Advanced materials – tomorrow is already here

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AluReport talked with Professor Dr. Peter J. Uggowitzer from the ETH Zurich, Member of the Supervisory Board and Chairman of the Scientific Advisory Board of AMAG, and with Chief Operating Officer Dr. Helmut Kaufmann, about the future requirements for advanced materials. A lot of research has brought AMAG one step closer to the future.

AluRep: Mr. Kaufmann, you were one of the initiators of the „Light Metals Technology (LMT)" Conference. In July 2013, this conference cycle is going to celebrate its tenth anniversary in London. What in your opinion has significantly changed in these ten years of research on light metals? Please tell us the key milestone in development.

Kaufmann: I can only answer this question from a subjective and very personal point of view. Peter Uggowitzer and I already demanded in our joint book on metallurgy and processing of high-integrity light metal pressure castings of 2007 [1] that, following the „decade of mechanical engineering" in pressure casting, we put more focus on the material itself. Meanwhile, AMAG, for which I have been working for more than five years now, has adopted this approach in all aspects of product development. AMAG produces recycled cast alloys for shape casting and rolled semis, such as plates and sheets. AMAG is thus a material manufacturer in the widest sense and should concentrate on the material.

As a result of a better understanding of the processes going on in aluminium alloys during the individual production steps, during storage or subsequent use and of their impact on the product properties, production facilities and process control now must meet more stringent requirements. The equipment must be adjusted to the material requirements and not the opposite.

I see this „process chain approach", with a process chain extending from melting, continuous casting and rolling to the necessary heat treatment and surface treatment steps, which is always focused on the material, as the most important step in development over the past decade.

Uggowitzer: From a university researcher's point of view, I would like to add that a number of simulation programs such as Pandat, Thermo-Calc, DICTRA and MatCalc today enable us to investigate, the influence of different alloy compositions on the individual microstructure and on the properties to predict, fairly precisely, the constitution and treatment required for the material in order to achieve the target properties. This optimization requires coordinated process control along the entire production route.

AluRep.: What are the consequences of these developments?

Uggowitzer: As we gained a better understanding of the relationships between the alloy composition, process control and product properties, we were in a position to design materials according to the specific application requirements and to actively influence the properties. We have learned that minor fluctuations in the alloy composition may lead to major changes in the properties of cast and wrought materials or components. Combined with increased customer requirements, this has probably doubled the number of specific alloy grades.

Today, it is not enough to roughly specify an alloy according to standard, for instance, automotive skin alloy AA6016 or recycled die-casting alloy A226, and the heat treatment, such as the T6 treatment according to the „Aluminiumtaschenbuch" handbook. With a view to the desired property profile, a fine tuning must be performed within the standard composition, which, in turn, requires a precise adjustment of the thermomechanical treatment. The precise tailoring of alloys, however, requires a deep understanding of microstructural relationships. Through its cooperation with a number of academic research institutions, AMAG has, figuratively speaking, grown from a dwarf to a giant in this field over the past five years. In my capacity as Chairman of the Scientific Advisory Board, I think it is quite remarkable that in that period more than 50 scientific articles from the environment of AMAG were published in international magazines.

AluRep: Let us take a look into the future. What megatrend do you anticipate for aluminium products during the next decade?

Kaufmann: The aluminium industry cannot escape the great global challenges, such as scarcity of resources and global warming. As a result, new tasks will have to be performed along the entire process chain in order to increase efficiency, and many new applications will emerge from the range of positive properties of aluminium alloys. The need for pushing lightweight construction will be a strong driver for new applications and growth in volumes of aluminium alloys.

Users and developers will be faced with a new area of conflicting priorities, which will require them to build up a cooperative partnership in development to find a compromise solution. The trend towards alloys and processes that are even more precisely adjusted to the individual application in order to tap to the full the respective alloy potential, as just described by Peter Uggowitzer, will lead to even narrower tolerance limits for the alloy composition and the process parameters. Contrary to that, the recycling proportion in high-grade cast and rolled products is expected to continuously grow. It will be necessary, for economic and ecological reasons, to extend the alloy limits as far as possible for easier recycling, whereas the opposite will happen if we try to optimize individual properties. In the final analysis, however, the wide variety of aluminium alloys will become even wider.

Uggowitzer: Additionally, it is essential to keep optimized lightweight construction affordable by using improved aluminium alloys. To me, this means that improved alloys must be capable of being produced and recycled on a commercial scale. Using very expensive elements such as scandium and lithium in aluminium alloys cannot be the solution for extensive optimization and, in the long run, will be economically reasonable in special applications only.

Our most recent work gives us a vision of the groups of alloys. Let us have a look at the two age-hardenable alloy families, AA7xxx and AA6xxx, which are AlZnCu and AlMgSi alloys. Both alloy families have great potential for lightweight construction but also several deficiencies. The AA7xxx group of high-strength alloys has its weak spot in the corrosion properties, and a combination of strength and ductility is desired for the AA6xxx family. Our studies on the interaction between vacancies and the main alloying elements and special micro-alloying elements, that is, alloying elements added in homoeopathic doses, have led us to believe that it should be possible to significantly improve intercrystalline corrosion and, in particular, stress corrosion in 7xxx alloys by selecting an appropriately modified alloy composition without adding exotic, expensive alloying elements. For 6xxx alloys, we expect the mechanical properties to be improved by substantially shortening the duration of thermal treatment.

If the theoretical concept of the „vacancy prison“ and the „vacancy drag“ can be put into practice, as intimated, I guess I know the answer to the question concerning the great achievements of the past decade that might be asked in 2022. Dr. Pogatscher received several awards for the scientific works on this subject (see article on page 19).

AluRep: For a company like AMAG, the research work done to arrive at the concept of the „vacancy prison“ and/or „vacancy drag“ is surprisingly basic-oriented; what is to be expected in the future?

Kaufmann: As already mentioned, AMAG is a material manufacturer in the widest sense and sees itself as a premium provider of recycled cast alloys and rolled semis. Therefore, our customers should not be surprised—on the contrary, they should expect AMAG to do more than just scratch the surface in research. This issue of AluReport is intended to make clear that we supply many industries with a variety of aluminium products and also commit ourselves to research in all product segments. For what it‘s worth, I believe that basic-oriented research work is essential to achieve the significant improvements that we all need to meet the great global challenges of the near future. We can be optimistic about the future if we are all committed and cooperate towards product improvement and increase in efficiency.

I would like to give you an impressive example of an optimization along the process chain: In 1886, when the Hall-Héroult process for the production of primary aluminium was invented, 55 kWh was required to produce 1 kg of primary aluminium from alumina by fused-salt electrolysis. In 1950, approximately 25 kWh/kg was required, and today‘s modern plants need less than 13 kWh/kg [2,3]. ■

Literature:

[1] H. Kaufmann, P.J. Uggowitzer, „Metallurgy and Processing of High-Integrity Light Metal Pressure Castings“, Schiele & Schön, Berlin, 2007, S. 2

[2] L. Marschall, "Aluminium – Metall der Moderne", oekom, München, 2008, S. 200

[3] G. Djunkanovic, „Analysis of production costs in the aluminium smelting industry“, Aluminium 7-8/2012, S. 26-30