

THE CHALLENGES THAT ALUMINIUM FACES AS MATERIAL OF CHOICE

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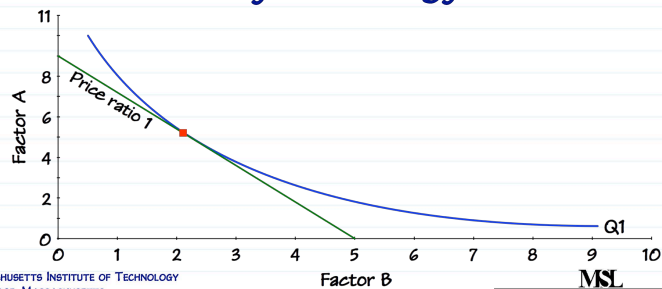
The Aluminum Industry: Perspectives on Our Future
TMS 2010; February 15

Introduction

- » Talk title really a 2-part question
 - The Challenges that [a competing material] Faces as Material of Choice
 - The Challenges that [Aluminium in particular] Faces as Material of Choice
- » Questions of materials selection, substitution and competition

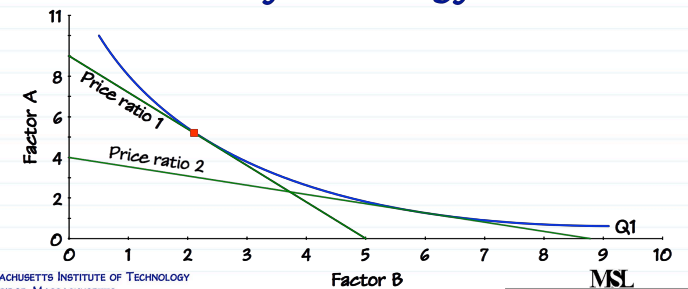
Classical View

- » Traditional economics:
Substitution of factors or production
 - driven by prices
 - constrained by technology



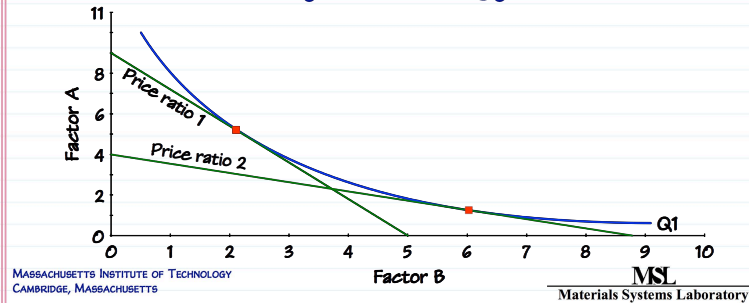
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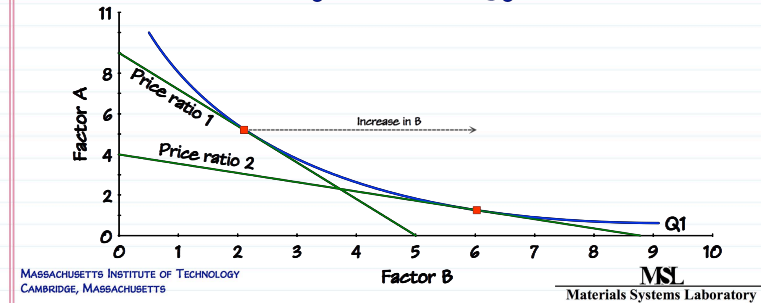
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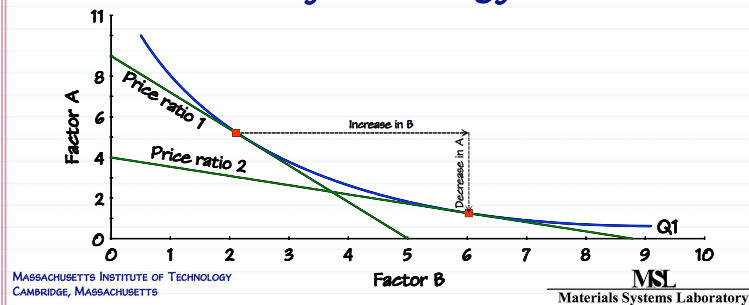
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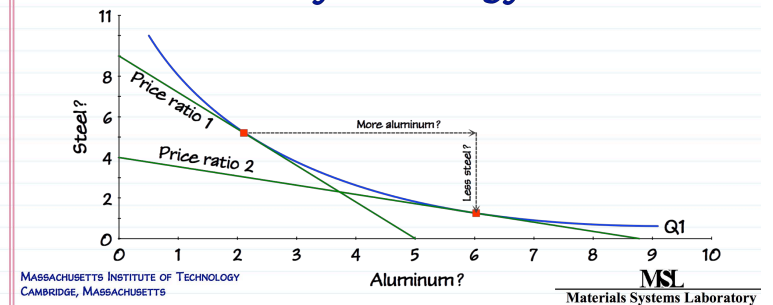
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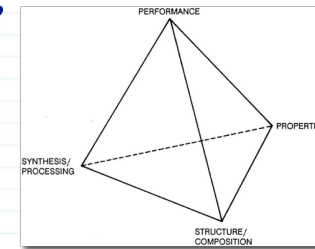


Problem: Doesn't Really Work That Way

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- » WHY?

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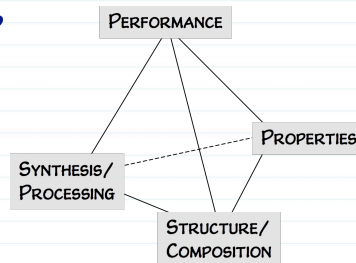


THE FOUR ELEMENTS OF MATERIALS SCIENCE AND ENGINEERING

Figure 1.10 from Materials Science and Engineering for the 1990s (NAP, 1989)

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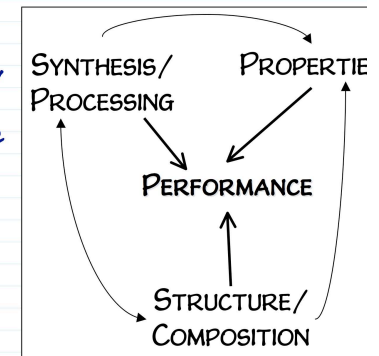


THE FOUR ELEMENTS OF MATERIALS SCIENCE AND ENGINEERING

Figure 1.10 from Materials Science and Engineering for the 1990s (NAP, 1989)

The Real Focus: Performance

- » Flattens out the tetrahedron
 - Structure, processing, properties
 - Engineered to achieve performance
- » So, we overcome the "challenges" through innovations in process and composition, yielding desired properties and performance?



From MATERIALS SCIENCE AND ENGINEERING FOR THE 1990S (NAP, 1989)

"Experience shows that the PROPERTIES and phenomena associated with a material are intimately related to its COMPOSITION AND STRUCTURE at all levels [...] and that this structure is the result of SYNTHESIS AND PROCESSING.

The final material must PERFORM a given task and must do so in an *economical and societally acceptable manner*."

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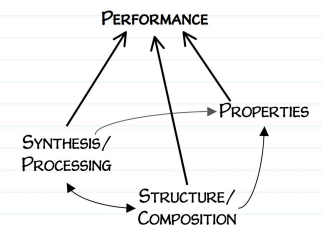
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"[M]aterial must [acceptably] perform a given task ..."

- » Really?
- » A fundamental disconnect
 - Designers & engineers care about what a material "does"
 - Consumers care about WHAT A PRODUCT DOES (and how well it does it)
- » Materials are (usually) only a means to an end
 - Technology that "enables" desired performance
- » "Performance" is a slippery objective
 - "economical and societally acceptable manner"

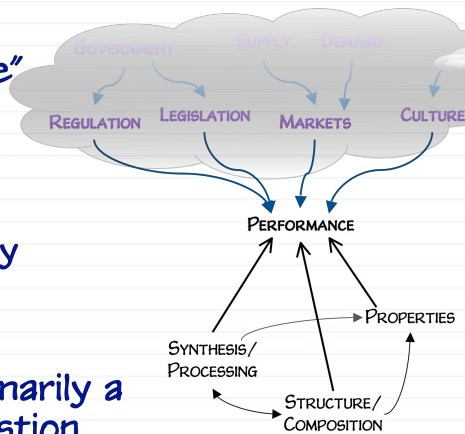
Context and Material Choice

- » Quality of "performance" is difficult
- » Design for X
 - Cost
 - Sustainability
 - Flexibility
 - ...
- » Not even primarily a technical question



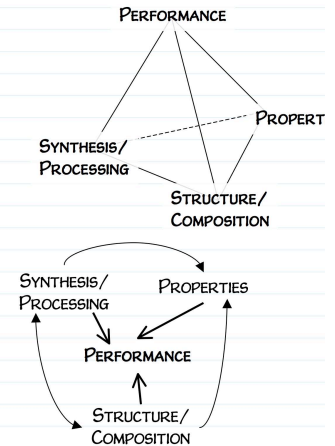
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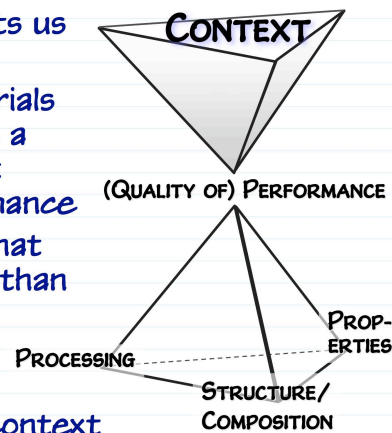
No "Performance" w/o Context

- » Performance often an "emergent" property
 - Meaningful (knowable) only within the context of the larger system
- » Successful substitution [frequently] depends on having better emergent properties than alternatives



Nature of Materials Competition

- » Materials science gets us into the game
- » But successful materials competition requires a grasp of the context determining performance
- » Must acknowledge that competition is more than technical
- » Further, that competition plays out in a very broad context



Realities of Substitution

- » It's difficult and risky
 - Materials choice \Rightarrow product performance
 - But it's hard to predict, especially if emergent
- » Level of performance is a moving target
 - Competitors are innovating
 - Marketplace expectations are evolving
- » Leads to a host of emergent measures of performance
 - Cost, sustainability, reliability, recyclability, flexibility
 - The "-ilities"

Another Key Component: History

- » Materials use patterns are path-dependent
 - Knowledge/familiarity/confidence
 - Networks of firm/designer cooperation
 - Sunk capital costs/"lock-in"
 - Risk of degraded performance
 - Materials market fluctuations
- » Little is "immediate" about response to changes

Consequence of Realities

- » Rapid material changes with
 - Overwhelmingly superior technology
 - Overconstrained design space
 - Disruptive market circumstances
- » Typical materials selection strategies
 - NOT optimizing
 - Rather, satisficing
 - too complex a decision space
 - many simplifying assumptions required

Challenge: Relating Materials and Performance

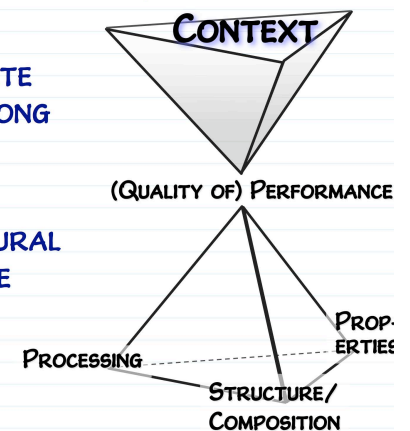
- » "Path dependencies" » All influence key emergent properties
 - Knowledge & confidence
 - Sunk capital/"lock-in"
 - Risks/uncertainties
 - Performance
 - [Materials] market fluctuations
 - Regulatory actions
- Cost
- Sustainability
- Flexibility
- Robustness
- ...

Nature of Materials Competition

"COMPETITION AMONG MATERIALS IS, IN CONCRETE TERMS, COMPETITION AMONG SOCIAL ENTITIES...."

"TODAY, ... WE ARE WITNESSING ... A STRUCTURAL TRANSFORMATION OF THE SYSTEM [OF MATERIALS DEVELOPMENT AND USE]"

(THE MATERIALS OF INVENTION; EZIO MANZINI; 1989; P.43)



Social Influences Are Hard To Miss

- » Many of the classic aluminum substitutions require some serious story-telling
 - Electrical wiring
 - Beverage cans
 - Transportation (air, land and water)
- » Today's challenges demand an equally broad and subtle approaches
 - Technical substitution depends on more than technology

Today, A New Set of Opportunities

- » Changes in social pressures
 - Market upheavals, product challenges
 - Environment, efficiency, energy, recyclability
- » New ways to express performance quality
 - Improved knowledge, techniques and assessment tools
- » Opportunity to reshape the context of competition

Revisit the History

- » "Those who cannot remember the past are condemned to repeat it" - G. Santayana
 - Not enough to "remember the past"
 - Must understand the technical underpinnings of the paths taken
- » Few materials decisions are singly valenced
 - Multiple factors converge to shape competitiveness
 - Avoid over-reliance on technical arguments

Overcoming These Challenges

- » First, understand them
 - How did we get here? How much of that outcome was grounded in technical factors? Economic? Social?
- » Second, learn what influences them
 - A technical argument is rarely sufficient
 - Role of other factors
- » Third, express innovations in terms of relevant emergent properties
 - And transmit that know-how to others

A Context For This Morning

- » "COMPETITION AMONG MATERIALS IS, IN CONCRETE TERMS, COMPETITION AMONG SOCIAL ENTITIES.... "
- » *Something to consider as we listen to this morning's presentations*
- » *What entities play a role in the approaches we will hear about today?*
 - *What technical resources might they wield?*
 - *What additional resources might they use to shape the challenges facing aluminum substitution today?*