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Forming Advanced High-Strength Steels

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In the Classroom

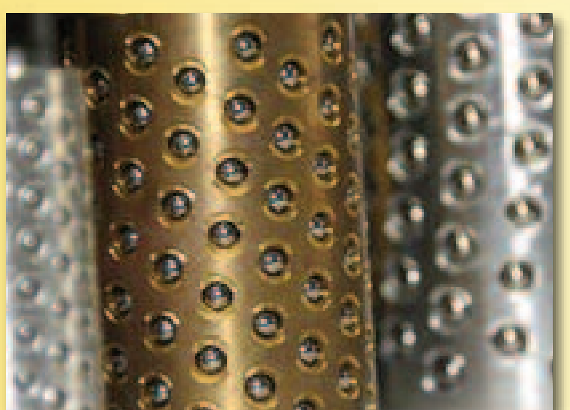
Troubleshooting— Data Versus Experience

Consider a stamping nearing completion of final die tryout at a die-build company. The steel supplier reviews the stamping to determine the most robust steel for the job. After review, the supplier sends two sample coils labeled A and B having identical type/grade and price but different processing. The die builder must run both coils and report back to the steel supplier which coil creates the more robust stamping.

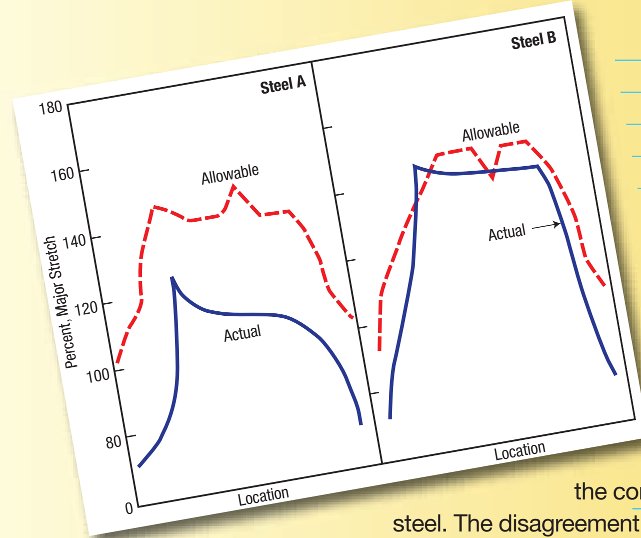
In our case study, both coils could show the same result—no breakage—without data provided from the stamping. One might have to run thousands of stampings before noticing some difference between the two coils. However, good troubleshooting techniques are available where a single stamping taken when the die is hot and production conditions have stabilized can yield significant information. Evaluating the first stamping after press startup does not represent a normal production environment.

In our case study, circle grids were electroetched into the surface of the steel. From the ellipses (deformed circles), the long axis represents the largest positive stretch and is called major stretch. For a line of ellipses through the most critical zone of the stamping, major stretch values are measured and plotted against their location in the stamping. These values are shown as a solid line for both coil A and B (see the illustration). Knowing the properties of both coils allows one to determine the forming limit curve for each coil.

From the forming limit curve one obtains the maximum allowable stretch before the onset of localized necking and tearing of the sheetmetal. The maximum allowable stretch (edge of the deformation cliff) is represented by the dashed line in each graph. Subtracting major stretch in the stamping from allowable stretch from the forming limit curve provides the safety margin. If the safety margin is negative (when the actual stretch is greater than the allowable stretch) as observed for one location for steel B, some percentage of necking and failure is expected. These failures usually result when the production variables increase the actual production major stretch. A larger negative safety margin means a higher percentage of stampings are expected to neck and fail. A safety margin of 10 strain percent or more (as observed for steel A) is desired to allow for production variability.



This illustration of the test results was presented to a group deciding whether to ask for steel A or steel B. Since you the readers have seen the data, which steel would you pick—A or B? Surprisingly, half of the group chose steel A and half chose steel B. Their choices were based on different past experiences in troubleshooting steel stampings. However, each group presented good logical and valid reasons why their steel would make more robust stampings. Each group highlighted the pros for their steel and the cons for the other steel. The disagreement was the result of opposite sets of personal experiences.



Arguments by the group who wanted steel A:

Our steel is well below the allowable maximum allowable stretch with a minimum safety margin of 22 stretch percent. Steel B already has one location over the edge of the cliff and another location just ready to fall off. That is a disaster waiting to happen.

Arguments by the group who wanted steel B:

Our steel has a nice flat distribution of stretch that is more stable. Steel A has a very sharp localized stretch gradient. Sharp stretch gradients are very unstable, and can easily spike to failure. Even an increase and decrease of the spike means the stamping is not robust and can affect springback and dimensional stability.

Finally, one person presented the following argument. If the sharp stretch gradient were not present, everyone would agree steel A was the best steel for production. However, in my experience, something is wrong with that gradient. The normal rule is that stretch gradients become worse as they approach the edge of the deformation cliff. The stretch gradient observed in steel B should be much worse than that found in steel A. But that is not the case. When general rules of forming are violated, one should go back and redo the test or at least recheck the measurements. Note that the sharp stretch gradient is created by only one data point. We need to go back and check the strain at that one location.

The final result? The correct major stretch for the point in question was 104 but was misreported as 124. The value of 104 resulted in a nice flat plateau of low-level stretch, no stretch gradient or spike, and a large safety margin. Steel A was ordered. Why did steel B have such a large amount of major stretch? A postmortem evaluation found steel B had a rougher surface with a higher coefficient of friction. Less material moved from the binder into the stamping forcing more stretch over the punch.

The most interesting aspect of this case study is that the answer was reached without even knowing what part was under evaluation. Had the part been identified, too many details of past experiences would have further earch for a solution. Another great sign to hang at

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