Propose the collaboration for R&D and implementation the following MHD technologies for aluminium industry:

**Liquid Heart Metal Stirrer (LHMS)** – Stage 4 (trial unit testing).
Application area – Aluminium casting process.

and

**Low Depth Metal Stirrer (LDMS)** – Stage 2 (laboratory models).
Application area – Aluminium recycling.

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Company history and products

Associated with Siberian Federal University, UniMet LLC company is represented by MHD Center GmbH and has great experience of innovation projects development in the sphere of magneto hydrodynamics (MHD) and equipment installations at the worldwide market.

Company activity includes:

- World level magneto-hydrodynamic (MHD) technologies development basically in the aluminium market segments, that successfully compete with the market leaders;
- Commercialization of innovative R&D developments in the sphere of MHD-technologies for metallurgy including aluminium, copper, zinc, magnesium;
- Organization of innovative products manufacturing;
- Organization of sales and supplies of the developed products and technologies;
- International markets products implementation based on JV creation.
- We are supported by our industrial partners: SUG GmbH (in Germany) and Insertec (in Spain)

List of developed technologies ready for implementation

1. **Innovative LHMS - stirrer of aluminium ingot liquid heart**
   Revolutionary technology providing increase of large rectangular aluminium ingots quality by means of crystallization process control in the liquid heart especially while casting aviation alloys 2xxxx, 5xxx, 7xxx series. At the moment trial unit has been produced and successfully tested after supply and installation at the plant in EU in order to solve problems with alloys 7xxx series.

2. **Innovative LDMS - stirrers for furnaces with low metal depth**
   Our team is developing innovative inductor that provides effective metal stirring in the furnace even at low metal depth ~ 10 cm, by means of special running field (compared to traditional technology). This revolutionary technology has great demand for stationary melting furnaces and for the cases when deep metal level is impossible (i.e. start of melting process, end of casting process, half load).

3. **New LMPS - metal pumping system and tap-out blocks based on MHD-pumps (Stage 1 idea)**
   The equipment provides flexible and precise metal flow control (with complete metal flow stop) which is especially important for stationary furnaces when metal flow is higher at full capacity and low in the end of casting. The design has no defects peculiar for traditional technologies, equipment is much easier in installation and operation, have relatively low cost, low energy consumption (~ 10 kW) and air cooling.

4. **Small size energy efficient MHD stirrers for crucibles and small furnaces and volumes (Stage 1 idea)**
   Special application small inductors are installed in small furnaces or intermediate volumes. They have very good characteristics by mass ~ 1.5 – 2 ton, energy consumption ~ 15 kW and size ~ 2 m, which makes them along with the low price very demanded at the market.
Current status of the developments and collaboration

What we have:

**LDMS** (for Al Recycling industry)
- Idea of liquid melt stirring at low depth with side mounted MHD stirrer;
- Mathematical calculations of the melt stirring in the aluminium recycling furnace;
- IP protection: application filed in USA, EU, Russia, China;
- Laboratory models of inductors and furnaces with eutectic alloy;
- Preliminary design of industrial testing unit.

**LHMS** (for Al casting process)
- Idea of liquid sump stirring during the process of large aluminium slab casting;
- Mathematical calculations of the sump stirring in the slab;
- IP protection: application filed in USA, EU, Russia, China;
- Laboratory models of inductors and slabs with eutectic alloy;
- Design and manufacturing drawings of the trial unit;
- Trial unit built;
- Trial unit test campaign results proving the effectiveness of the technology based on 7xxx series Al alloys.

What we want from collaboration with universities and industrial partners:

- We would like to establish good collaboration R&D work with the Institutes and Universities in EU in order to continue the development of the technologies and their industrial implementation (together with the Siberian Federal University);
- Support with Laboratory facilities and Techno park office space;
- Support in search for possible industrial partner interested in testing and application of the developed technologies;
- Mutual scientific program realization based on such programs as IRA SME, Horizon 2020, etc.
- Common R&D work in testing and industrial application of the developed technologies;
- Mutual work in perspective technologies development upon industrial partner requirements.
1. LHMS – Liquid Heart Metal Stirrer

Aluminium ingot liquid heart MHD stirring (LHMS) is based on running electromagnetic field, created by a couple of stirrers from both sides of the ingot, influence to the liquid heart during the process of casting. This allows solving all tasks arising during the process of value added products manufacturing. This includes homogenizing of chemical and structural composition along the whole ingot volume with a dramatic penalty reduction, especially for the alloys 1xxx, 2xxx, 5xxx, 7xxx series for airspace and automotive industries. Main peculiarity of the electromagnetic stirrer technology is settings flexibility depending on the type of alloy, relatively low energy consumption, compact size, easiness for installation. Moreover, it provides more than 150 types of flows (regimes) in the sump.

- **Technological task**
  During rolling process of ingots manufactured with hidden defects like structural or chemical inhomogeneity serious problems can occur at operation of end-products.

- **Proposed solution**

- **Technology**
  
  Result – improved microstructure
  
  Schematic view of liquid heart MHD stirring
  
  Aluminum particles movement in the liquid heart

Economical efficiency and advantages of the LHMS technology

In the process of complex multicomponent alloys casting into large aluminium ingots there are different ways of the profit improvement: increase the capacity of existing casting equipment, reduce current penalty rate, improve the quality of the products, manufacture new higher value added products, decrease in the percentage of cuttings, receipt of additional profit due to the absence of defects in the ingot.

LHMS technology allows to achieve all these goals and provides the obtaining of economical effect from 1 to 3 mln. USD/year per one mould casting pit.

Competitive advantages:

- Slab casting cycle reduction up to 40%;
- Casting speed improvement by 85%;
- Chemical composition homogenizing along the whole slab volume that leads to the rejected production decrease during further slabs rolling and milling by 10-90% or completely eliminates it (depending on the type of the alloy). Elimination of the cracks and porosity;
- Reduction of cut off zones (bottom part and top part) by 50% that guarantees significant increase per each casing mold;
- Macro segregation reduction by 55% and mesosegregation reduction by 50% that further excludes the possibility for the defects in the rolled or milled products;
- Possibility to cast new complicated alloys in the shape of large rectangular slabs with the thickness up to 1 meter that was impossible to cast before – AlLi alloys, 2xxx, 5xxx, 7xxx (with the Zn content up to 11%

Economical Estimation

The calculation presented was done based on one mould casting pit with capacity of 30 000 ton/year, mould size 1.5 x 0.6 m, casting speed – 60 mm/min, 7xxx alloys series, rejection - 4%.

It is necessary to take into account that calculation is done for the casting pit with one mould. During simultaneous casting of several ingots at a time the economical benefit with the LHMS technology implementation will be higher.

<table>
<thead>
<tr>
<th>Case</th>
<th>Description</th>
<th>Profit (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>Net profit loss caused by reduced capacity (USD/year)</td>
<td>$1,993,215</td>
</tr>
<tr>
<td>Case 2</td>
<td>Rejection remelting loss and the resulting lost income and cutting (USD/year)</td>
<td>$1,310,738</td>
</tr>
<tr>
<td>Case 3</td>
<td>Customers reclamation</td>
<td>USD 0,000,000</td>
</tr>
<tr>
<td>Case 4</td>
<td>Value added profit for new alloy and quality warranty up to 500 USD/year</td>
<td>$2,591,180</td>
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</tbody>
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In summary the potential benefit could be (USD/year) $3,303,953

Total potential benefit per mould with new alloys $5,895,133
Inductive Low Depth Metal Stirrer is inside non-magnetic slot in the furnace wall. General principle used is creation of transverse running field that penetrates the alloy through the surface thus making this method of stirring independent from the metal depth. It provides good stirring effect even at low metal depth ~ 5-10 cm. It is impossible to achieve with traditional inductors like MHDS-AL or other due to they create longitudinal running magnetic field.

Differences between **Classic** stirrers and **LDMS** technology

**Longitudinal field created by traditional inductor**

With this type of magnetic field, eddy currents and mixing forces creation depend on the metal depth. Thus with the depth decrease eddy currents become lower as they are created in the vertical plane and it is dramatically reduced with the metal depth reduction.

**Transverse field created by LDMS**

Specially organized magnetic field penetrates the melt through its' surface and eddy currents are formed in the horizontal plane. It makes inductor performance and alloy stirring independent from the metal depth as horizontal plane is not reduced.
During the process of alloys preparation especially with the usage of multicomponent master alloys there is a necessity of heat and mass transfer improvement in the melt to uniform the temperature and chemical composition along the whole melt volume. This is especially needed at the beginning of melting process due to the process of cold scrap melting in the working area could be improved by the hot liquid metal flow. **Low Depth Metal Stirrer (LDMS)** allows improving heat and mass transfer, melting rate and master alloy dissolution thus reducing the operating temperature of the gas burner and melting cycle time.

The technology is distinguished by the extraordinary stirring method which aims to create specific running field application for making stirring process independent from the reduced metal depth.

**LDMS Advantages:**

- metal loss reduction up to 30%;
- energy consumption decreased up to 15%;
- furnace productivity increased up to 25%;
- effective chemical and temperature homogeneity;
- no water cooled parts, air cooling;
- providing 20 times more powerful metal flow at low depth (~10-30 cm) compared to current traditional side mounted stirrers;
- low capital costs due to the principle of side installation. There is no need to cover additional expenses for the basement modernization, furnace sump construction, scissor lift, trolley, rails, extra space for installation and auxiliary equipment.
UniMet LLC is always ready to discuss all possible means of cooperation with Your Company or University.

We are always ready to answer your questions via WebEx (unimetllc@gmail.com), Skype (unimetllc)

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