



## Forming

High strength DILLIMAX steels are very suitable for processing due to their exceptional homogeneity as well as their cleanness. The narrow dimensional tolerances and high surface standards facilitate processing.

In the following, Dillinger provides information on cold forming by means of bending, bending radii and hot forming.

The information on DILLIMAX forming has been developed to the best knowledge and experience of Dillinger. It is intended to support the manufacturer in developing his own processing procedure for DILLIMAX. The proper working method must be carried out with suitable tools. Since different manufacturers have developed varying tools, the instructions should be observed carefully (working method, speed, etc.).

The recommendations in accordance with CEN/TR 10347 (Forming) should also be observed. During processing, the necessary safety measures have to be taken, to avoid any danger by a possible fracture of the work piece during the forming process.

**Table 1 Forming methods in general**

Method	Description
<b>Cold forming</b>	Deformation below the maximum allowable stress relief temperature (usually 560 °C)
<b>Hot forming</b>	Deformation above the maximum allowable stress relief temperature (usually 560 °C)



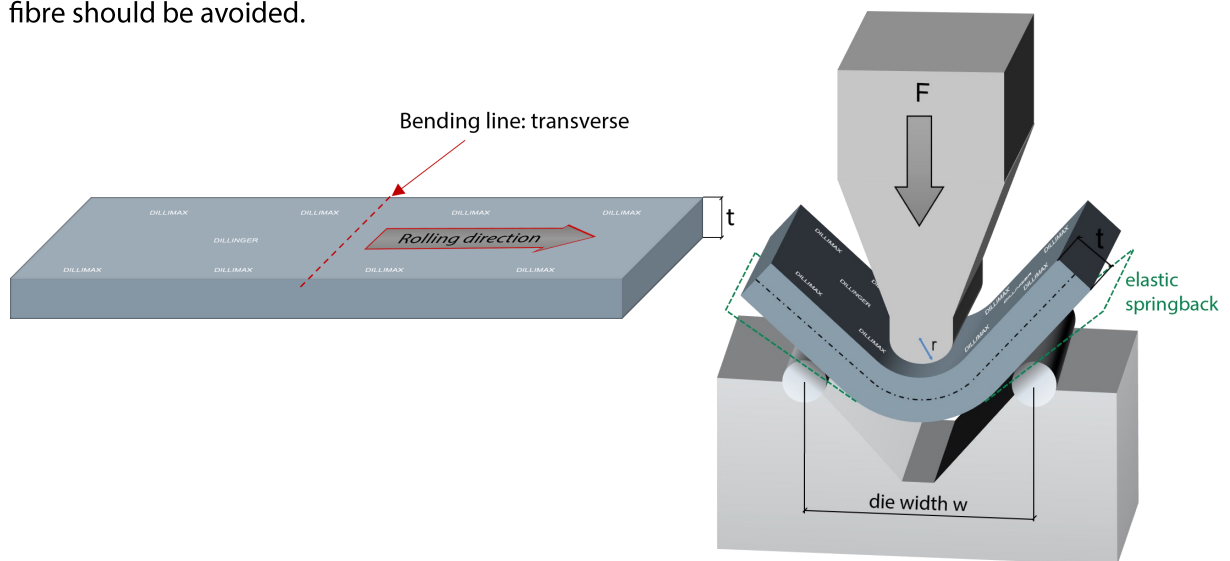
The surface condition can have an influence on the formability and the achievable radii of the plates.

It is advisable to clean the workpiece in the bending area from scale, rust and other impurities.

Scratches can be removed by smooth grinding perpendicular to the bending line.

## Cold forming

DILLIMAX can be cold formed easily by bending. Increasing yield strength of the steel at a same given plate thickness also requires higher forming forces. Springback also increases. Table 2 shows the different minimum bending radii and die widths of DILLIMAX. Due to the rolling process, these values are lower transvers the rolling direction than in the longitudinal direction. The hard stamping usually shows the rolling direction. Bending with the hard stamping in the area of the outer fibre should be avoided.



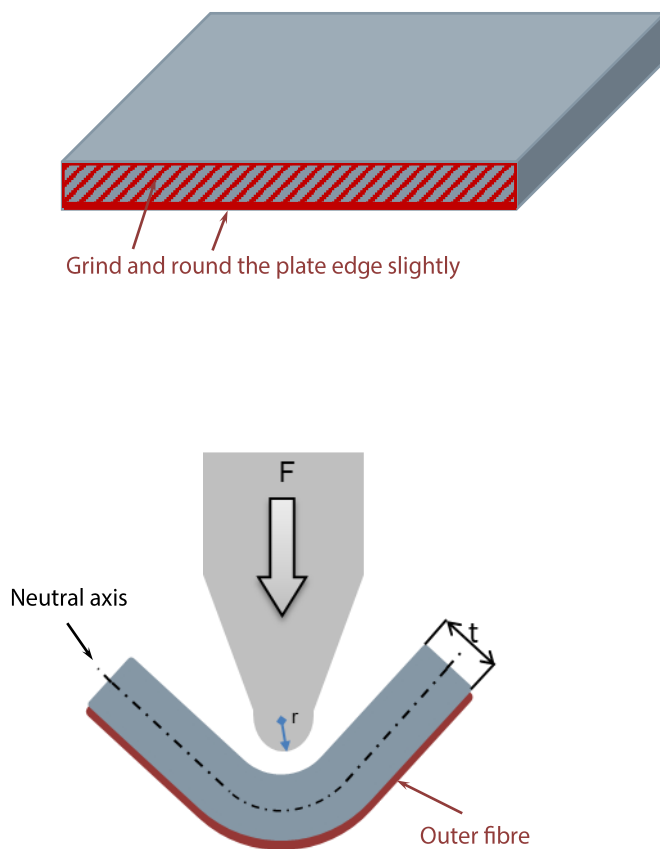
Graphic 1 Visualisation of bending line and die width

The following minimum bending radii can typically be achieved by cold forming without any formation of surface defects:

**Table 2 Minimum bending radii and die width for DILLIMAX**

Bending line to rolling direction	Steel grade	Min. bending radius $r$ [ $\times t$ ]		Min. die width $w$ [ $\times t$ ]	
		$t < 20$ mm	$t \geq 20$ mm	$t < 20$ mm	$t \geq 20$ mm
Transverse	<b>DILLIMAX 500/550</b>	2	2	7	7
	<b>DILLIMAX 690</b>	2	2	7	7
	<b>DILLIMAX 890/965</b>	3	3	9	9
	<b>DILLIMAX 1100</b>	4	5	12	14
Longitudinal	<b>DILLIMAX 500/550</b>	3	3	9	9
	<b>DILLIMAX 690</b>	3	3	9	9
	<b>DILLIMAX 890/965</b>	4	4	12	12
	<b>DILLIMAX 1100</b>	5	6	14	16

For all high strength DILLIMAX, the hardened oxy-cutting edge should be ground before bending. It is also advisable to round the plate edge slightly on the outer fibre, which exposes the greatest elongation because it is on the outside during bending.



## Elongation at the outer fibre:

$$\epsilon (\%) = 100 \cdot t / (2 \cdot r + t)$$

r bending radius  
t plate thickness

**Graphic 2 Processing of a cut edge and elongation on the outer fibre**

The plastic elongation on the plate surface, which occurs during bending, arises from the bending radius (r) and the plate thickness (t): Elongation (%) =  $100 / (1 + 2 \cdot r / t)$ .

Some standards and guidelines limit the permissible elongation during cold forming. Depending on the applied standards, this could result to larger bending radii than those given in table 2. For higher degrees of cold forming, we recommend consulting Dillinger.

DILLIMAX 1100 can be cold formed below 150 °C taking into account its high yield strength. Compared to lower yield strength steels DILLIMAX 1100 can not be heat treated at > 150 °C to reduce the strain hardening effects.

Annealing in the stress relieving temperature range is carried out:

- ♦ before and during forming to reduce required forming forces.

Forming at higher temperatures (below the tempering temperature) reduces the required forces and affects toughness less than cold forming at room temperature.

- ♦ after forming to increase toughness.

The highest stress relieving temperature should be 40 °C below the tempering temperature. The holding time when annealing should not exceed 60 minutes. If longer holding times and higher temperatures are prescribed Dillinger should be consulted.

General improvement of the bending performance by:

- ♦ Take into account increasing forming forces with increasing yield strength,
- ♦ Surface inspection of plate and tool,
- ♦ Avoiding notches: No hard stamp in the area of the outer fibre during bending,
- ♦ Ground the plate edge at the outer fibre,
- ♦ Correct alignment of tools to sheet and bending line,
- ♦ Avoid multiple bending, consider possible springback.

The tool should be harder than the workpiece to avoid wear.

## Hot forming

Forming above the permissible stress relieving temperature (usually 560 °C) requires lower forming forces and is used for larger wall thicknesses and tighter bending radii.

If the stress relieve temperature is approached, the initial tempering can be altered so that the mechanical properties are affected. To regain the initial properties new quenching and tempering becomes necessary.

However, water quenching of a formed workpiece or component will often be less effective than the original quenching in the plate mill so that the fabricator may not be able to re-establish the required properties and therefore hot forming may not be suitable. In this respect we recommend you to contact Dillinger.

## Disclaimer:

The information and data provided concerning the quality and/or applicability of materials and/or products constitute descriptions only. Any and all promises concerning the presence of specific properties and/or suitability for a particular application shall in all cases be deemed to require separate written agreements.

This processing information is updated at irregular intervals. The current version is relevant. The latest version is available from the mill or as download at [www.dillinger.de](http://www.dillinger.de).

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