Mining and Generation of Magnesium Alloys

Kenneth J. Clark
Magnesium Elektron

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IAMFTWG
Atlantic City, NJ
AGENDA

Magnesium!

Extractive Metallurgy

Alloy Development History

Wrought Plate Manufacturing

Machining Magnesium
Magnesium is the eighth most abundant element by mass of the earth.

It’s a fact that magnesium is a necessary element for all living organisms, both plants and animals.

The green material in plants, chlorophyll contains magnesium.

Human beings also need magnesium.

The U.S. National Academy of Sciences has estimated that a nation-wide initiative to add calcium and magnesium to soft water might reduce the annual cardiovascular death rate by 150,000 in the United States.
Magnesium

Magnesium is not found in a pure form because it bonds with other elements. It’s necessary to apply a process to retrieve a usable amount of Mg.

The majority of magnesium product produced today is obtained from the processing of naturally occurring minerals such as magnesite (magnesium carbonate), magnesium chloride rich brine, and seawater.
There are more than 300 million cubic miles of seawater

A cubic mile of seawater is estimated to contain six million tons of magnesium.
Sea Water Electrolytic Extraction Process

1. **Sea Water**
2. **Dolomite Rock**
3. **Kilns**
4. **Precipitation to Magnesium Hydrate**
5. **Purifier**
6. **Drier**
   - Dehydration From 35% to 73% MgCl₂
7. **Electrolytic Magnesium Cells**
8. **Refining, Alloying & Casting**
9. **Liquid Chlorine**
10. **Mg(OH)₂**
11. **Filters**
12. **Neutralizers**
13. **HCL from Organic Chlorination**
14. **Hydrochloric Acid Furnace**
15. **Liquefaction**
16. **Magnesium Ingots**
17. **Sea Water**
The Electrolytic Extraction Process

- Purification Plant
- Electrolytic Magnesium Cells
- Brine Concentration Ponds
- Transportation to the Cast House
- Ingot Casting Line

(brine)
The Thermal Reduction Process

- Bauxite ($\text{Al}_2\text{O}_3$)
- Dolomite Rock
- FeSi

Kilns:

- Refining, Alloying
- Casting

Magnesium Ingots

Steel Scrap
Wood Chips
Quartzite
Coke & Coal

Vacuum Furnace:

- Condenser / Retort
- Mg Crowns

Ladle:

- Spent FeSi

Mg Crown

Spent FeSi

Refining, Alloying & Casting

Magnesium Ingots

Slag
The Thermal Reduction Process

Dolomite Mine

Briquettes Being Charged into Retorts

Reduction Building With 64 Retorts

Magnesium Condenser Tubes with Crowns

Unloading Slag From Retorts
AGENDA

- Magnesium!
- Extractive Metallurgy
- Alloy Development History
- Wrought Plate Manufacturing
- Machining Magnesium
Magnesium Alloy Development History

**SAND CASTING ALLOYS**

**AI - Zn - Mn**
1930s → mid 1980s

**Zn - Zr**
1940s →

**Zn - RE - Zr**
late 1940s → late 1960s

**Zn - Th - Zr**
early 1950s →

**Ag - RE - Zr**
early 1960s →

**Y - RE - Zr**
late 1980s →

**Nd-Gd-Zr**
late 1990s →

**AZ63A**
**AZ81A**
**AZ92A**
**AZ91C**
**AZ91E**
**ZK51A**
**ZK61A**
**EZ33A**
**ZE41A**
**HZ32A**
**ZH62A**
**QE22A**
**EQ21A**
**WE54A**
**WE43B**
**Elektron 21**
**EV31A**
# Magnesium Alloy Development History

<table>
<thead>
<tr>
<th>Alloy Composition</th>
<th>Development Period</th>
</tr>
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<tbody>
<tr>
<td>Al-Zn-Mn</td>
<td>1930s → mid 1980s</td>
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<td>Nd-Gd-Zr</td>
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### SAND CASTING

- **AZ63A**
- **AZ81A**
- **AZ92A**
- **AZ91C**
- **AZ91E**
- **ZK51A**
- **ZK61A**
- **EZ33A**
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- **QE22A**
- **EQ21A**
- **WE54A**
- **WE43B**
- **Elektron 21**
- **EV31A**
Magnesium Alloy Development History

**WROUGHT ALLOYS**

**Al - Zn - Mn** 1930s

**Zn - Zr** 1940s

**Zn - RE - Zr** late 1940s

**Zn - Th - Zr** early 1950s

**Ag - RE - Zr** early 1960s

**Y - RE - Zr** wrought early 2000s

**Nd-Gd-Zr** early 2000s

**Elektron675** mid 2000s

Now developing large scale production capability

- M1A
- AZ80A
- AZ61A
- AZ31C
- AZ21A
- ZK30A
- ZK60A
- EZ33A
- ZE41A
- HM21A
- HK31A
- QE22A
- EQ21A
- WE54A
- WE43B
- Elektron 21
- EV31A
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MENA

Cast house

Rolling mills

½ mile
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**Tool life**
With carbide tools, tool life when machining magnesium alloys is *five to ten times the life when* machining aluminum alloys. Tool life is also favorable using high speed steel.

**Power required**
The table below gives a good indication of the relative power requirement for machining various metals:

<table>
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<tr>
<th>Metal Type</th>
<th>Power Required</th>
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<tr>
<td>Magnesium alloys</td>
<td>1.0</td>
</tr>
<tr>
<td>Aluminum alloys</td>
<td>1.8</td>
</tr>
<tr>
<td>Cast iron</td>
<td>3.5</td>
</tr>
<tr>
<td>Mild steel</td>
<td>6.3</td>
</tr>
<tr>
<td>Titanium alloys</td>
<td>7.6</td>
</tr>
</tbody>
</table>
Thank you for your kind attention!

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