# Fast warm stamping of ultra-high strength steel sheets

## Background and problem addressed

High strength steels are uniquely lightweight and engineered to meet the challenges of today's vehicles for stringent safety regulations, emissions reduction, solid performance, at affordable costs. To deploy high strength steel in mass scale automotive manufacturing an effective and scalable sheet metal forming technique is required. Processes using hot or warm stamping are emerging as solutions for forming high-strength parts from steel sheets, e.g. for applications in automotive "body in white" (BiW), and chassis and suspension (C&S) parts. Existing methods for forming high strength steels involves heat treating the steel sheet to be formed at sufficiently high temperatures (e.g. more than 900°C) for a prolonged period of time. Austenitisation is thus enabled, thereby prompting a phase change to a softer phase of the material. This aspect of the existing methods is energy intensive and is known to take approximately 75% of the overall processing time to create the finished part. Furthermore, using existing methods, the hot stamped part is held in cold dies, with a high cooling rate (e.g. more than 25 $°Cs^{-1}$ on average) to enable the hardest phase of the material to be formed. This too is time consuming. Leading researchers from Imperial College have devised a fast warm forming method that overcomes these shortcomings to improve manufacturing productivity of high-strength metal sheet parts. Using this novel method, cycle times and energy costs are reduced, whilst avoiding major negative changes to the microstructure, retaining a similar strength post-forming vs pre-forming. Current hot stamping methods could take 12-16s per forming cycle (without considering time for heating the blank), whilst our technology could take just ~6s including heating, forming and quenching.

## Technology overview

The Fast Warm stamping technology broadly involves heating up a metal blank rapidly to an elevated temperature and forming a part by way of tools such as a water-cooled die set. The rapid heating and elevated temperature during processing enhances ductility of the workpiece material and reduces flow stress, thus enabling parts of complex shapes to be formed. This temperature is below a critical microstructure change temperature, i.e. below a temperature which would cause substantial change to the microstructure of the metal being heated. It has surprisingly been found that rapid heating of the metal sheet prior to forming, within specific conditions, avoids any substantial changes to the microstructure of the metal sheet. Remarkably, this also improves ductility and post-form strength of the formed part compared to using conventional methods. Even more notable is that the post-form strength of parts formed using this new method has been found to provide formed parts with similar strength properties to those of the metal sheet before it was heated and formed.

## Benefits

- Short cycle time, approximately 6s.
- Reduced energy cost.
- Negligible oxidization. No coating is required.
- Good post-form strength.

## Applications

Manufacturing of lightweight steel components for automotive applications.

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The new method provides a number of significant step changes:

• Firstly, there is no need for initial substantial heating and then rapid cooling from the high temperature (known as quenching), in order to form a desired “hard phase”. In this way, the time necessary for heating and then cold die-quenching is substantially reduced.

• Secondly, the physical properties of the metal sheet remain largely unaltered after the part is formed. In this way, the material of the formed part can be selected based on the properties of the initial phase of the material being used, and not based on the properties of the desired end phase. As a result, more uniformity of physical properties in the formed part is attained.

• Thirdly, the method can be applied to a variety of types of metals and metal alloys without needing to consider the properties of any resultant metal phases that would result if processed using existing hot stamping methods.

## Intellectual property information

The international patent application number which describes this technology is WO2019/038556. Patent applications in Europe (EP3673090A1) under examination and granted in the US (US11313010B2).

## Inventor information

The lead inventor is Dr Li-Liang Wang, senior lecturer in the Department of Mechanical Engineering.