LUCCHINI 4542 ESR

PRECIPITATION HARDENING MARTENSITIC STAINLESS STEEL IN ESR QUALITY: A INNOVATIVE APPROACH TO CORROSION RESISTANT PLASTIC INDUSTRY

General characteristics

LUCCHINI 4542 ESR is a stainless steel and it is it particularly suitable for the manufacture of dies and moulds subjected to high mechanical stress.

LUCCHINI 4542 ESR is obtained through a special 'super clean' manufacturing process and by using the ESR (Electro Slag Remelting) technology which allows an excellent level of micro-purity to be achieved.

LUCCHINI 4542 ESR represents the ideal option for the end user who is looking for:
- high and homogeneous mechanical characteristics throughout the whole mould regardless of its complexity;
- machinability and mirror polishability;
- micro-purity;
- resistance to corrosion.

LUCCHINI 4542 ESR quality heat treatment occurs below the phase transformation points, this process can also be carried out on a semi-finished mould, causing minimal deformation and no cracking during the hardening phase.

Delivery conditions

LUCCHINI 4542 ESR is supplied in age hardened condition in a dimensional range up to 500 mm in thickness.

The surface hardness is 300 – 350 HB and the mid-thickness hardness value is guaranteed in section up to 500 mm, according to the following correlation: $(HB_{Surface,min\ required} - HB_{Core}) \leq 20HB$.

Main features

- excellent machinability;
- excellent suitability for embossing;
- excellent suitability for mirror polishing;
- excellent wear resistance related to the mechanical properties obtained on a finished mould;
- exceptional dimensional stability after age hardening;
- no cracking during heat treatment, regardless of shape and structure of the mould;
- excellent weldability, in case of repair by welding;
- excellent resistance to corrosion.

Main application

Plastic moulding:
- dies of big/medium size for the automotive industry;
- special dies for the food industry;
- dies for rubber moulding;
- dies for compression stamping (SMC, BMC);
- die bolsters for plastic die casting;

Extrusion:
- matrices and gauges for PVC;
- various components for extrusion.

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Chemical analysis

	Range	C [%]	Si [%]	Mn [%]	Cr [%]	Nb [%]	Cu [%]	Ni [%]
LUCCHINI 4542 ESR Alloying [% in weight]	min	-	-	-	14,00	0,15	2,50	3,00
	max	0,08	1,00	1,00	17,00	0,45	5,00	5,00

Comparison with international classifications:
W. Nr. 1.4542 / 17-4 PH
DIN EN ISO 4957: X5CrNiCuNb17-4
AISI: 630

Physical and mechanical properties

Main physical properties

LUCCHINI 4542 ESR	20°C	250°C	500°C
Young modulus E [MPa]	210	198	180
Coefficient of linear thermal expansion α [10-6/K]	19,0	19,8	20,5

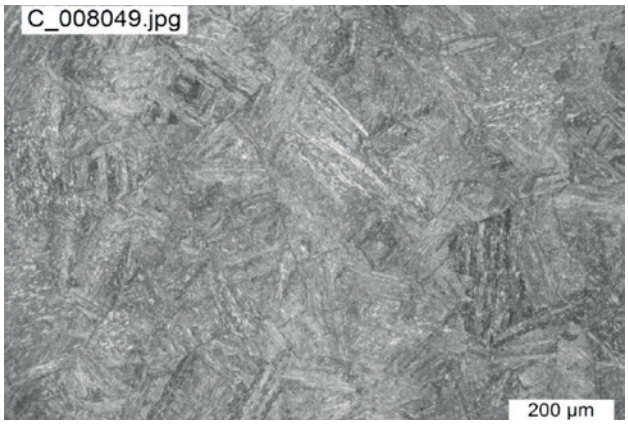
Main mechanical properties

LUCCHINI 4542 ESR	20°C	200°C
Ultimate tensile strength UTS [MPa]	1070	1020
Yield strength YS [MPa]	900	860
Elongation (A) [%]	18	20
Reduction of area (Z) [%]	50	55

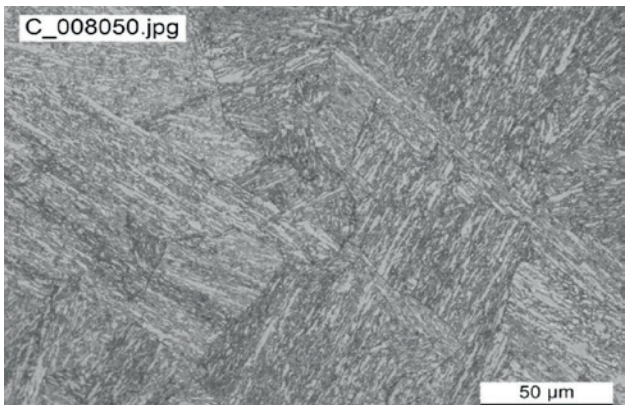
The above mentioned are average values of a sample age hardened to achieve hardness value of 35 HRC.

Microstructure

The main microstructure of LUCCHINI 4542 ESR in age hardened condition is tempered martensite.



100x – Tempered martensite



500x – Tempered martensite

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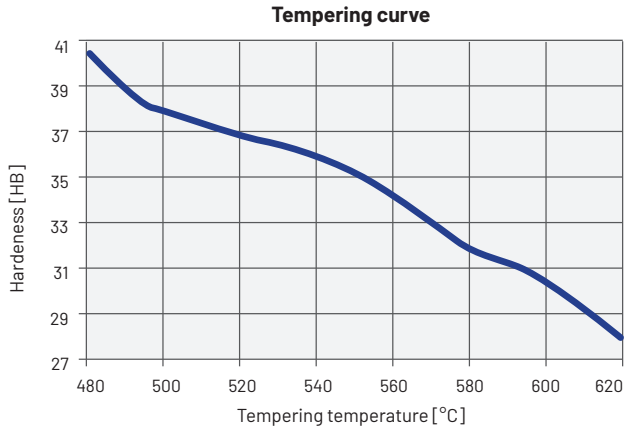
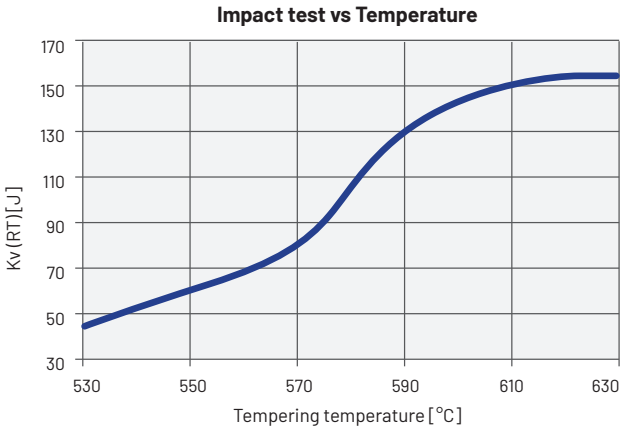
Surface hardness vs tempering temperature



Toughness (Charpy V-notch test at 20°C) vs tempering temperature



Remark: the above data are representative of the typical behaviour of a 300 mm thick block made in LUCCHINI 4542 ESR and are reported for information only.

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Heat treatment

LUCCHINI 4542 ESR is supplied in age hardened condition with no need for additional heat treatment operations.

If different hardness/heat treatment procedure are required, we recommend the following parameters.

Note that the reported data are for information purpose only and must be adjusted to the heat treatment facility and the dimensions of the block therefore, before carrying out any heat treatment operation, it is strongly recommended to contact Lucchini RS for help and support.

Stress relieving

Suggested temperature	400°C
Soaking time	60 min every 25 mm thickness
Cooling	Slow cooling in furnace (20°C/h)

Stress relieving is recommended to reduce the tensions generated by certain manufacturing operations (e.g. machining) without affecting the hardness in the as-delivered conditions.

Solubilisation

A pre-heating step at 700°C is recommended to reduce the stress during the heating up to solubilisation temperature.

Suggested temperature	1040°C
Soaking time	60 min every 25 mm thickness
Cooling	Polymer or water quench

Precipitation hardening

Suggested temperature	1030°C
Soaking time	60 min every 25 mm thickness
Cooling	Polymer or water quench

The age hardening temperature should be selected form the graph "Tempering curve" reported above. After age hardening we suggest to carry out stress relieving at temperature 50 °C lower than the last tempering temperature.

Other properties can be deeper analysed against specific Customer request: please contact our Metallurgy Department.

Polishing and photo-engraving

LUCCHINI 4542 is the suitable material when polishing and photoengraving are needed. Thanks to its integrated manufacturing process, those material manufactured by Lucchini RS are characterized by a high degree of purity.

Polishing for graining: 4 Excellent
Suitability for medium gloss polishing:4 Excellent
Suitability for mirror polishing: 4 Excellent
Suitability for engraving: 4 Excellent

Rating scale:
4 Excellent – 3 Very good – 2 Good – 1 Normal – 0 Unsuitable

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The advantages of the ESR technology

The ESR (Electro-Slag-Melting) manufacturing technology offers the following advantages:

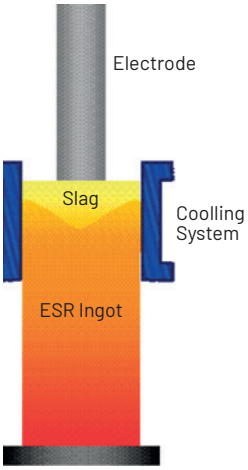
- increase of material toughness;
- high micro-cleanness level;
- total isotropy of the material;
- very low segregation level.

The ESR process is based on ingot remelting, through a traditional VD (vacuum degassing) process, using a particular copper ingot mould that contains basic slag.

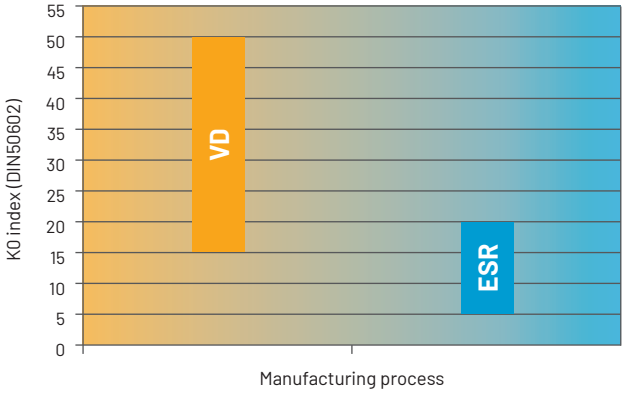
The ingot is remelted in a way that the liquid metal passes through the slag, which acts as a filter and retains the inclusions.

The process of solidification inside the ingot mould is faster than in a traditional process.

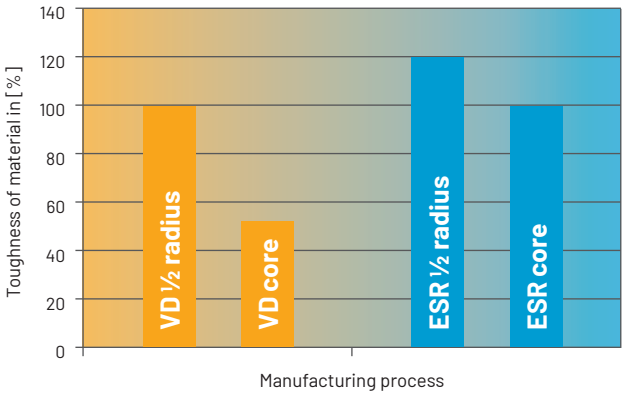
The result is homogeneous and isotropic steel.



K0 Purity level according to DIN 50602



Toughness vs. manufacturing process



Thanks to the ESR process, LUCCHINI 4542 ESR satisfies the most difficult requirements in terms of toughness and suitability to polishing. It is suitable for the manufacture of moulds subjected to mirror polishing and to high mechanical stress.

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Guidance for machining

The following parameters are approximate only and must be adjusted to the specific application and machine tool.

Turning

	Rough machining	Finish machining		
Type of insert	P20-P40 coated	HSS	P10-P20 coated	Cermet
V_c cutting speed [m/min]	150 ÷ 190	(*)	190 ÷ 230	260 ÷ 320
a_r cutting depth [mm]	5	(*)	< 1	< 0,5

Milling

	Rough machining		
Type of insert	P25-P35 not coated	P25-P35 coated	HSS
V_c cutting speed [m/min]	120 ÷ 140	160 ÷ 180	(*)
f_z feed [mm]	0,15 ÷ 0,3	0,15 ÷ 0,3	(*)
a_r cutting depth [mm]	2 ÷ 4	2 ÷ 4	(*)

	Pre-finishing		
Type of insert	P10-P20 not coated	P10-P20 coated	HSS
V_c cutting speed [m/min]	140 ÷ 160	180 ÷ 200	(*)
f_z feed [mm]	0,2 ÷ 0,3	0,2 ÷ 0,3	(*)
a_r cutting depth [mm]	< 2	< 2	(*)

	Finishing		
Type of insert	P10-P20 not coated	P10-P20 coated	Cermet P15
V_c cutting speed [m/min]	200 ÷ 240	250 ÷ 270	300 ÷ 340
f_z feed [mm]	0,05 ÷ 0,2	0,05 ÷ 0,2	0,05 ÷ 0,2
a_r cutting depth [mm]	0,5 ÷ 1	0,5 ÷ 1	0,3 ÷ 0,5

(*) not advisable

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Drilling

Type of insert	tip with interchangeable inserts	HSS	brazed tip
V_c cutting speed [m/min]	130 ÷ 160	(*)	90 ÷ 120
f_z feed per turn [mm/turn]	0,05 ÷ 0,15	(*)	0,15 ÷ 0,25

(*) not advisable

General formulae

Type of machining	**Drilling**	**Milling**
n: number of turns of mandrel	$V_c * 1000 / \pi * D_c$	$V_c * 1000 / \pi * D_c$
V_f: feed speed [m/min]	$V_f = f_z * n$	$V_f = f_z * n * z_n$
f_z feed per turn [mm/turn]	-	$f_n = V_f / n$
Note	D_c: Milling cutter or tip diameter [mm] V_c: cutting speed [m/min] f_z: feed [mm]	f_n: feed per turn [mm/turn] z_n: No. of milling cutter inserts

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Welding

Welding LUCCHINI 4542 ESR can give good results if it is carried out using the recommended procedure.

We recommend to carry out pre-heating and heat treatment after welding.

In order to obtain the best results, we recommend the following procedure:

Material condition	Solution treating	Age hardening
Welding technique	TIG	
Pre-heating at	200 – 250°C	
Recommended Heat treatment	Age hardening aimed to obtain the required hardness (*)	

(*) The necessity for heat treatment is to be evaluated based on the zone welded. In the case of a very extensive repair it will be necessary to solution treat the piece again and age harden it a second time.

Electrical Discharge Machining (EDM)

LUCCHINI 4542 ESR can be machined by EDM to obtain complex shape. Afterwards we advise to carry out the stress relieving procedure.

Process and materials selection for product recyclability

According to the potential of steel recycling, Lucchini RS is adopting a strategy for environmental excellence in designing and manufacturing its tool steel grades, putting eco-effectiveness into practice.

The main adopted steps are:

- to carry out an environmental assessment on processes and products, with the minimum use of virgin materials and non-renewable forms of energy;
- to move toward zero-waste manufacturing processes, considering that the ultimate destination of scrapped steel moulds becomes food for the next steel making process, that is the “waste equals food” philosophy;
- to carry out a life cycle assessment for each product and process, minimizing the environmental cost of product and service over its complete life cycles, from creation to disposal, that is the “Cradle to Cradle” philosophy

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