Niobium in Aluminium Cast Parts
Disclaimer

“The information in this presentation has been prepared by CBMM - CBMM Europe B.V. (the “Company”) with the only purposes of introducing the company’s activities, in 2017. This document and its contents are confidential and are being provided to you solely for your information and may not be reproduced, retransmitted, further distributed to any other person or published, in whole or in part, by any medium or in any form for any purpose. The opinions presented herein are based on information gathered at the time of writing and are subject to change without notice. The Company relies on information obtained from sources believed to be reliable but does not guarantee its accuracy or completeness. This presentation may contain certain forward-looking statements and information relating to the Company and its affiliates, related companies, directors, officers, shareholders, agents or employees that reflect the current views and/or expectations of the Company and its management with respect to its performance, business and future events. Forward-looking statements include, without limitation, any statement that may predict, forecast, indicate or imply future results, performance or achievements, and may contain words like “believe”, “anticipate”, “expect”, “envisages”, “will likely result”, or any other words or phrases of similar meaning. Such statements are subject to a number of risks, uncertainties and assumptions. We caution you that a number of important factors could cause actual outcomes to differ materially from the plans, objectives, expectations, estimates and intentions expressed in this presentation. In any event, neither the Company nor any of its affiliates, related companies, directors, officers, shareholders, agents or employees are or will be liable to any third party for any investment or business decision made or action taken in reliance on the information and statements contained in this presentation or for any consequential, special or similar damages. The information contained in this presentation has not been independently verified. This presentation and its contents are proprietary information and may not be reproduced or otherwise disseminated in whole or in part without the Company prior written consent.”
Contents

- About Niobium
- How does Niobium work in aluminium
- Development of Niobium technologies in Aluminium
- Potential Niobium applications
  - Wheels
  - Engine parts
  - Welding
About Niobium

- Naturally occurring chemical element (Nb) discovered in 1801
- Available and reliable supply
- Soft, metal which is ductile, malleable, and highly resistant to corrosion
- Mined, processed and formulated to products for alloying to create a range of high performance materials
- Small amounts combined with aluminium improves integrity, strength and elongation
Niobium’s Growth Story

FeNb Market Growth since 1995 (%)


-50% 0% 50% 100% 150% 200% 250% 300%

How Niobium works in Aluminium

- Aluminium silicon casting technology used widely in automotive industry
- Addition of Niobium via Aluminium-Niobium-Boron master alloy reduces grain size and significantly improves performance by
  - Increasing integrity of thin and complex parts
  - Reducing porosity and hot tearing
  - Increasing and improving homogeneity of mechanical properties
- Potential for weight savings without loss of strength
- Also, important additional benefits from Niobium
  - Improves inhouse recycling rates
  - Tolerates iron impurity
  - Retains fine grain structure in several remelt cycles

Niobium grain refinement in Al-Si alloys

A354 alloy used widely in production of cylinder heads and other powertrain parts

A357 alloy used in production of aluminium wheels powertrain and suspension parts
Development of Niobium aluminium technologies

- Brunel University (UK) patented Niobium master alloy for use with Aluminium-Silicon (Al-Si) and Magnesium-Aluminium casting alloys
- Further research found master alloy showed much greater grain refinement in widely used Aluminium-Silicon alloys than titanium
- Niobium master alloy delivered significant improvements in both tensile strength and ductility in Aluminium and Magnesium based alloys
- Brunel researchers believe Niobium could deliver potentially weight savings of up to 30% in Al-Si alloy applications by improving integrity and mechanical properties
- Also, potential for increased recycling as Niobium master alloy could offset iron contamination which causes embrittlement
- Additional, detailed research into applications and benefits ongoing with industry partners
- Won Institute of Materials Charles Hatchett Prize and the Cast Metal Federation’s 2015 Innovation Award
Niobium improves mechanical performance

- Niobium addition creates fine and uniform grain structure
  - Improving strength
  - Reducing casting defects and shrinkage porosity
  - Consistent across thin and thick sections
- Enables lightweighting
Niobium grain refinement improves strength and ductility in laboratory tests

Machined from cast bars

Improved
- Crash Performance
- Fatigue performance

Yield 82.4Mpa → 102Mpa

Niobium improves Aluminium scrap recovery

- Iron can occur in Aluminium casting alloys either from contamination or casting techniques
- Iron reduces the tensile strength and elongation of Aluminium alloys
- Grain refinement with Niobium reduces this problem
  - Enables increased onsite recovery of scrap without need for reprocessing
- Niobium containing Aluminium ingots retain fine grain structure in several remelt cycles

Recovery of properties in Fe-rich aluminium scrap
Potential Niobium Applications

- Gearboxes
- Cylinder Heads
- Engine blocks
- Suspension
- Welding
- Wheels
• Research underway to confirm real world benefits of Niobium master alloy to wheels with leading wheel producers
• Potential to reduce thickness of rim and disc material to
  - Reduce weight
  - Improve design
  - Increase fatigue resistance
  - Extend wheel life
Niobium in Engine Parts

- Niobium master alloys can deliver significant grain reductions in Al-Si alloys used in engine blocks and cylinder heads
- Potential to improve the integrity of the part and reduce porosity
- Industrial scale research and testing with leading OEM is underway
- Leading to possible weight reduction and improved wear characteristic
Niobium in Gearboxes

- Niobium master alloys can deliver significant grain reductions in Al-Si alloys
- Potential to improve integrity and reduce porosity, creating parts that are
  - Thinner, with more complex designs
  - Tougher and harder wearing
• Research underway to confirm that Niobium grain refinement increases strength and elongation
• Potential to reduce part thickness to
  - Reduce weight
  - Improve design
  - Increase fatigue resistance
  - Extend life
Aluminium welding faces major challenges in terms of reducing the strength of Aluminium by up to 50%. Applying Niobium to the weld creates grain refinement that has potential to improve weldability and solidification cracking. It reduces the base metal’s susceptibility to cracking during weld solidification. Niobium in welding can increase yield strength, ductility and in some cases tensile strength of the weld metal.
Conclusion

- Niobium-Boron addition to Aluminium-Silicon alloys refines the grain structure of cast parts

- End-user benefits
  - Improved strength and ductility: lighter and thinner structures
  - Homogenous properties (thick and thin sections): complex structures
  - Tolerant to Fe contamination: closed loop recycling of scrap containing higher Fe
  - Reduced shrinkage porosity - improved soundness: reduces component rejection ratio