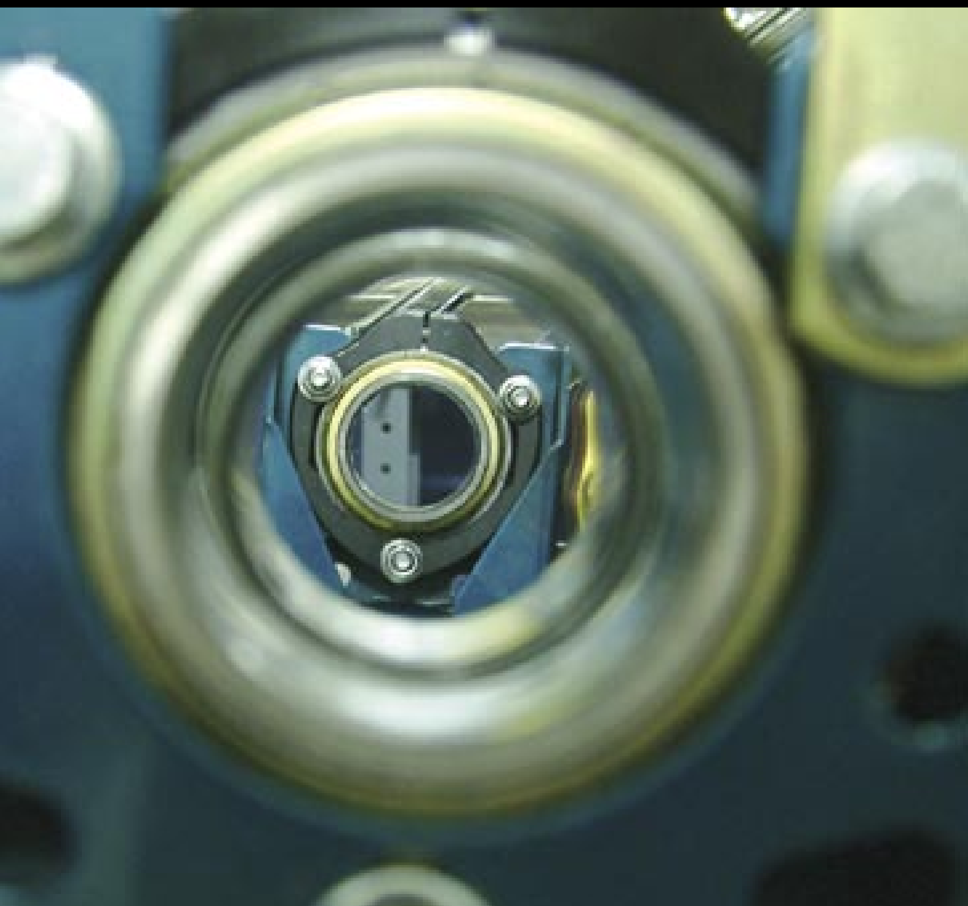
– migrate inside the crystal that however maintains the original cubic shape.
Starting from pure iron to its liquid state and considering the solidification process – hence cooling -, you get the following transformations: iron forms at 1538°C δ if atoms are arranged on vertexes and in the centre of the face of the cube – centre face cubic grid;

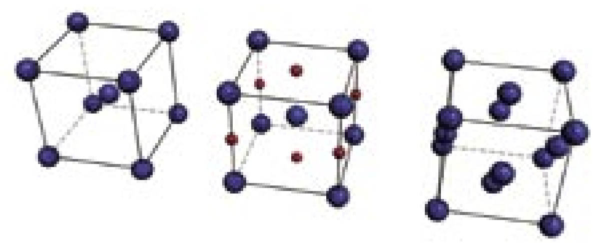


- iron forms at 898°C, up to environmental temperature δ with a cubic structure again with centred body. This last transformation is particularly interesting; you go from a compact structure to another that is less compact because the size of the crystal remains the same while the number of atoms in it diminishes – with a consequent variation – reduction – in volume according to material.
The importance of the "carbon" element is connected to its smallness respect to the "iron" element, which enable it to penetrate into the crystal in question distorting it a bit.
Tension created by the presence of this "alien" atom of carbon increases the strain characteristics of the alloy obtained this way.
As far as the remaining alloying elements – that is, the other elements present in the solution with the iron to form the alloy - you see that the chrome and molybdenum increase hardening ability as they reduce speed at which the metal to be tempered is cooled down. Furthermore facilitating the formation of carbide – well known carbon compounds with metals – they harden the material and with it resistance and toughness. Besides helping to improve the above-mentioned elements, Manganese reduces dimensional sensitivity to overheating and therefore reduces thermal expansion. The silicon helps to increase the elastic limit that is in our applications helps axle to bend more without deforming.

l component, which makes the exchange of forces and sis-engine system and rear wheel-ground system possible



The drawings below show how the elementary iron cells change according to temperature. In the picture you can see layout of iron atoms, represented by the blue spheres and the red ones show the possible positions that can be taken up by the carbon atoms. Logically in fact, iron atoms are much bigger and this is why it looks as though all locations available for hosting atoms all seem to be taken up



The developing phase change the alloy crystal

Both types of material, Fe35-Fe45 and 25CrMo4, can give life to axle through a plastic machining known as drawing. This is practically drawing a hot metal cylinder and letting it pass through a circular matrix with a mandrel, all accurately lubricated to help sliding and, it is sized so as to respect the required allowance for the following finishing off machining. Like all the plastic machining, also when making axles you encounter problems to resolve. The material is deformed whilst hot in order to help pliability, despite this the resulting part has some residues strain in the crystal lattices, if they aren't eliminated, they could sum up with the tension that the axle has to bear when working. A study of the microstructure of the material tells us the treatment that will follow.

Axles that are more flexible, then, undergo a thermal "stress relieving" treatment that is carried out keeping the part at a temperature of about 200°C for a set length of time, long enough however to eliminate the stress that developed in the previous machining.

For harder axles, the process is a bit more complicated, it is called "hardening and tempering", or we could say it is a real "tempering" treatment, which is followed by "drawing".

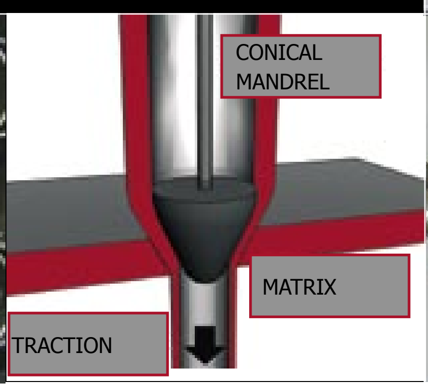
To harden this alloy, the part is heated to a high temperature so that the crystal lattice takes on a cubic-faced structure and is then rapidly cooled so as to get a centred body cubic struc rapid cooling makes it possible that during the transformation of the elementary cell you get the most carbon atom "trapping" inside the crystal lattice. The solid solution you get is known as "martensite".

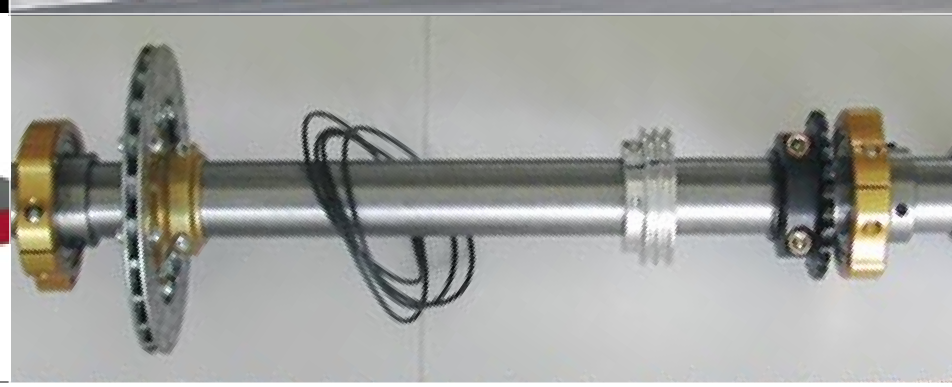
The material obtained has strong internal strain caused by the fact that the part has changed its crystal configuration, going from a less compact structure without giving the crystal grain time to settle in a uniform manner. To eliminate such strain you carry out tempering, that is, the material is kept at about 600°C, long enough so that besides martensite you also get a small amount of sorbite (ferrite plus cimentite) forming and this gives the alloy a special mechanical characteristic.

After this treatment, the part has been

The parts of a die plate that plasma the material are schematically represented in the picture. In this particular case, you must reduce both external and internal diameter of the starting cylinder. This come about by pulling the tube to work on, which has to pass through the matrix die and then brought to the required size.

As you can see, the axle doesn't always rest on the ground, in fact, its job is to cushion all forces that work round corners.

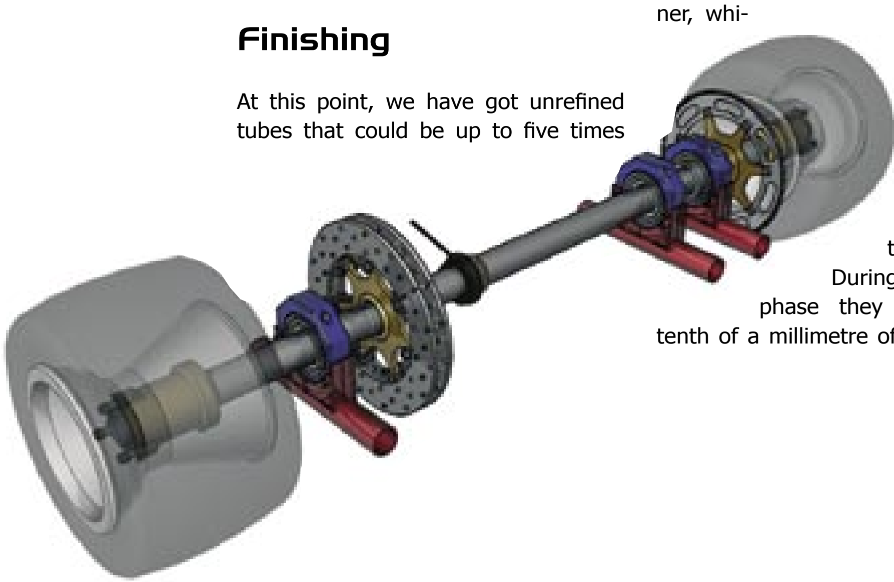




given a hardness that gives an idea of how much one axle can bend respect to another, even if, in fact, there's a theoretical error when one gets it mixed up with bending resistance.

Finishing

At this point, we have got unrefined tubes that could be up to five times as long as the required length, so they must be cut into lengths measuring one metre and one metre-six centimetres, and then finished off at the ends. An automatic machine called straightner, which removes any deformations in the parts not conform to size, then straightens them.



During the planning phase they included one tenth of a millimetre of machining allowance, which is removed with a final surface machining with abrasive discs, grinding.

This machining process brings the external diameter of the required size and after the surface undergoes final chrome treatment, which protects it from rust. The chrome layer that covers the surface is one tenth of a millimetre – burnishing – carried out by dipping the part in an emulsion of colourings and protective oil – or it is left as it is. To conclude, in order for it to be ready to use, the axle is milled and/or bored so that it can house the tabs or keys required for hub, disc carrier and crown carrier to be correctly keyed.