



DILLIDUR

Forming

Wear resistant DILLIDUR steels are very suitable for processing due to their exceptional homogeneity as well as their cleanliness. 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 DILLIDUR 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 our material. 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) could 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
Cold forming	Deformation in the temperature range without metallurgical impairment (especially hardness drop) below the maximum working temperature
Hot forming	Deformation in the temperature range causing metallurgical impairment (especially hardness drop) above the maximum working temperature



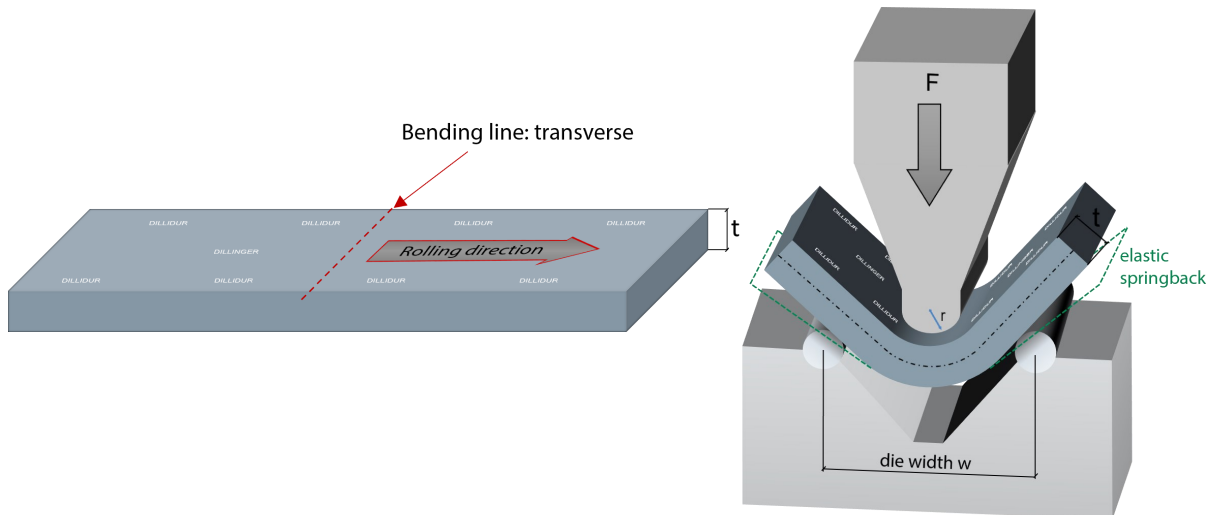
The surface condition can have an influence on the formability and the achievable radii of the plates.

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

Despite its high hardness, DILLIDUR can be cold formed easily by bending. Increasing hardness and yield strength of the steel at a same given plate thickness also require higher forming forces. Springback also increases. Table 2 shows the different minimum bending radii and die widths of DILLIDUR. 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.



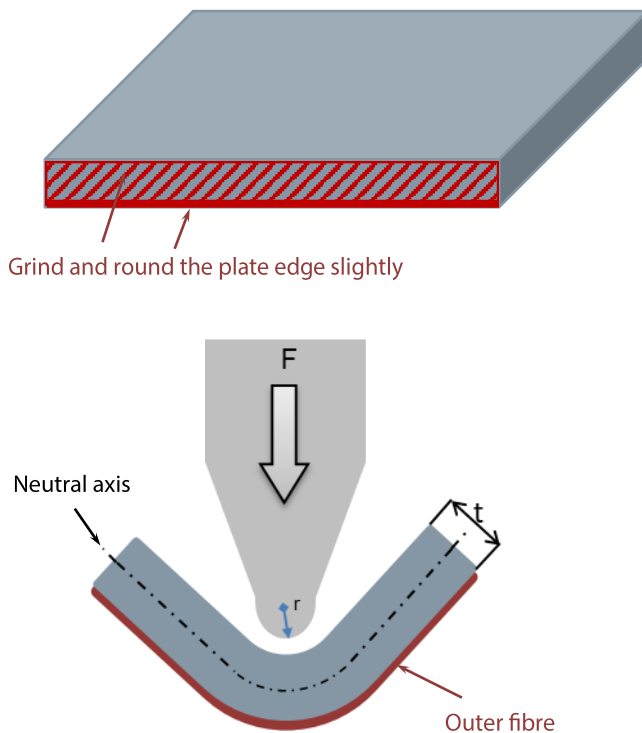
Graphic 1 Visualisation of bending line and die width

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 DILLIDUR

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	DILLIDUR 325 L	5	5	14	14
	DILLIDUR IMPACT	3	3	9	9
	DILLIDUR 400	3	3	10	10
	DILLIDUR 450	3.5	4.5	14	14
	DILLIDUR 500	7	7	16	16
	DILLIDUR 550	Only with limitations, please contact Dillinger			
	DILLIDUR 600				
Longitudinal	DILLIDUR 325 L	6	6	16	16
	DILLIDUR IMPACT	4	4	12	12
	DILLIDUR 400	4	4	12	12
	DILLIDUR 450	4.5	5	14	14
	DILLIDUR 500	9	9	20	20
	DILLIDUR 550	Only with limitations, please contact Dillinger			
	DILLIDUR 600				

For DILLIDUR steel with a nominal hardness of 400 HBW and above, 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

Increasing yield strengths cause an increase in the forces for forming at the same wall thickness.

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

Improve bending performance by:

- ◆ Surface inspection of plate and forming tool,
- ◆ Avoid notches: No hard stamp in the area of the outer fibre during bending,
- ◆ Grind the plate edge at the outer fibre,
- ◆ Correct adjustment of the tools to the plate and to the bending line,
- ◆ Avoid multiple bending, consider possible springback.

Hot forming

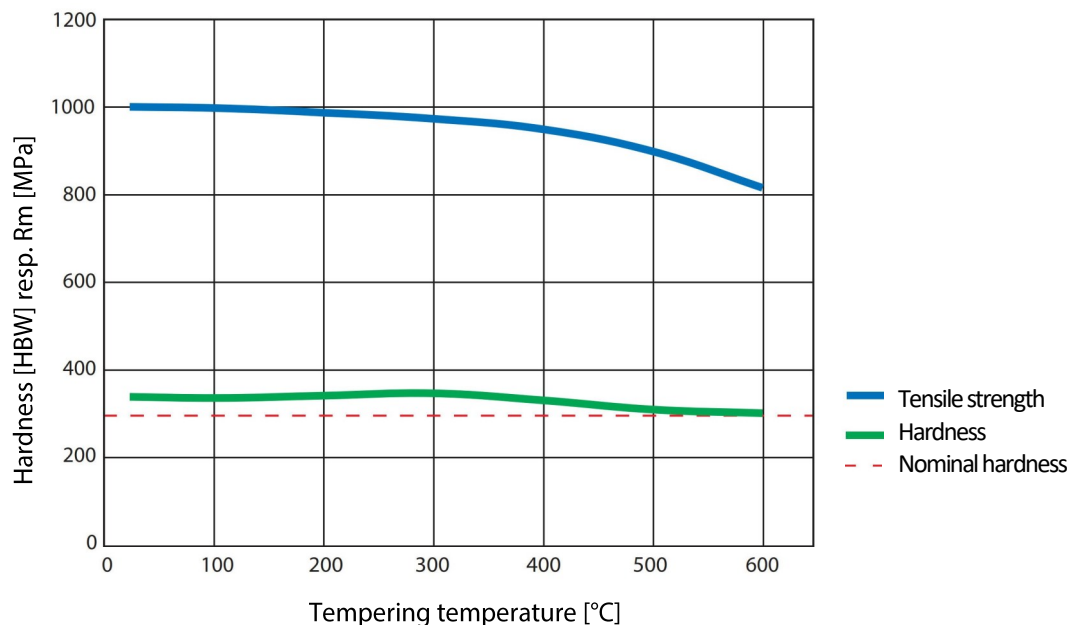
Hot forming means forming above the maximum processing temperatures which will affect the mechanical properties. For this reason, only DILLIDUR 325 L and DILLIDUR IMPACT are suitable for hot forming.

Maximum temperatures for DILLIDUR

Steel grade	Maximum temperature
DILLIDUR 325 L	500 °C
DILLIDUR IMPACT	500 °C
DILLIDUR 400	250 °C
DILLIDUR 450	200 °C
DILLIDUR 500	200 °C
DILLIDUR 550	200 °C
DILLIDUR 600	180 °C

Forming DILLIDUR 325 L without significant loss of hardness is possible up to 500 °C. It reaches its hardness by air cooling after normalizing. If hot forming is carried out at temperatures higher than 500 °C, the properties can be readjusted by another normalizing (at 900 to 950 °C).

The influence of temperature on hardness and tensile strength values can be seen in the following graphic 3.



Graphic 3 Typical effect of tempering temperature on mechanical properties of DILLIDUR 325 L after cooling down to room temperature (auxiliary data for 10 mm, holding time 30 minutes)

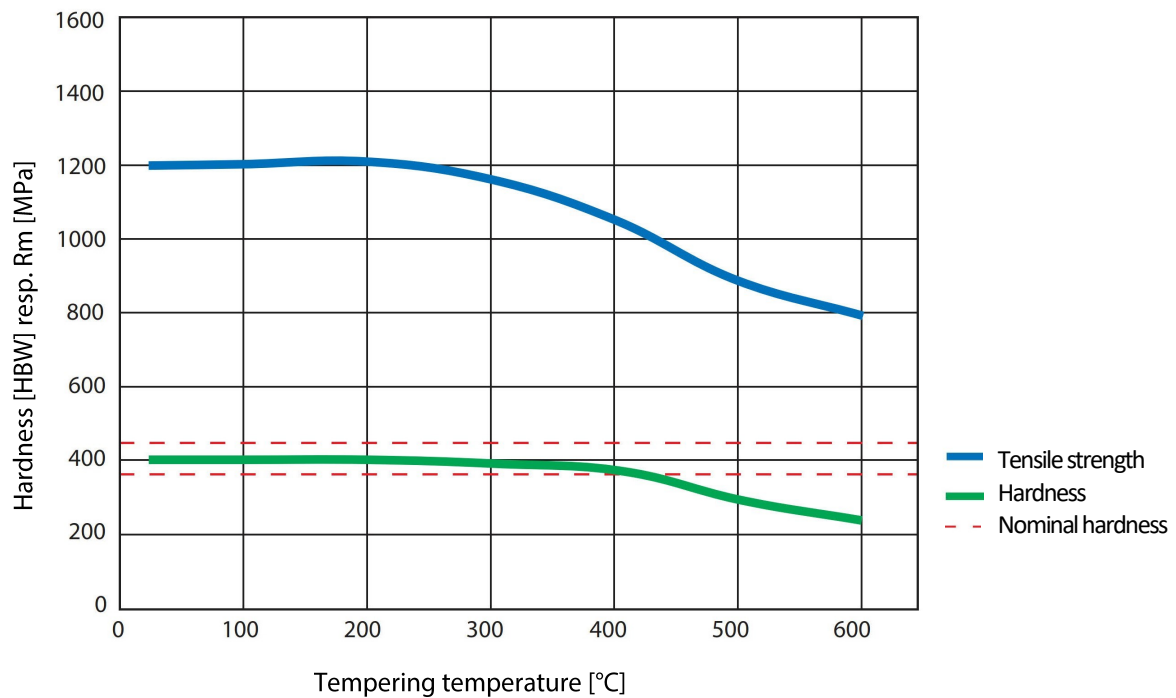
DILLIDUR IMPACT is water quenched and tempered under controlled conditions. Forming below 500 °C is possible without affecting the properties. If forming is carried out at higher temperatures, the mechanical properties are affected. To regain the initial properties new quenching and tempering becomes necessary.

DILLIDUR 400/450/500/550/600 are hardened by accelerated cooling. Hot forming without loss of hardness is not possible. If hot forming is nevertheless necessary, the workpiece must be hardened again.

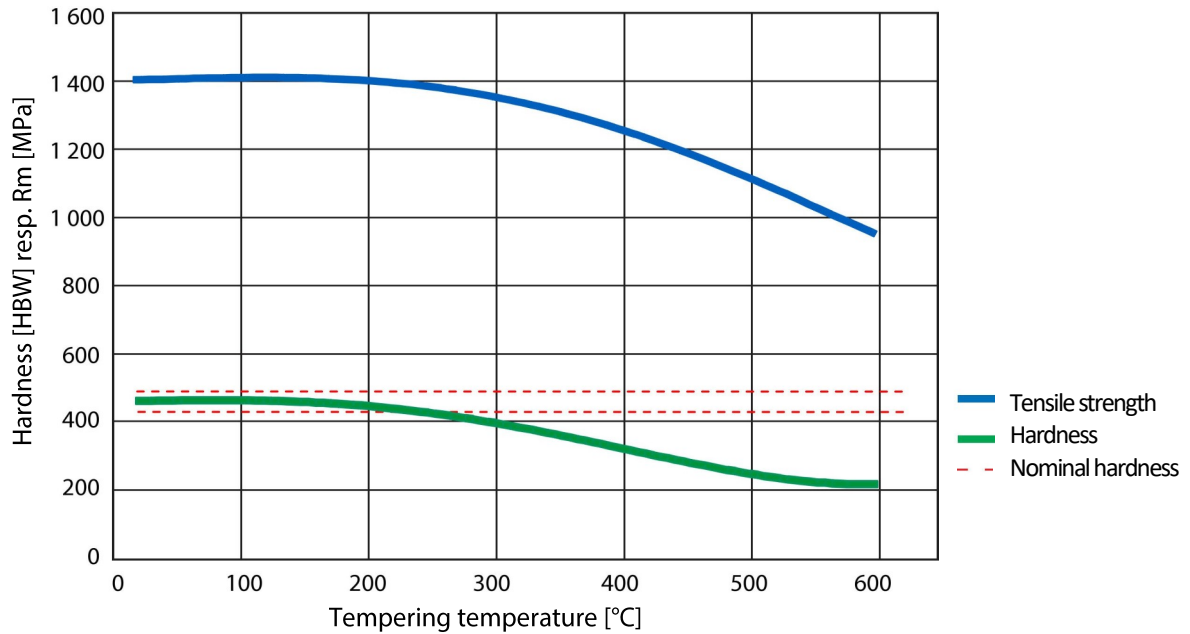
Due to the different heat treatment equipment of the processing factory and the geometry of the component, the cooling rate and consequently hardness achieved is generally lower as in the Dillinger rolling mill.

The original hardness and through thickness hardening produced in the mill can generally not be achieved again. Additionally, there is a risk of distortion. For components which must be quenched during processing, the chemical composition can be adjusted accordingly in consultation with Dillinger.

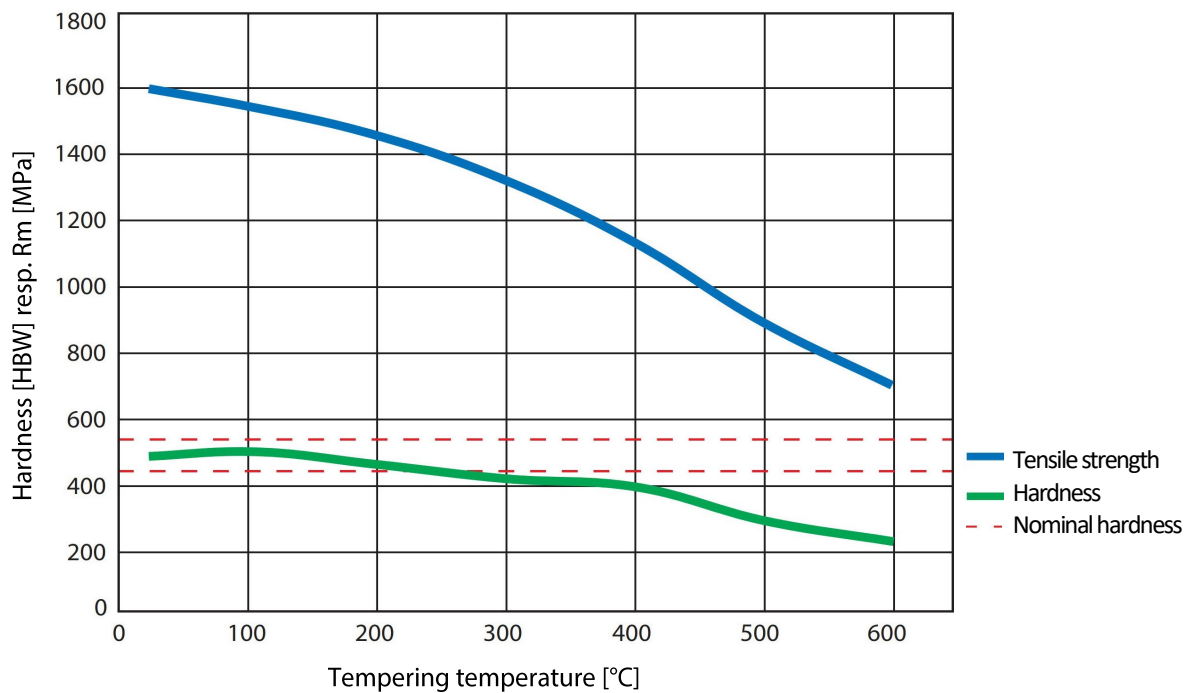
Typical effect of tempering temperature on mechanical properties (holding time 30 minutes)



Graphic 4 Typical effect of tempering temperature on mechanical properties of DILLIDUR 400 after cooling down to room temperature (auxiliary data for 20 mm)



Graphic 5 Typical effect of tempering temperature on mechanical properties of DILLIDUR 450 after cooling down to room temperature (auxiliary data for 20 mm)



Graphic 6 Typical effect of tempering temperature on mechanical properties of DILLIDUR 500 after cooling down to room temperature (auxiliary data for 20 mm)

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 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.

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