Thermodynamic and mechanical investigations of novel binders for cemented carbides

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Context

Source: Cobalt Institute

High price of raw Co and WC powders

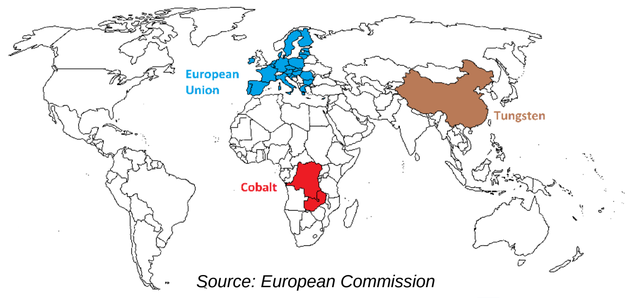
Resources
Co: Africa (65 %)
W: China (70%)

Co and W

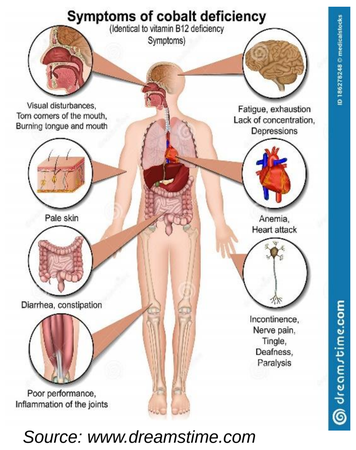
Critical raw materials

Huge consumption of Co in batteries of electrical vehicles

Health and ethical issues



Source: European Commission



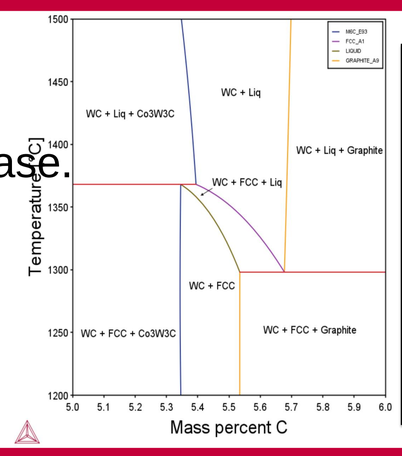
Source: www.dreamstime.com

Method

1. Thermodynamic approach

- Non critical raw materials.
- Compatible materials with WC phase.
- Carbon window important.

Thermo-Calc Software

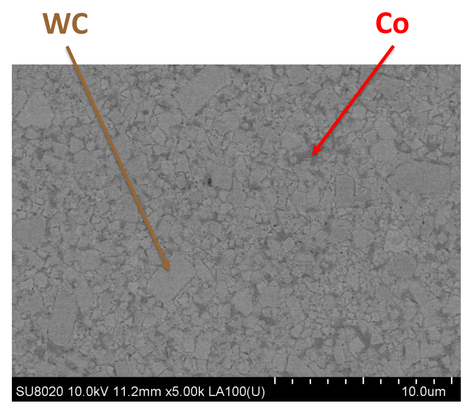


2. Mechanical approach

- Assessment of the microstructures.
- Assessment of the mechanical properties.

Microstructures

Hardness/Toughness



Results

1. Choice of the potential elements

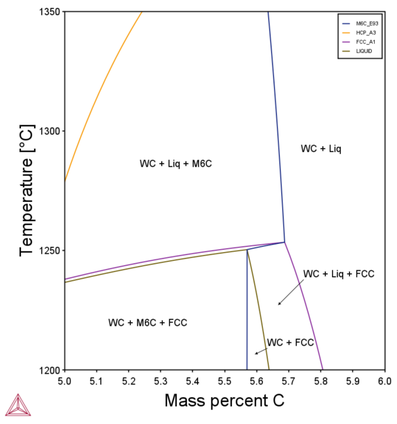
- Fe, Ni, Mn, Cr ✓
- Mg, Al, Si, Cu, Zn… ×

2. Technical issues

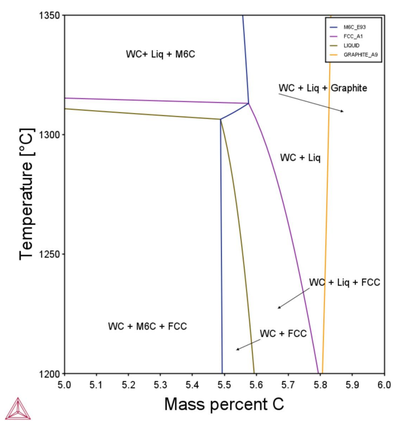
- Chromium cannot be processed in the lab: Cr ×

3. Evaluation of the carbon window

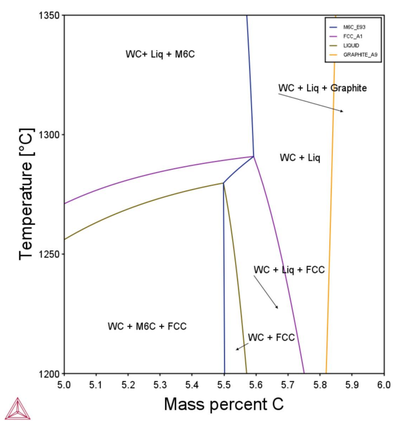
- No single element fulfills the conditions!
- Alloying is necessary: Fe-Mn, Fe-Ni, Fe-Ni-Mn.



80Fe-20Mn

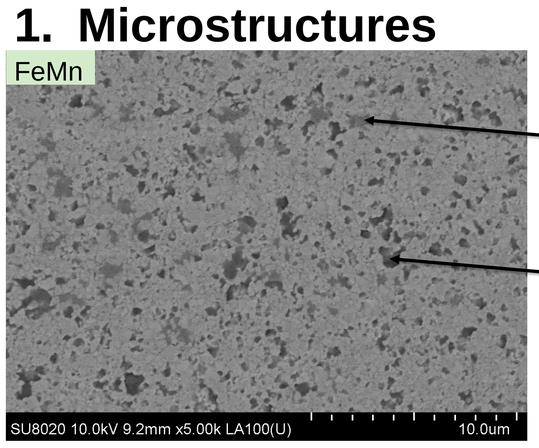


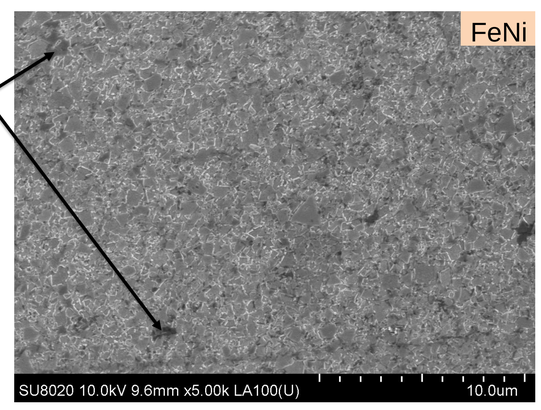
72Fe-28Ni



60Fe-30Ni-10Mn

1. Microstructures





2. Mechanical properties

Samples	K_{1c} (MPa $m^{1/2}$)	Hardness HV30
WC – 10 Co	11.31 ± 0.61	1618 ± 81
WC – 15 Co	23.27 ± 9.41	1313 ± 64
WC – 10 FeMn	7.61 ± 0.35	1760 ± 75
WC – 15 FeMn	8.15 ± 0.21	1855 ± 80
WC – 10 FeNi	8.55 ± 0.53	1214 ± 222
WC – 10 FeNiMn	Not sinterable	

Conclusion

- WC-10 FeMn binders can keep hardness, and even be harder than Co, but at the cost of toughness.
- WC-10 FeNi has the best structure, in comparison with WC-10 Co.
- **FeMn binder** seems to be the best alternative, with the best properties, adequate phases, non-toxicity and lower cost.

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