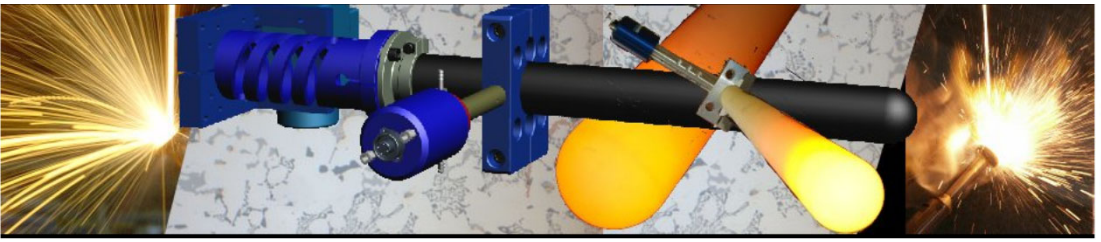

Ultrasonic vibrations in metallurgy…

with **MMM** Technology

Grain refinement of AlTiB master alloy

Prepared by Miodrag/HPuga

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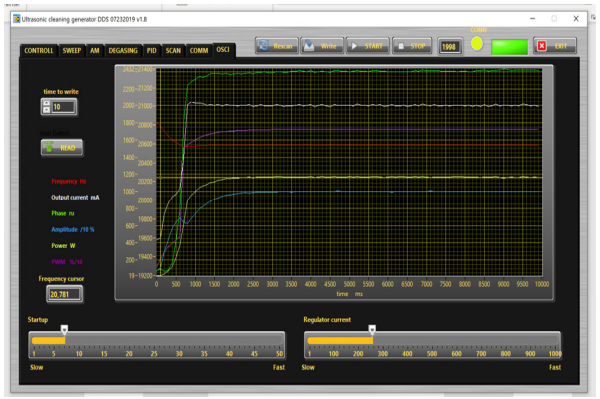
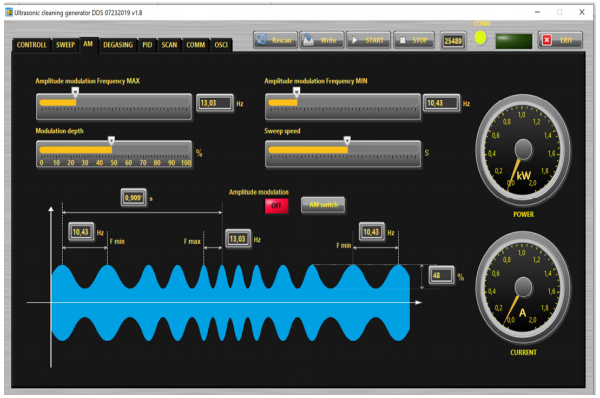
October 2024

Patent

European Patent Application (related to MMM technology): EP 1 238 715 A1. Multifrequency ultrasonic structural actuator
Applicant**: Prokic Miodrag**, MP Interconsulting, 5.03.2001 – 11.09.2002

… Ultrasonic Equipment Based on MMM Technology for Industrial Application …

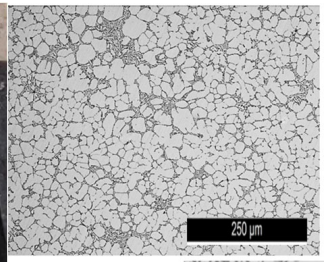


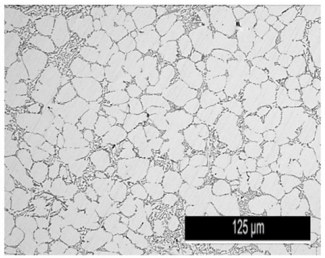


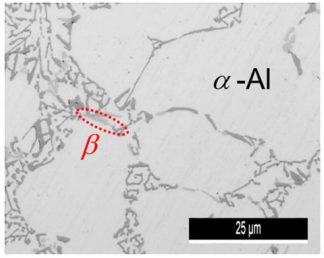
… Ultrasonic Equipment Based on MMM Technology for Industrial Application …

Application of the System for Degassing of Al Alloy in a 500 kg Furnace

Application of the System for Degassing of Al Alloy in a 5 kg Furnace



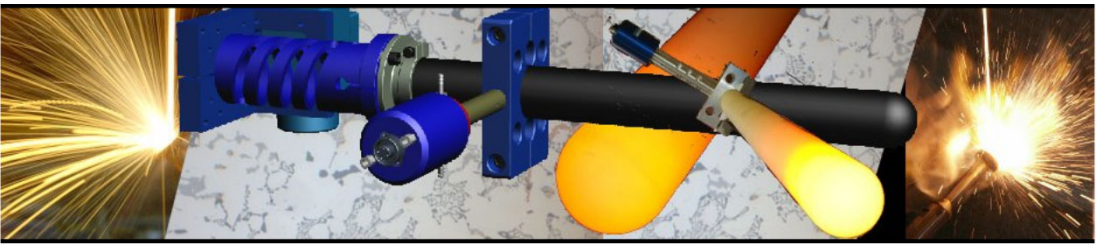




AlSi7Mg alloy
T = 640 ºC
t = 60 s
US MMM with **f = 20.3±0.2 kHz**
P = 600 W

Isothermal Treatment [°C]	**Mechanical Properties**[1]		
	Yield Strength [MPa]	Ultimate Strength [MPa]	Elongation at Break [%]
700	190±12	218±16	2.0±0.6
660	195±10	230±12	2.9±0.4
640	210±15	246±12	3.6±0.3

[1] The mechanical properties were obtained in heat-treated test specimens



The ultrasonic system has shown very positive results when compared to conventional treatment processes. **However, it is important to note that there are some factors to be considered.**

1. **Maturity level of the system at an industrial scale** - it is still low, as the investment by foundry companies in the search for innovative and efficient solutions remains limited.

2. **Level of knowledge among foundry professionals** - it is still limited. A certain learning period is required, as well as the willingness to take risks due to the unknown and the optimism for success (an open mind!).

3. **The role of acoustic energy application in a liquid molten metal** - degassing/refining/modifying. Here, the question arises:

   What is your goal? Is it to degas?

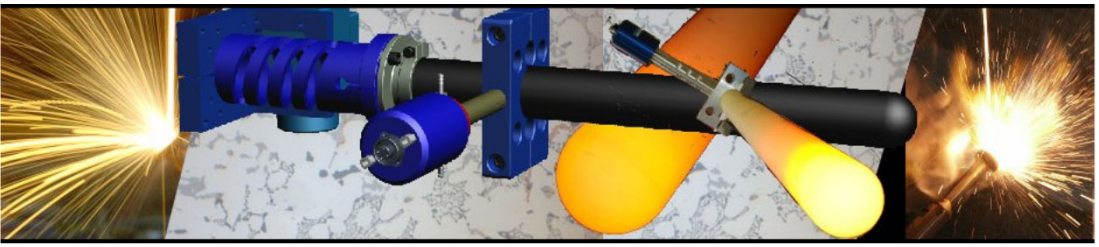
   Then you should work at temperatures of 700 - 720°C.

   Is it to refine alpha grain (Al)? Then you should work at lower temperatures, 660 - 680°C (this does not mean that some grain refinement does not occur at 700°C. It does, but it is not as efficient as working at lower temperatures—there are explanations for this, which can be provided after the project starts).

   Is it to modify eutectic Si? The answer is the same as for alpha grain refinement.

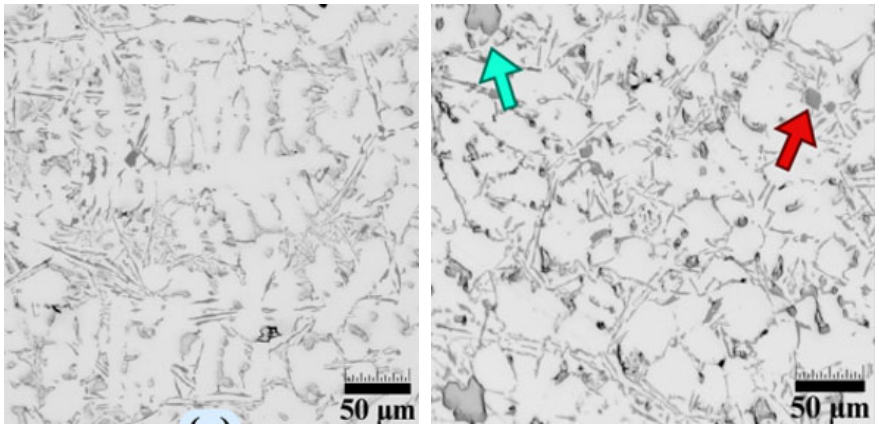
But, **it could be for the refinement of intermetallics**. And I think this is what you are looking for. If that is the case, we are on a different level. It is possible. We have had very encouraging results at a laboratory scale (20 to 60 kg of AlSiFe), but at this point, and as with the two previous objectives (with the exception of degassing), **there is an optimal temperature**. It is not worth implementing an ultrasonic system and just waiting for the results. It is necessary to understand what we are aiming for.

I understand that modifying the channel may not be ideal for you, but it is ideal for the success of intermetallic refinement. Installing two ultrasonic systems in the crucible is unnecessary and adds no value. There is a compartment (confined) where an ultrasonic system can facilitate degassing and promote some refinement of Al grain. However, it is necessary to work at a slightly lower temperature (probably 680°C) to achieve good refinement and distribution of the Al2Ti and TiB2 phases. I believe these are the phases you are looking to 'work with'

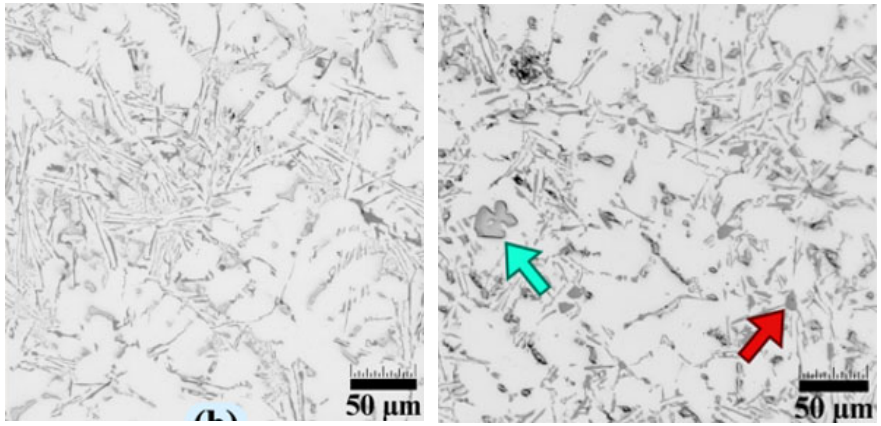


Without US | With US

660 C

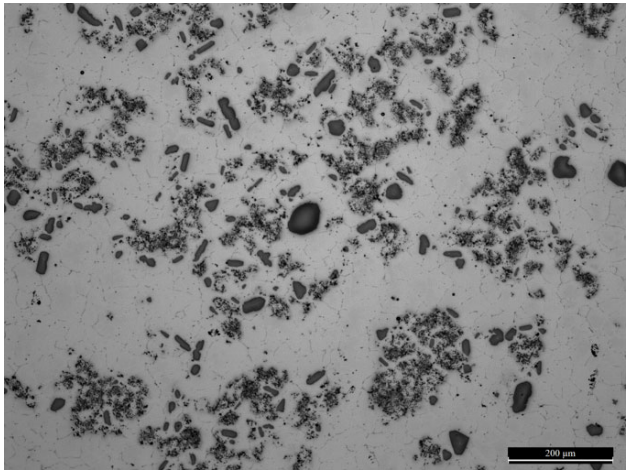


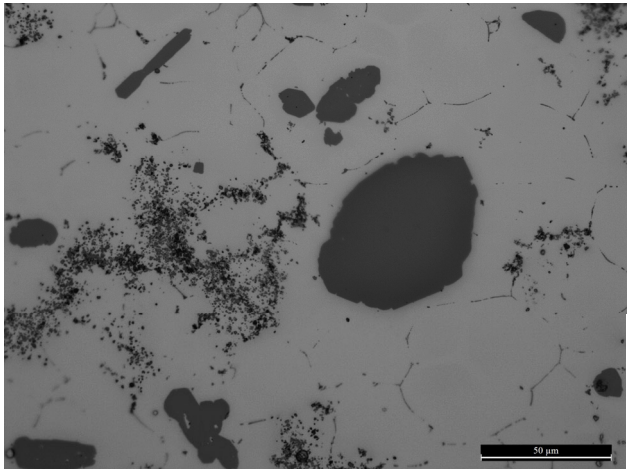
680 C

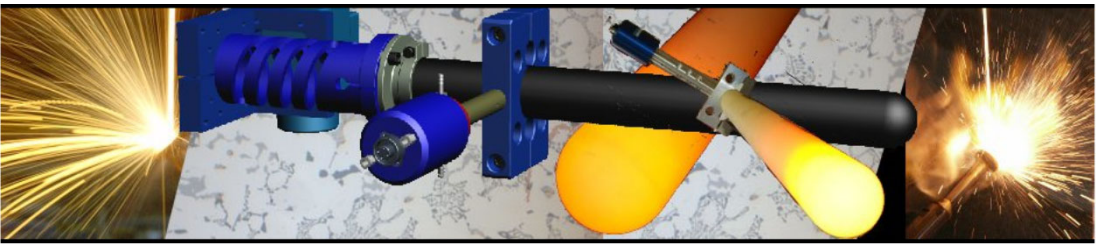


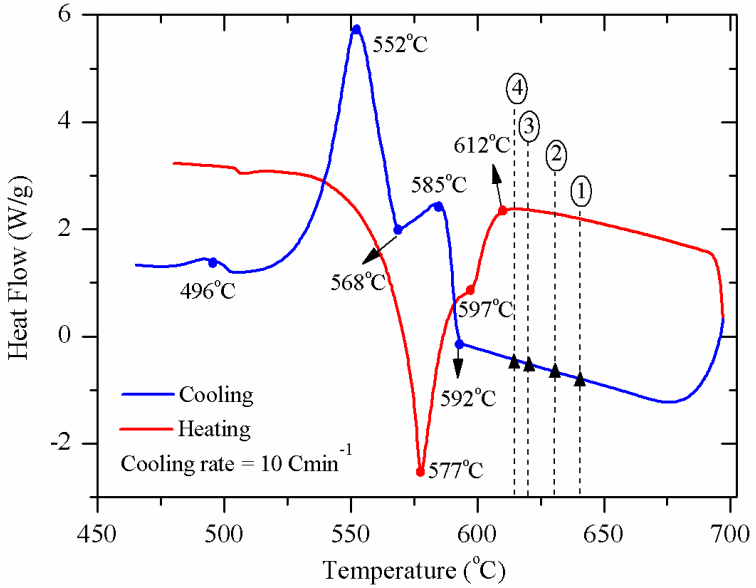
Red arrows: Si
Teal arrow: Fe

Ultrasonic Treatment master Alloy Al5Ti1B





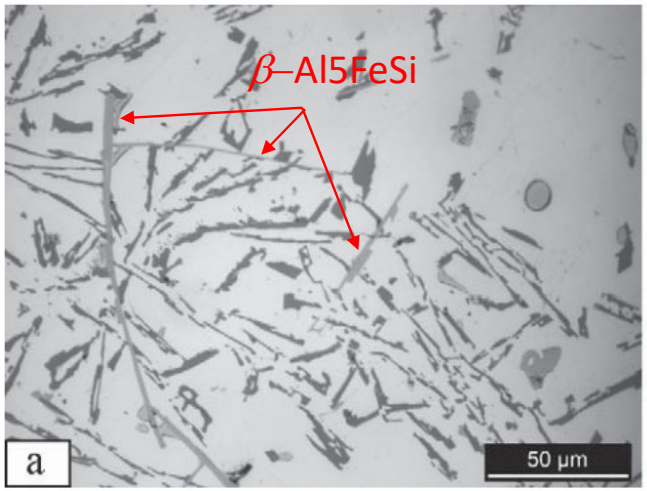




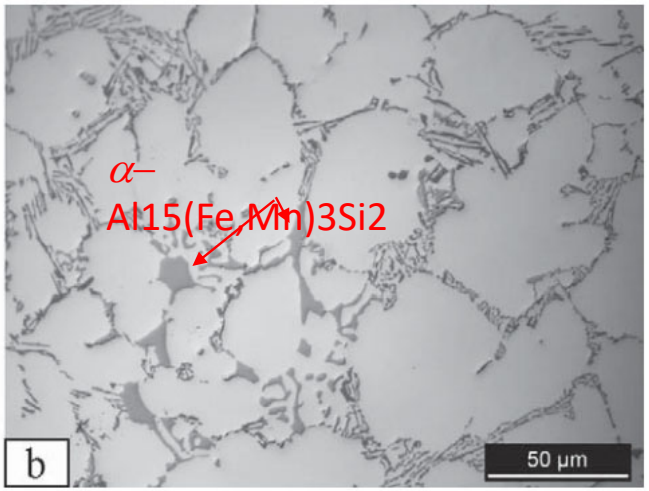
UST of A380 Alloy

TL = 612 ºC

TS = 577 ºC

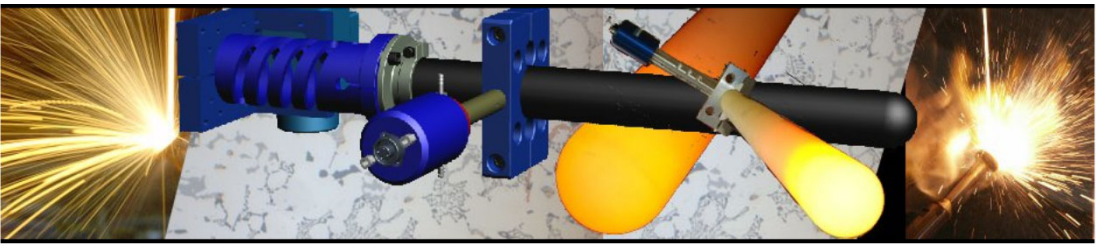


(a) Non UST @615 ºC

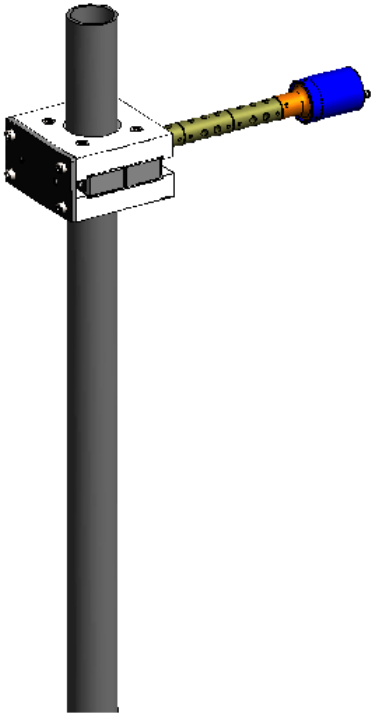


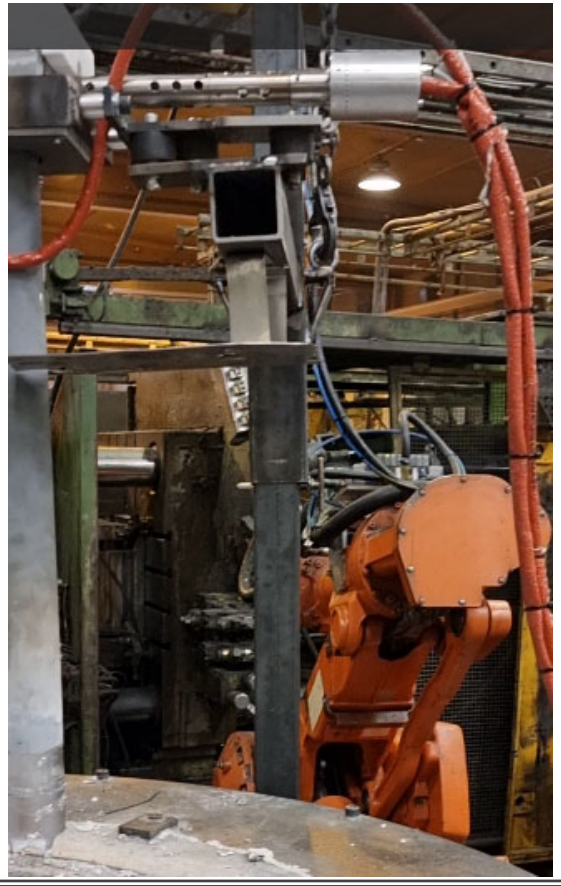
(b) UST@615 ºC

For 615 ◦C the iron containing intermetallic phases changed their morphology from large needles or coarse “Chinese Script” shape into short and thin particles with different shapes, uniformly distributed throughout the matrix.



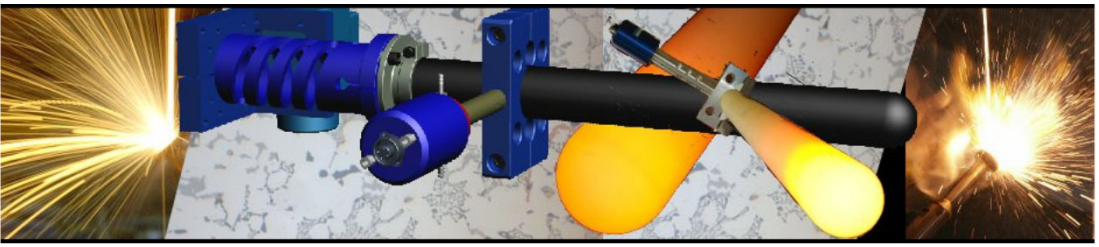
… OPTION 1



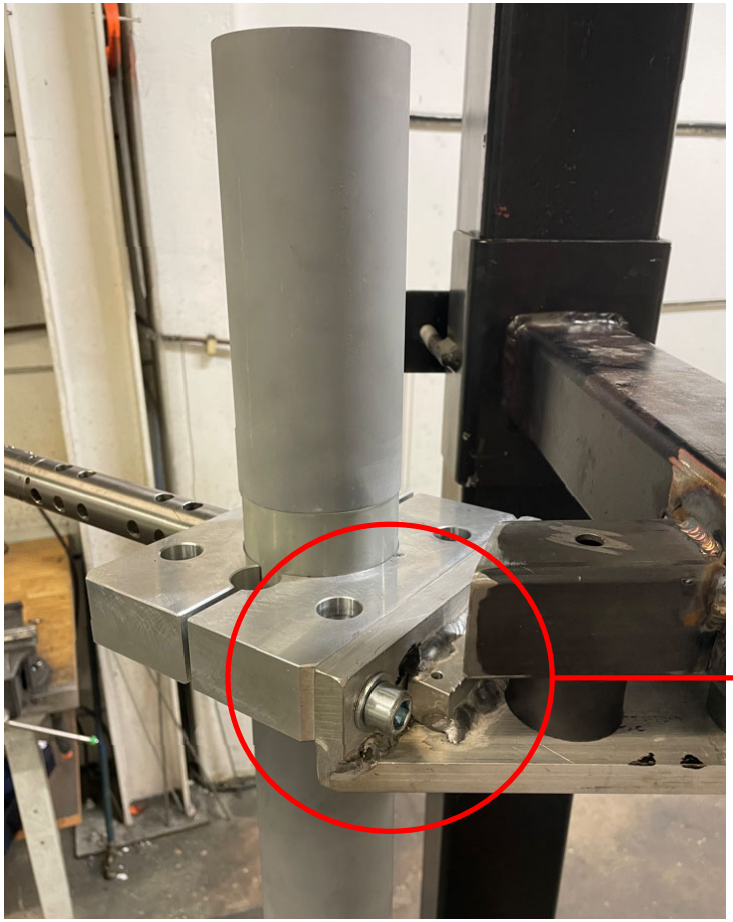


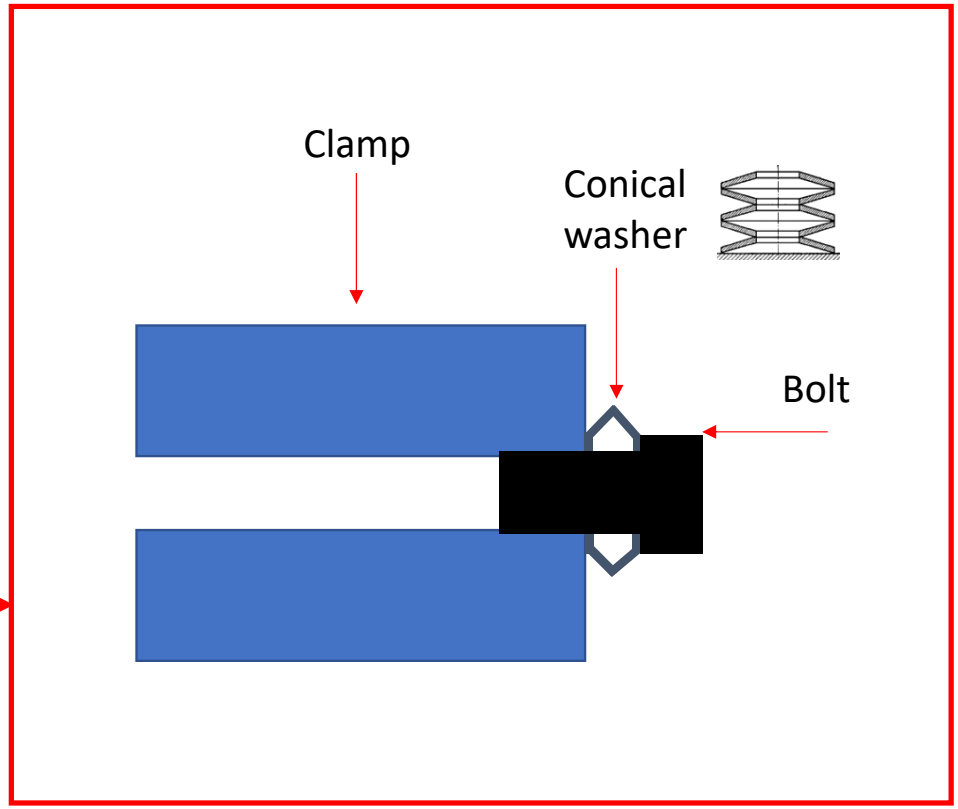
When it is necessary to remove the remaining material from the bottom of the crucible, the process will be simple. To do this, just choose one of the following options to fix the ultrasonic system. More details can be provided after the project starts.

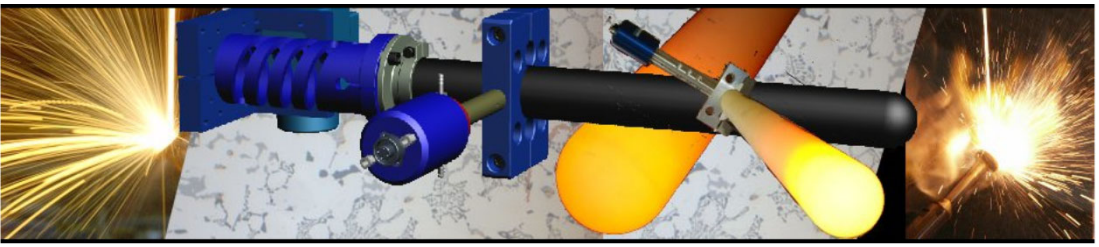
Conclusion: The ultrasonic system will be mounted on a structure that should be integrated with the furnace (external part). Therefore, if the furnace rotates, the ultrasonic system will also move accordingly.



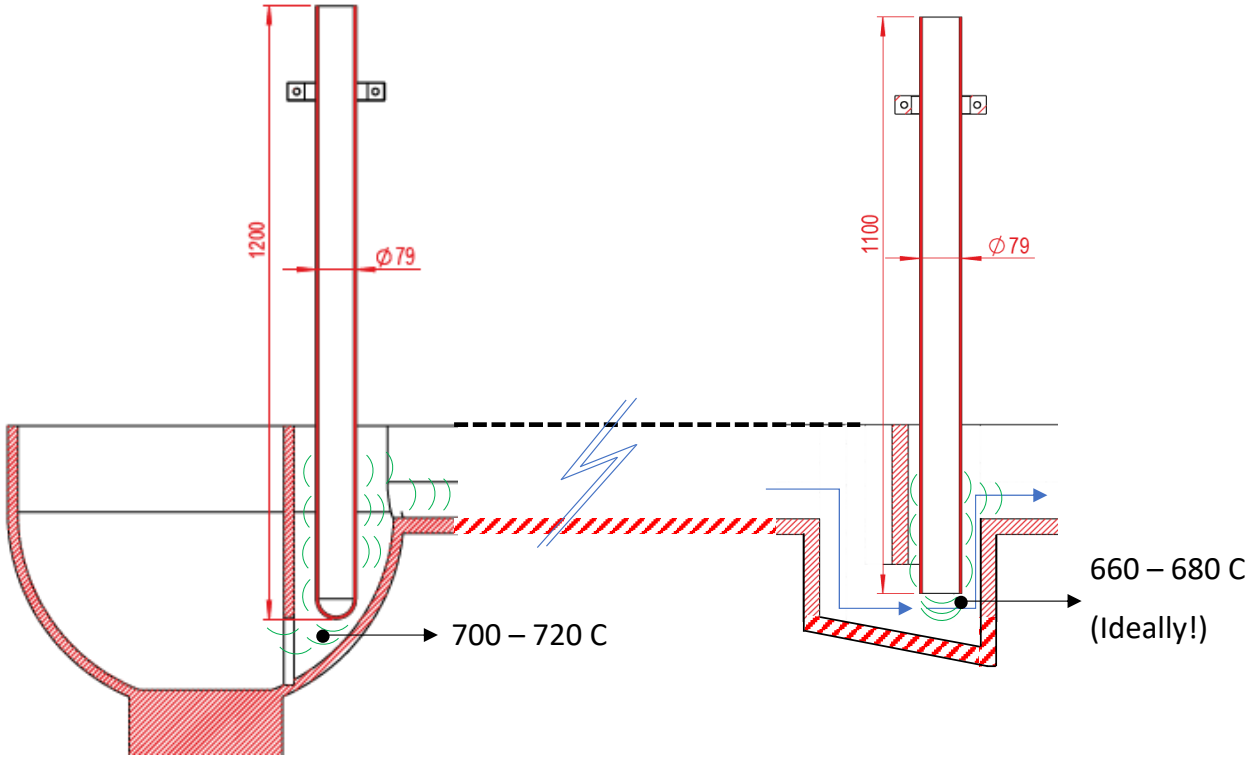
… OPTION 2

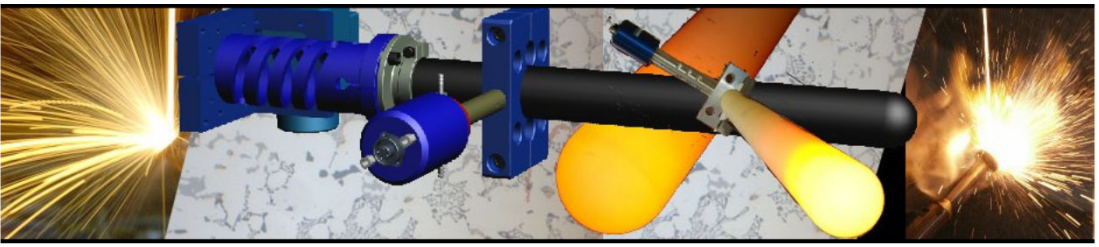






... Ideal system for its intended purpose





… the future of Metallurgy starts here, with MMM Technology.

Thank You.