TATA STEEL

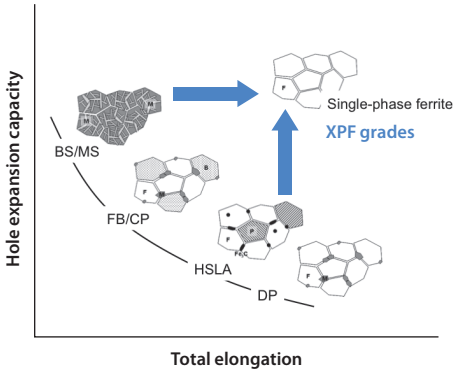
XPF steels

Strong, durable and highly formable steels for chassis applications

Background

Reducing the weight of new cars in order to deliver better fuel economy is a major focus for automakers worldwide. This focus extends to the chassis system where engineers are striving for lower weight solutions capable of meeting stringent safety, durability and environmental requirements. To meet these goals, engineers need new materials featuring high specific strength and fatigue resistance, together with the manufacturability that enables them to innovate.

The new hot-rolled XPF family of steels promises a major breakthrough in automotive structural materials technology. It addresses the known challenges of current high-strength steels in terms of forming and manufacturing by combining the mechanical strength and fatigue resistance that designers require, with a formability that provides even greater freedom to reduce vehicle weight without compromising manufacturing robustness or safety standards.



Key
- BS: bainitic steel
- MS: martensitic steel
- FB: ferritic-bainitic
- CP: complex phase
- HSLA: high-strength low-alloy
- DP: dual phase

Figure 1:
A key measure of the formability of steel is hole expansion capacity (HEC) – how far the material around a stamped hole will stretch before fracturing. XPF combines the hole expansion performance associated with bainitic and martensitic grades, with the elongation characteristics of dual phase (DP) and high-strength low-alloy (HSLA) steels

Product concept

The XPF family has a single-phase ferrite microstructure with a nano-precipitate-reinforced matrix at strength levels between 800-1000 MPa. This novel metallurgical concept yields several benefits over other steel grades typically found in chassis applications. XPF steels are at least as strong as equivalent high-strength, low-alloy steels (HSLA), and advanced multiphase steel grades (AHSS), but improve on both in terms of stretch flangeability (measured in hole expansion capacity (HEC) (Fig 2A) and elongation (Fig 2B)).

XPF steels provide increased product homogeneity compared to multiphase AHSS. In addition they are at least as easy to weld as HSLA steels, and easier to weld than AHSS.

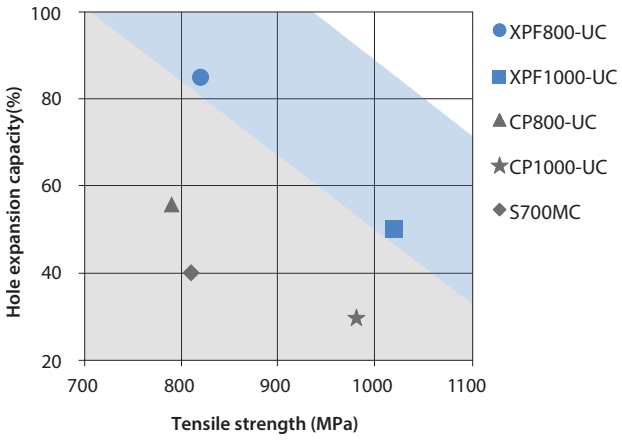


Figure 2A:
HEC versus tensile strength for XPF800-UC from laboratory trials

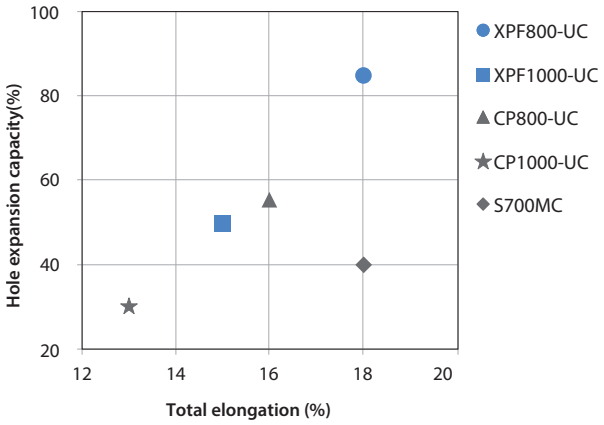


Figure 2B:
HEC versus total elongation for XPF800-UC from laboratory trials

Laboratory trials also demonstrate that as well as providing superior stretch-flange formability, the ductile single-phase ferrite microstructure of XPF offers excellent fatigue characteristics. Figure 3 shows fatigue curves of XPF800-UC respectively, in comparison with AHSS with similar tensile strength. This comparison clearly shows the superior fatigue performance delivered by single-phase XPF compared to multiphase AHSS. In fact, Figure 3 suggests that XPF even provides a benefit over conventional HR-HSLA with regard to endurance limit.

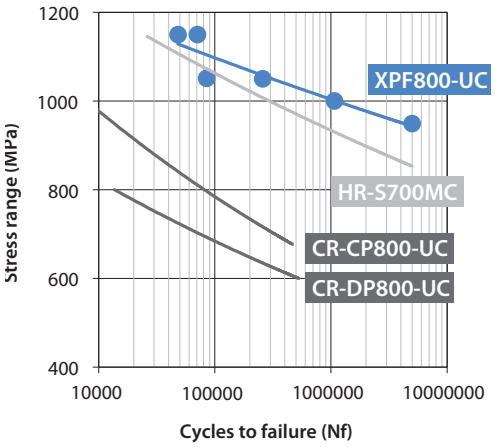


Figure 3:
S-N fatigue curves (R = -1) of XPF800-UC in comparison with hot-rolled S700MC

Besides formability and fatigue performance, weld fatigue is crucial for chassis and suspension applications and mass-saving opportunities. In order to assess weldability and weld fatigue at an early stage, XPF blanks were used for a gas metal arc welding study (GMAW) with an overlap fillet type of joint configuration. This study found that XPF800-UC had better weldability than HSLA, and showed that material could be welded without any defects.

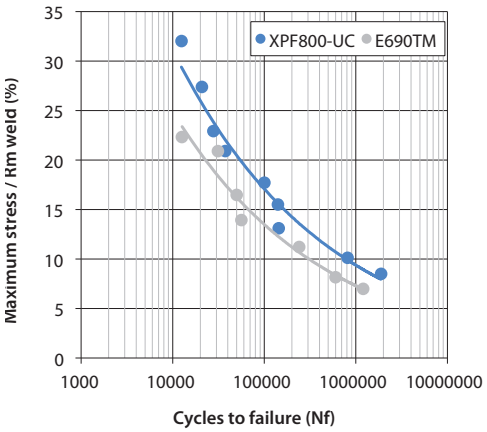


Figure 4:
S-N weld fatigue curves (R = 0.1) with lap shear loading configuration based on GMAW arc welding of XPF800-UC compared with E690TM. Plotted vertically is the maximum stress divided by the tensile strength (3xHV) of the weld. Filler wire used: ER120S for XPF800-UC and E690TM

TCO benefits for XPF grades

Tata Steel has developed a process to review and quantify how its steel grades perform against objectives of weight, cost and performance - the TCO Scan (total cost of ownership). Using this method, Tata Steel engineers concluded that XPF grades can yield two significant TCO benefits:

1. **Safer component with increased performance at the same mass:**
   Tata Steel engineers found significant benefits when substituting a multiphase grade baseline, in this case a hot-rolled HDT780C lower control arm (LCA), considered a leading design in the market. Simple grade substitution at the same material thickness, and without altering the design, will offer an improvement in collapse strength of up to 20%. The higher formability also results in improved manufacturing robustness.
   The small associated assembled cost increase for this performance is outweighed by the benefits of production yield improvement expected when applying XPF grades.

2. **Mass reduction at equivalent performance:**
   Tata Steel engineers were able to leverage the improved ductility of XPF grades to optimise the shape of the LCA geometry. This allowed them to reduce the material thickness, leading to component weight reduction, without any loss in key performance metrics such as stiffness and collapse strength.
   The resulting benefit for XPF800-UC when compared against the HDT780C baseline was around a 10% weight saving without any impact on the manufacturing feasibility of the component.

   It was concluded that XPF grades offer mass saving potential without loss of performance, achieved through optimising grade attributes against component shape. A cost analysis also concluded that XPF800-UC could offer these mass saving benefits at no additional cost to the customer.

Conclusions

The combination of higher strength and enhanced ductility of new XPF grades compared to existing multiphase grades offers two distinct value propositions to our customers. Firstly, XPF grades offer improved in-service performance and manufacturing robustness at a small cost premium – which does not factor in any additional benefits from potential production yield improvement. Secondly, the increased elongation and hole expansion coefficient can enable design optimisation to yield mass reduction at equivalent in-service performance and cost.
This new family of products will support our customers in reducing their TCO, through offering a steel optimised for the challenges of manufacturing chassis components.

Interested in this product?

Please check the current offering of our XPF-family where you can also find datasheets on available grades (www.tatasteeleurope.com/automotive).

www.tatasteeleurope.com

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