The today and future potential of magnesium in the automotive industry

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Abstract

The raw material and its transformation cost (the die casting process) together with important corrosion issues convinced the automotive industries to reduce dramatically the use of the magnesium alloys in the mid of the 70's.
The energy shortages at th end of the 70's focused again car designers on "light metals" and the magnesium was one of the most attractive.
The raw material suppliers developed high purity alloys (low iron, nickel and copper content) to overcome the corrosion issues. At the same time the die casters improved significantly the transformation process able to guarantee cost competitive components.
The market today is growing in excess of 16% per year: this interesting datum is linked to the high technological level reached in the die casting process capable to produce structural components to substitute alternative materials (i.e. steel assemblies).
The weight saving achievable is around the 40% with the same component's performances. Due to these interesting features and to the possibility to easily recycle it, Magnesium will play an important role in the automotive industry in the years 2000.

Riassunto

Tra le ragioni principali che convinsero, alla metà degli anni 70, le case automobilistiche a ridurre notevolmente l'impiego delle leghe di magnesio vi furono sicuramente il costo della materia prima, quello della sua trasformazione e le problematiche di corrosione.
La successiva crisi petrolifera orientò nuovamente i progettisti alla ricerca di soluzioni alleggerite per componenti del veicolo: il magnesio, per le sue caratteristiche meccaniche specifiche, rappresentava una interessante alternativa. Stimolate da una prospettiva di mercato in forte crescita le industrie fornitrici della materia prima svilupparono leghe iperpure (a basso contenuto di Ferro, Rame e Nickel) con caratteristiche di resistenza alla corrosione nettamente migliorate. Parallelamente le industrie di trasformazione, tipicamente fonderie di pressocolata, misero a punto processi innovativi di produzione in grado di fornire componenti competitivi nei costi.
La vera svolta alla crescita del mercato di getti pressocolati in lega di magnesio, con una domanda che oggi aumenta del 16% all'anno, è comunque legata alla moderna tecnologia di trasformazione in grado di permettere la realizzazione di componenti strutturali a geometria complessa in sostituzione di assemblati in materiali tradizionali (es. lamiera in acciaio).
Il risparmio in peso ottenibile, a parità di prestazioni, è dell'ordine del 40%: un risultato particolarmente interessante per il progettista degli anni 2000, sempre di più alla ricerca di alleggerimento componenti in ottica di riduzione dei consumi e delle emissioni.

INTRODUCTION

When, in the mid of the 70's, the use of magnesium in the automotive industry showed an important fall (the engine and the drive train of VolskWagen- Beatle were magnesium die-castings in the previous productions years), most of the people involved in the die-casting business easily realized that magnesium was not the material for the future.
The main reasons for the automotive to reconsider others materials, like aluminum, as the best choice in making foundry components and switch back from magnesium alloys were basically the following:

- Raw material cost
- Transformation cost
- Corrosion issues

The high and unstable raw material cost was attributed to the limited production sources in the industrial world associated with an unclear strategy of investment from the companies leading the market. On the other hand those companies had no clear messages from the automotive industries in the evolution of the magnesium employ for future cars: research and product development were not justified in a field in which no transformation industries, die-casters, were available.
Nevertheless at the end of the 70's the energy shortages focused again the attention and investment of the automotive industries on "light metal", and government sponsored programs on the need to reduce the car's weight for fuel consumption improvement (figure 1).
The magnesium alloys showed very interesting specific mechanical properties (Young modulus, tensile and yield strength ratio over the density) (figure 2), putting these materials on the top of the list for future applications, with a weight saving around the 40% compared to steel and cast iron, and 20% when compared to aluminun for equal component performances. Those material's features, associated with the potential function integration at low cost linked to the die-casting process, increased again the understanding of magnesium and the clear request to make effort in reducing the raw material and transformation's cost, in improving the corrosion properties.

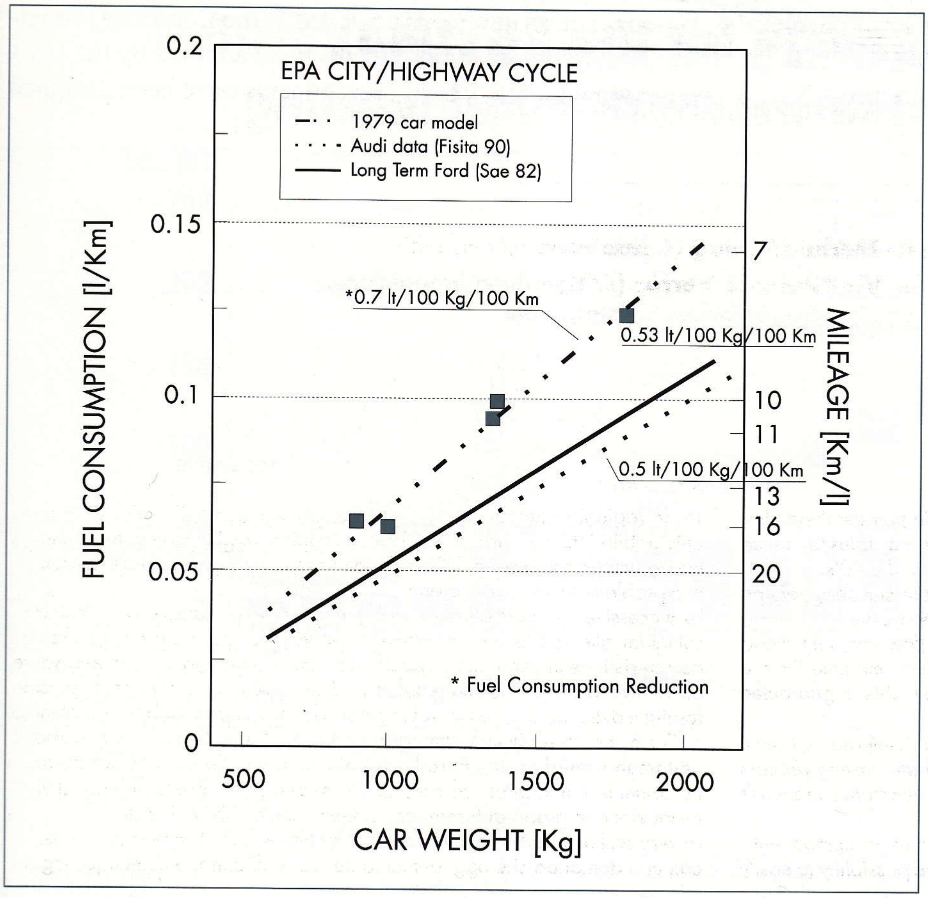

Figure 1: Car's weight effect on fuel consumption

The 80's saw important development driven by this new status both in the transformation industries (die-caster) and raw material suppliers:

- the production base for magnesium alloys increased
- new high purity alloys were developed
- new transformation methods were patented and installed (figure 3)

The magnesium production industry showed potential to become reliable sources of supply for stable prices, the die-caster put in place method to cast the new high purity alloys at reasonable cost and high volume.

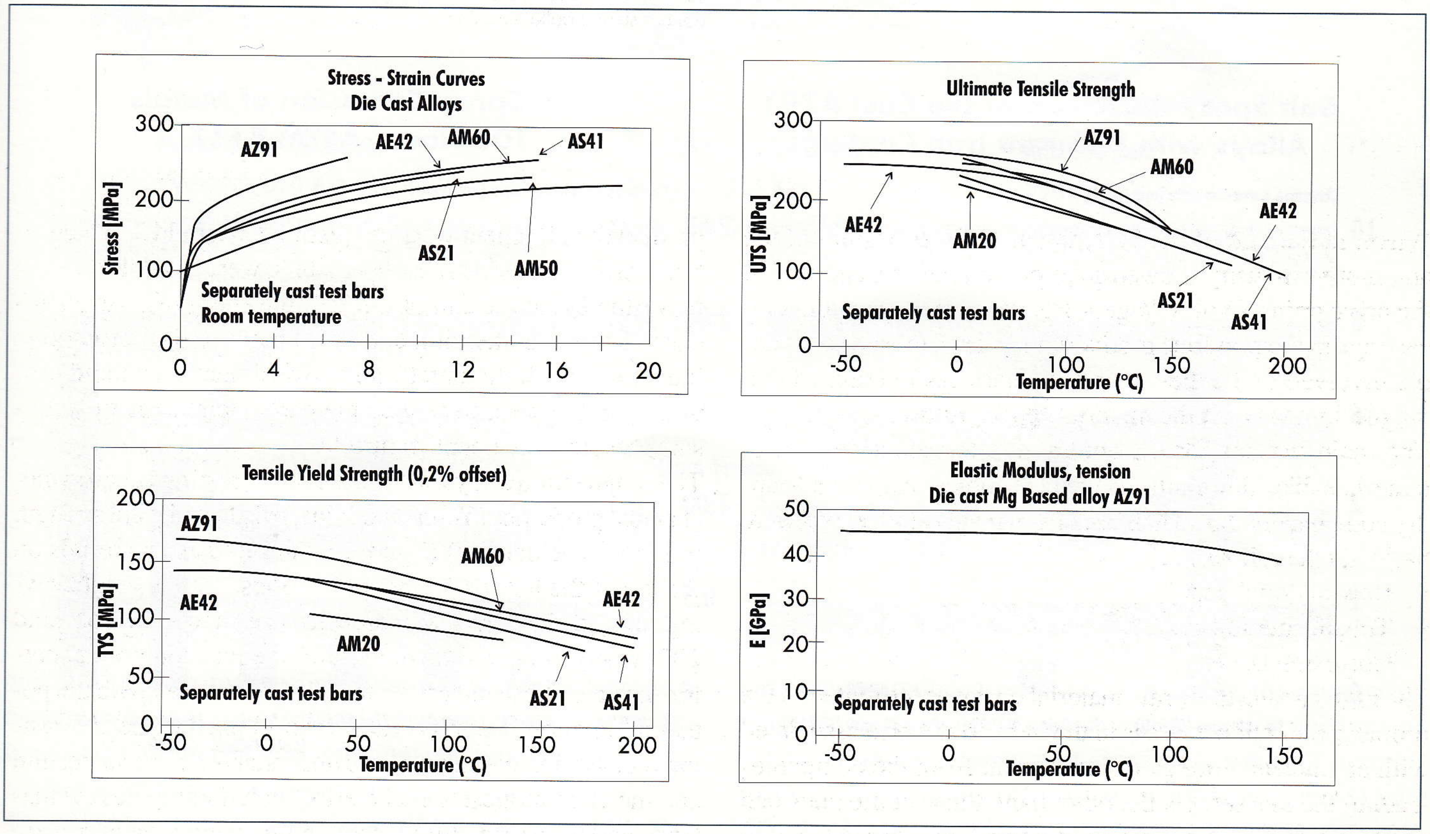

Figure 2: Typical magnesium alloys mechanical properties

The high purity alloys are today supplied with low iron, nickel and copper content. For these alloys (AM60B, AZ91D), the corrosion behaviour improves significantly (figure 4).

Based on these new steps achieved as the Corporate American Fuel Economy requirements were adopted by the USA government, many "light" components have been designed

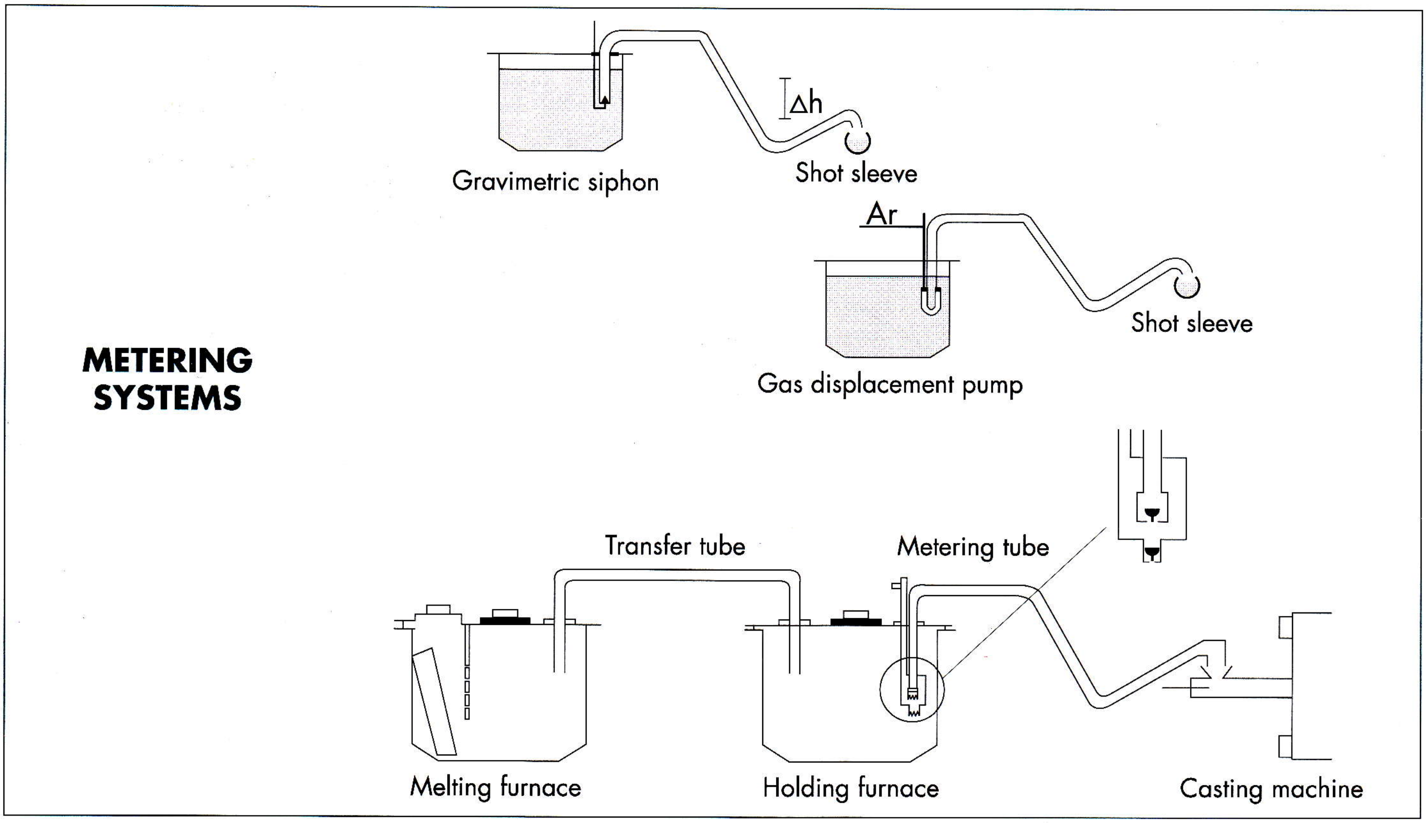

Figure 3: Metering systems applied to die cast cell

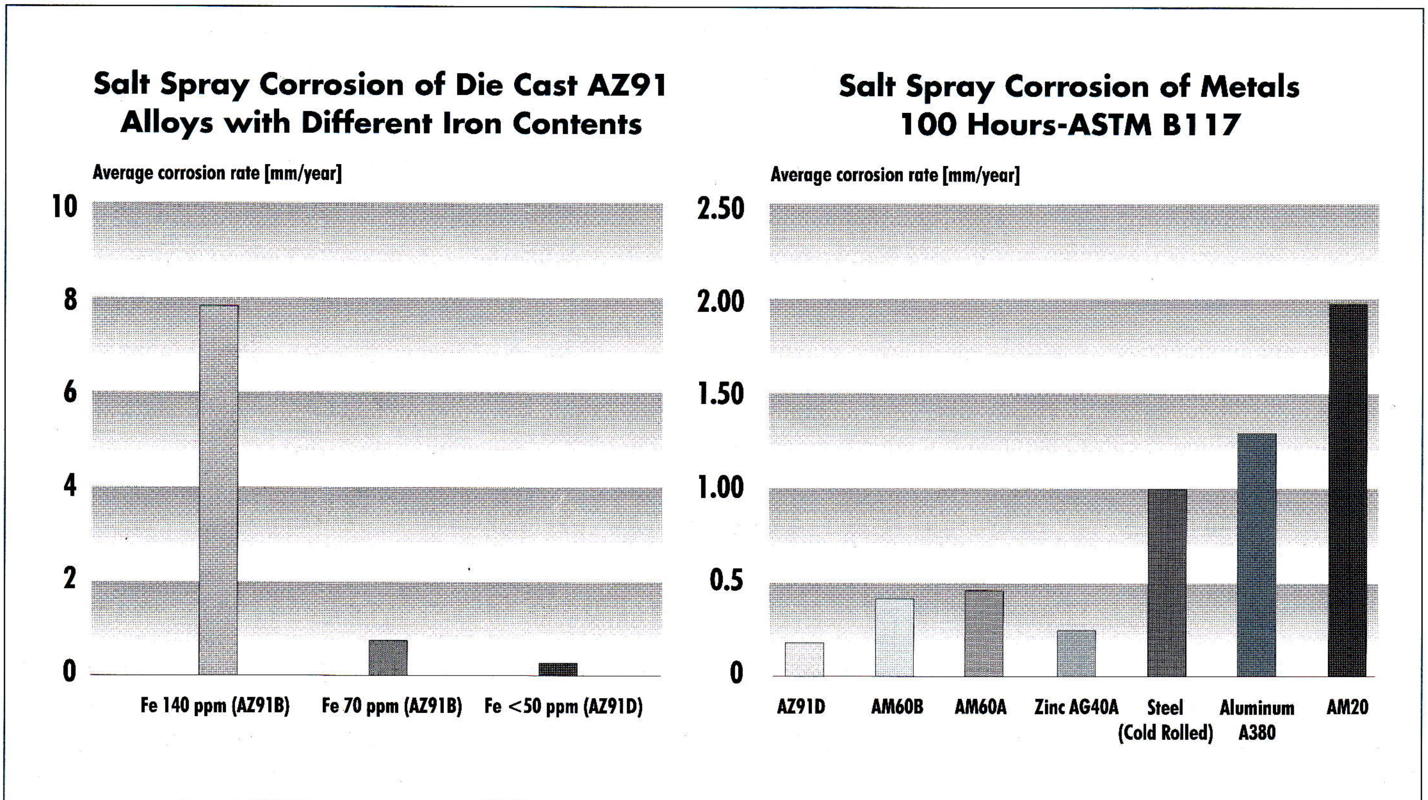

Figure 4: Corrosion behaviour of high purity magnesium alloys (AZ91D, AM60B)

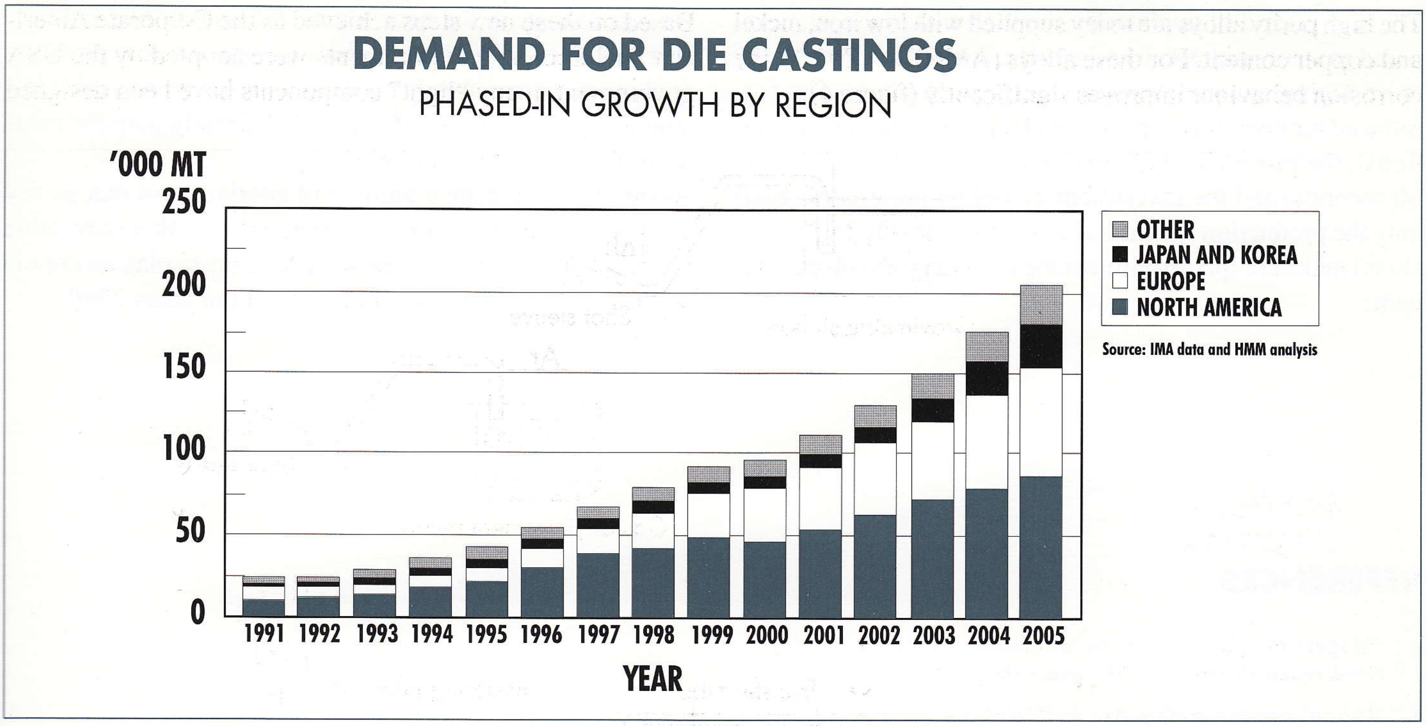

Figure 5: Demand for magnesium die castings

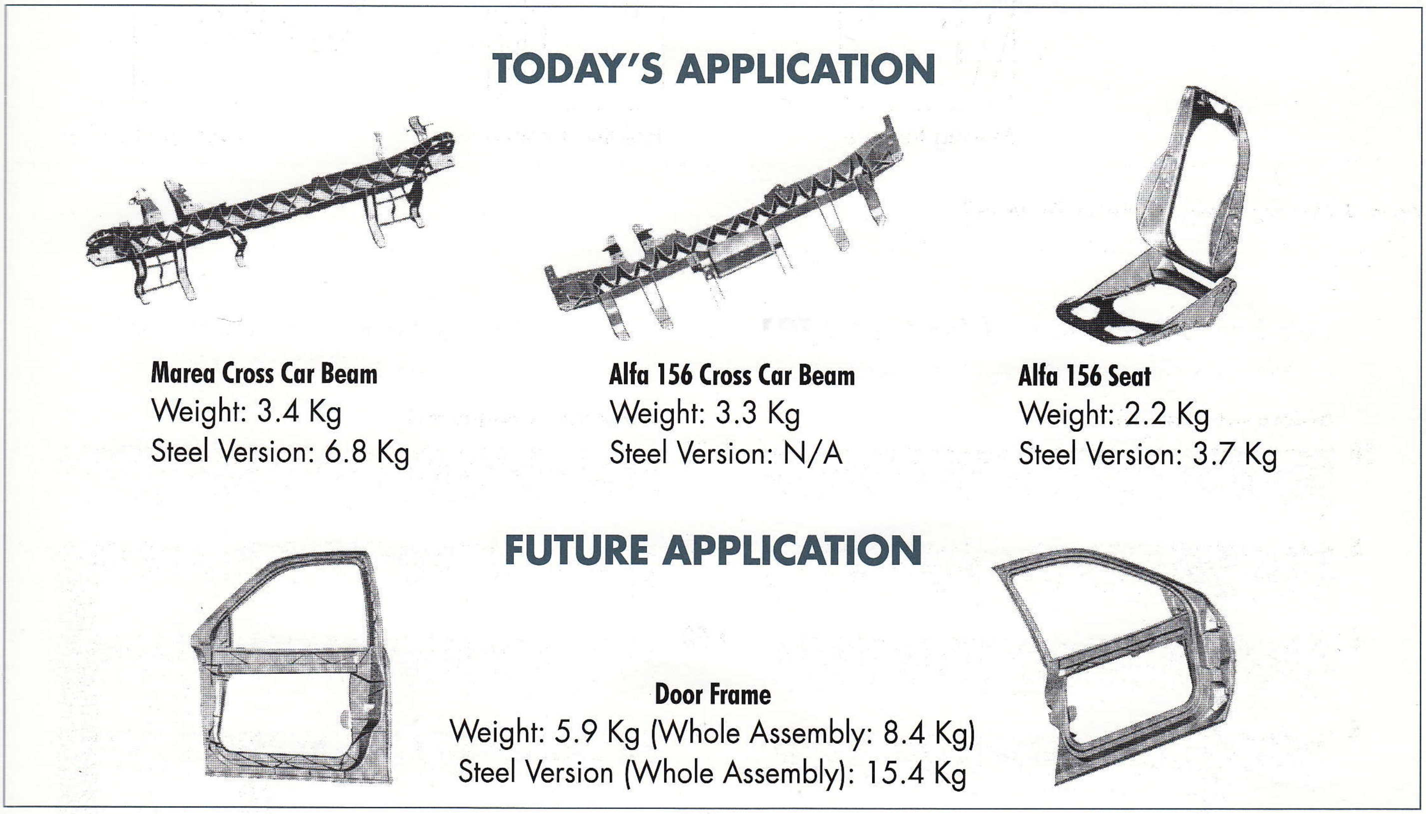

Figure 6: Examples of today's and future magnesium applications

and produced in magnesium (transmission housings, gear boxes, wheels, steering columns components, pedal brackets).The interest in magnesium continues today and the market is growing in excess of 16% per year (figure 5).
Those incouraging data can be justified also by the fact that magnesium die-castings are today employed as substitute of parts never produced as casting, enlarging the number of magnesium components introduced on one car: instrument panels, cross car beams, seat structures, sun-roof system, grill-opening reinforcement are some examples already into high volume production. Door and rear door frame are some examples of future application (figure 6).

For such a kind of application the high material cost, compared to steel, aluminum and plastic, doesn't lead necessary to an higher component cost: the function integration (i.e. reduced number of component and reduced assembly operations), the process capability (i.e. typical cycle time around 60 seconds) and the investment in tooling required to guaranty the production volumes (i.e. average tool life of 250.000 shots) make competitive in cost the final magnesium component.

On top of that, in the near future, the automotive industry will be forced to reduce the car's weight and it is probably ready to pay extra money for weight reduction on each component to reach this target: this will definitely help the magnesium boost in such a market.

As outlined, there are a number of good reasons that justify the attention now focused on magnesium; this recyclable material seams to have interesting features to play an important role in the automotive industry for the years 2000.

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