ULTRASONIC Treatment of Molten and Solidifying Aluminium

1.0 Technology:

Based on fundamental research of Ultrasonic Interaction in molten and solidifying metals technologies were developed for processing aluminium alloys as follows:

- de-gassing and filtering of molten metal (aluminium melt refining technology)
- refinement of metal structure (aluminium grain modification technology)

In both technologies ultrasound above the threshold of acoustic cavitation is introduced into molten metal during, for example, a continuous casting process.

Both technologies are environmentally friendly, nonpolluting, purely based on the physical effects of Ultrasound

2.0 Requirements:

The equipment used for these technologies consists of a set of Standard Ultrasonic Probes and Generators, a holding device for the probes, water cooling system, and process controls.
The systems can be incorporated into new plant, but can also be easily fitted into most existing melting or casting facility. They also fit readily into existing continuous casting process and do not require a massive capital outlay.

3.0 Applications and Process Advantages:

✓ especially suited to produce high quality ingots, including large sizes.

✓ for extrusions, forging, rolled sheet or foil.

✓ typical products are used by the aerospace, automotive, packaging, electronic, building and construction industries.

4.0 Stage of Development

The Technologies have been well implemented in Russia for many years.

Aluminium Melt Refining Technology

The proposed Technology is intended to remove effectively impurities from liquid metal during continuous casting of Aluminium and Aluminium based Alloys.
The impurities can be solid nonmetallic and gaseous.

The Technology is using High-intensity Ultrasonic treatment of the melt at the entry into a multilayer filter, usually made of glass fibre, mesh size 0.4 x 0.4mm.

The filter is positioned en route from the distributing melt furnace to the continuous casting mould or directly into the liquid ingot pool.

The Ultrasonic de-gassing and filtration of the Aluminium alloy melt substantially improves the melt purity as far as nonmetallic solids and gases are concerned.
The application of Ultrasonics allows to filter out alumna particles above 1 μm in size. The concentration of Hydrogen in Aluminium Alloys is reduced to 50 - 65%, in comparison to untreated metal.
The mechanical properties of the final products improves accordingly.

This Ultrasonic Technology is specially recommended for all Aluminium Alloys, where material defects due to solid nonmetallic or gaseous impurities are giving concern or must be reduced to a minimum.

Aluminium Grain Modification Technology

This Technology is recommended for the production of ingots with a fine nondentritic grain structure instead of macro grain size, usual in untreated ingots.

Again High-intensity Ultrasonic treatment is applied to the liquid metal, in the melt pool of a continuously cast ingot. Acoustic Cavitation is developed during the process, which heats up the melt and activates impurities. Also the the solidification conditions are changed, as the Ultrasound Activity increases the number of active crystallisation nuclei and moves the areas of crystal growth towards the solidification border.

This Process can be applied to any ingot size, up to 1000mm wide.

Ultrasonic treatment of solidifying ingots can effectively refine macrograin by a factor up to 10 to 20. The Process also lowers the Hydrogen content in the ingot by 50%. This results in a general increase of metal plasticity by 1,2 to 1.5 times. Better plasticity reduces the risk hot cracks and facilitates the production of good quality large size ingots.

In our experience, products made from Ultrasonically treated ingots proved to have better ductility and resource characteristics - a higher tensile strength and improved fatigue properties.

The Technology can be applied to all Aluminium Alloys containing small amounts of transition metals. The process can also be applied to Aluminium-Lithium

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Technical Data:

Typical Effects of Ultrasonic Treatment of Metal
Comparison using Aluminium Alloy 2124 and extruded Test Bar 65x200mm

	H_2 $cm^3/100g$	Oxides in Fracture mm^2 / cm^2	UTS MPa	δ %	K_{1C} MPa $m^{0.5}$	LCF.10^3 Cycles see Note ☒
Before Treatment	0.13	0.032	422	6.4	30.7	162
with Ultrasonic Treatment	0.07	0.001	436	7.6	41.4	259

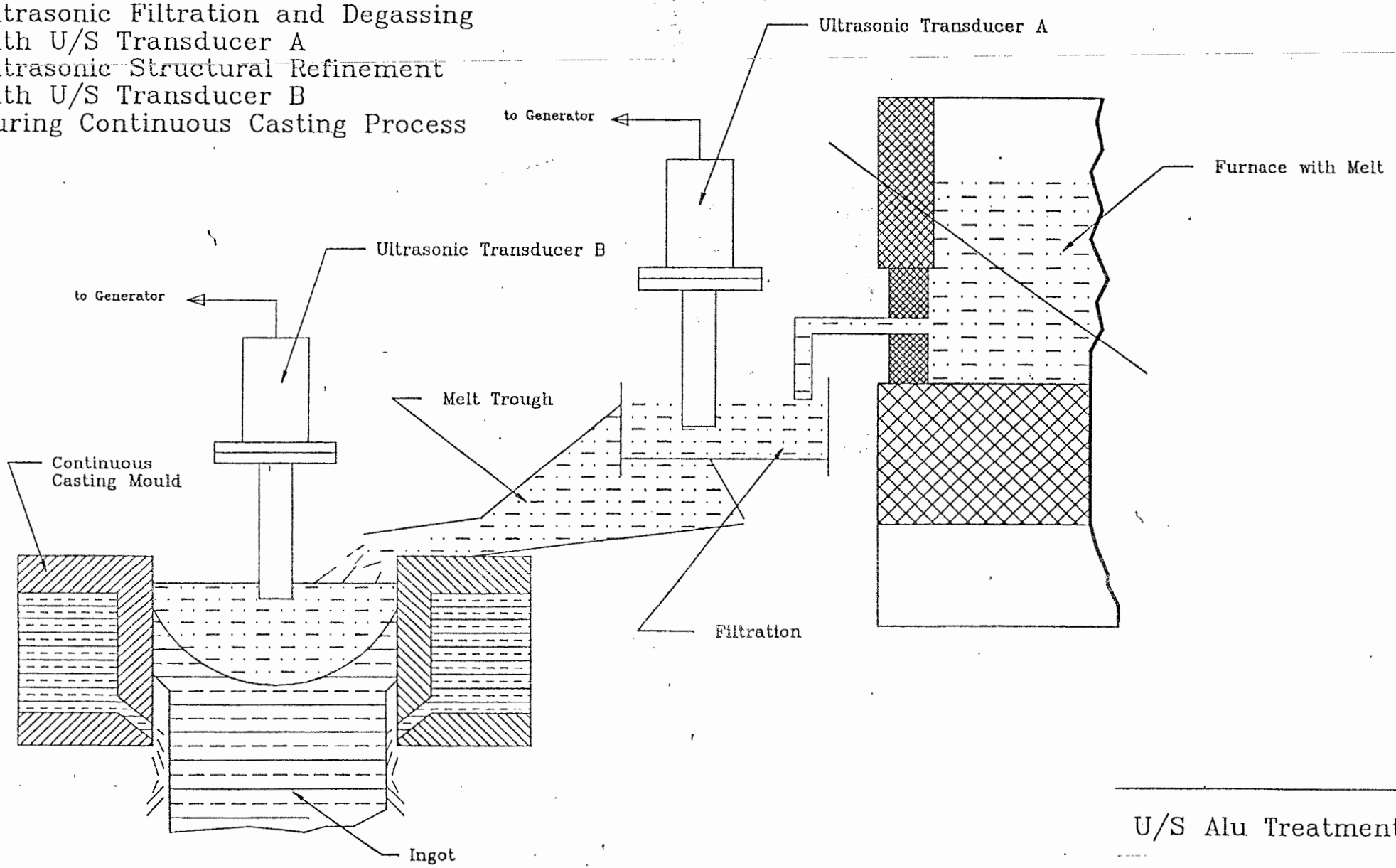
☒ Note: Maximum cycle stress 160 MPa

Typical Effects of Ultrasonic Treatment for Nondendritic Structure on Mechanical Characteristics at Transverse Direction of 60 mm thick Plate, Aluminium Alloy 2124 (Condition T)

	YS MPa	UTS MPa	δ %	Ψ % see Note ◆	K_{1C} MPa $m^{0.5}$	LCF.10^3 Cycles see Note ☒
Before Treatment	293	432		16.7	45	132
with Ultrasonic Treatment	317	453	%	17.5	50	239

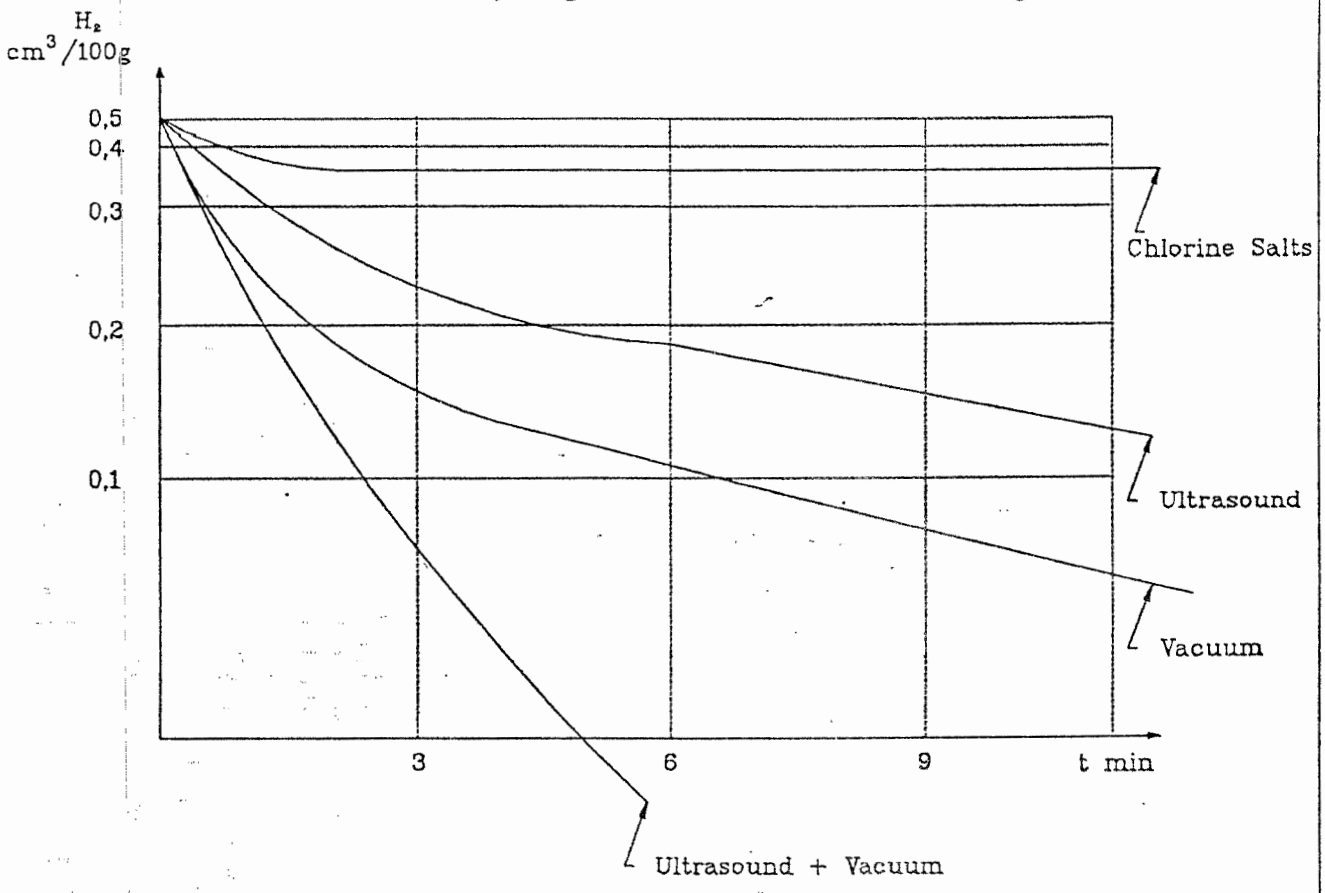
◆ Note: Reduction of Area

Schematic of
Ultrasonic Filtration and Degassing
with U/S Transducer A
Ultrasonic Structural Refinement
with U/S Transducer B
during Continuous Casting Process

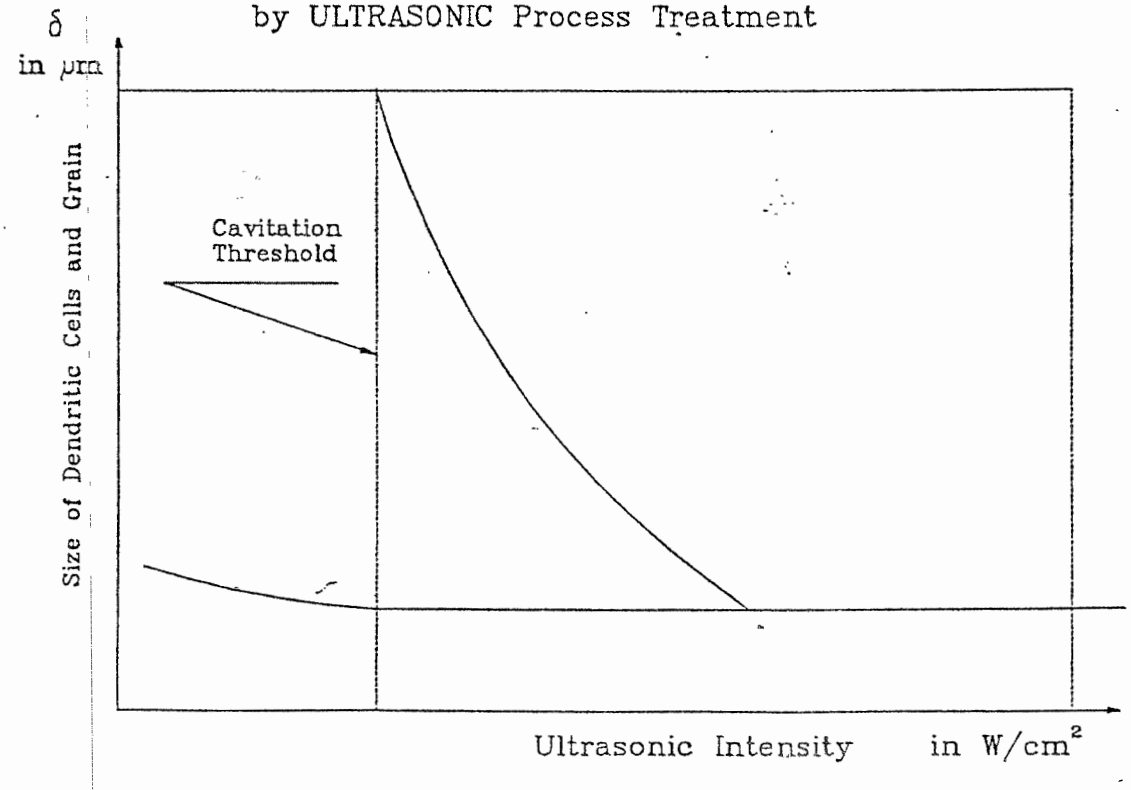


U/S Alu Treatment

Comparison of different Processes
Kinetic of Hydrogen Removal from Al–Si–Mg Melt



NON–DENTRITIC Structure Formation
by ULTRASONIC Process Treatment



U/S Alu Treatment