ISSN 1983-4764

THE R&D PROCESS AND THE R&D SYSTEM AS PERFORMED BY EISENWERK SULZAU WERFEN[1]

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Abstract

R&D is considered to be one of the most important activities conducted by ESW and the R&D process is a vital key parameter for the success and long term survival of our company. Using development processes that enable us to comply with our customer's needs in combination with our R&D efforts ensure that we can always maintain a competitive edge. In addition possible future developments at ESW concerning modified and new roll grades/materials will also be elaborated. Finally the paper will illustrate some potential future alternative production routes for manufacturing of rolling mill rolls.

Key words: R&D process; R&D system; R&D management.

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1 R&D MANAGEMENT

1.1 Definition of R&D and R&D Management

There are many various definitions regarding R&D but for sure if one knows:

- what one is doing;
- how long time it takes;
- how much it costs.

Then it is not R&D.
In the area of roll making the R&D spending is of course far away from medical companies that sometimes spend more than 25% of the TO. In the case of ESW this number corresponds to around 2%.

- research: a systematic way of working to seek after new knowledge or new ideas with or without a specified application in mind.
- development: a systematic way of working that uses the knowledge from research results, scientific knowledge or new ideas to produce. New materials or noticeable improvements of already existing materials.

Research is in practice very often a combination of research and development and sometimes also called Desearch and Revelopment.
R&D management is the process and techniques used to control the amount of money and effort invested in research and development (R&D) projects.

1.2 The Purpose of the Roll Makers R&D Efforts

As a roll maker we are supposed to develop the roll material in such a way the roll does not:

- wear;
- break;
- (have a price increase);
- etc.

In essence this means that we are supposed to increase the life of the roll without influencing negatively neither the quality of the rolled product nor the behaviour of the mill. As one can easily understand this is not always a simple task even though it may seem as a rather limited activity.

1.3 How to Decide What Should Be a R&D Project

The most difficult aspect with most R&D activities is to define:

- what to do?;
- why to do it?;
- when to do it?;
- how long time will it take?;
- how much money will it cost?.

There is normally one question though that must be answered prior to starting any activities and that is what is broken (= what needs to be fixed).

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Several important inputs are to be used in this decision making of what and why to do:

- customer requirements (known and unknown) – short term and long term;
- product life cycle analysis;
- own ideas;
- company strategic decisions;
- competitors activities;
- etc.

The term product life cycle is used to determine the different stages that a product goes through. By studying a product's life cycle it is thus possible to evaluate the effectiveness of a product and the eventual need for a new product in a certain segment. One example of a life cycle curve is shown in the Figure 1.

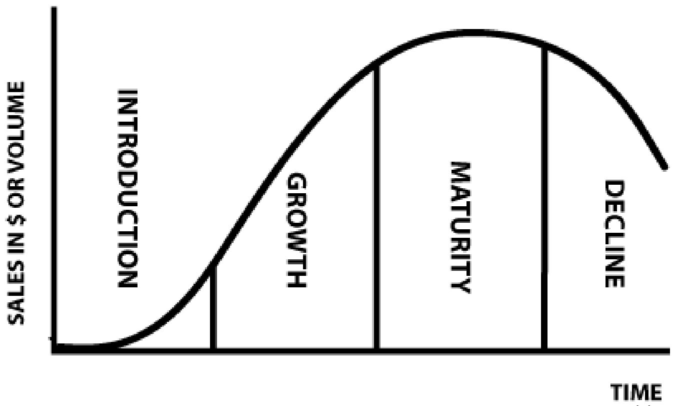

Figure 1. Principal sketch of a life cycle curve.[1]

All products begin with the Introduction Stage that occurs when a product is first to be found on the market. Products than move to the Growth Stage (if not previously pulled out of the market) and must then be developed and marketed. If a product proves to be accepted with our customers normally sooner or later other companies will begin to produce similar products.
The Maturity Stage is reached when the sales volume of a product begins to decline.
In rare cases a product may gain a steady consumer acceptance e.g. Indefinite Chill rolls that is a more than 90 years old invention.

1.4 R&D - The Different Project Types – ESW Definition

At ESW we are working with essentially 3 different categories of R&D projects. They can be classified as described below:

- competence projects (classified as a R project);
- strategic projects (classified as a R project);
- development projects (classified as a D project).

Figure 2 describes these activities and how they interact. It is of course the ambition that the activities within the competence and strategic areas finally will lead to the development of a new product via the product development module.

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Figure 2. Different categories of R&D projects.

1.5 Competence Projects – ESW Definition

With competence projects we define that these are activities aimed to increase our basic scientific and technical understanding thus it is activities not necessarily (but could be and very often are) directed to a specific product or problem.
Examples of projects/activities in this field are mentioned below:

- simulation of horizontal centrifugal casting;
- modelling of the phase distribution and residual stress in a composite mill roll;
- welding a wear resistant coat on a roll;
- modelling for life cycle analysis of HSM work rolls.

1.6 Strategic Projects – ESW Definition

Activities with reference to products not yet sought after by the market but that has been by ESW judged to have a potential significance for the future. This in principal concerns both new materials and new processes not yet used (at least for roll making).
Examples of possible activities/projects in this field (to be also described later):

- new materials: ceramic (Sialon); cemented carbide.
- new processes: cladding; spray forming (Osprey); welding; PM HIP process.

1.7 Product Development Project – ESW Adaptation

The development of new or modified products that have been identified as needed or sought for by our customers.
Modification means in this respect very often alteration of an existing products by chemical composition and/or heat treatment.
This activity also includes testing of existing grades but for “new” applications – e.g. HSS rolls for the very last stands in the HSM finishing mill.

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To facilitate the R&D process there has been some modifications of the general description of the product development process. Figure 3 is trying to visualize this in a schematic way.

Figure 3. Schematic presentation of the ESW R&D process.

1.8 Transparent R&D Process/System

In addition to what has already been mentioned below some additional comments why a R&D (or other) management system needs to be transparent.

- to create a common goal throughout the company and increase the understanding of the importance of R&D for long time survival;
- identify resources needed to be successful in terms of:
  - R&D
  - push for trials
  - follow up
  - marketing;
- identify the “owner” of products to be developed;
- facilitate the cooperation from production in terms of:
  - “gold on floor”
  - Investments;
- clarify where R&D costs should be allocated.

2 R&D EQUIPMENT TO SUPPORT THE R&D PROCESS

2.1 Introduction

It is of great importance that as much as possible of the needed R&D work could be done in house. Not only for the secrecy of some of the work but also for the speed of development. In this respect advanced R&D equipments are essential for solving task.

2.2 Fundamental R&D Equipment

Since 100% of the production at ESW is based on the centrifugal casting it is essential to have a pilot plant machine that could simulate that process.

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In the following a list is given with some of the most important R&D equipment (or equipment that is used to support the R&D work):

- laboratory melting equipment;
- thermal analysis;
- metallographic laboratory;
- chemical analysing equipment;
- pilot casting machine;
- cutting machines;
- heat treatment furnaces;
- mechanical testing (hardness and strength);
- dilatometers;
- optical microscopes;
- SEM;
- image analysing systems;
- computer simulation programs for casting and solidification;
- thermal imaging camera;
- stress measurement equipment;
- residual austenite measuring equipment.

Below are some photos showing some of the R&D tolls at ESW.

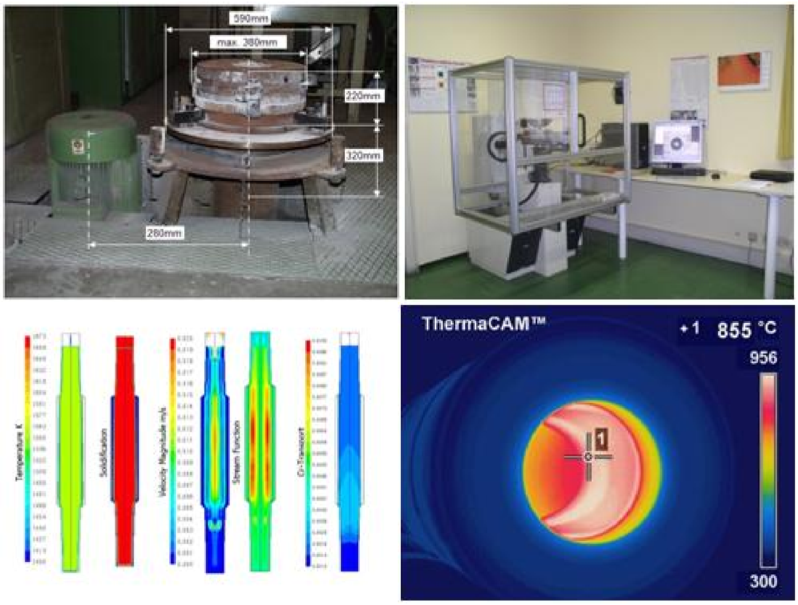

Figure 4. Spin casting pilot machine, Hardness tester, Computer simulation, Investigation with Thermal Imaging Camera.

3 SOME RECENT ACHIEVEMENTS

3.1 VIS Development (Enhanced ICDP Roll)

The development of the ICDP roll grade has been an ongoing and successful process at ESW for several years. In the last recent years a continuous improvement of VIS types has been made. On the market the 4^{th} and 5^{th} generation have been introduced. Since we now also have the possibility to determine and predict the graphite content in a very narrow range we could again take a further step for improvements.

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One way to characterize the differences between the various generations of VIS is to calculate the AE (Alloy Equivalent) as described below:

AE = 2 * %Cr + 5 * %W + 10 * %Mo + 40 * %Nb + 70 * %V

The early VIS types was in the range of AE 40 till 120 (Figure 5).
The newly developed **VANIS** (generation 6) has an AE far above over 200 (Figure 5).[(2)]

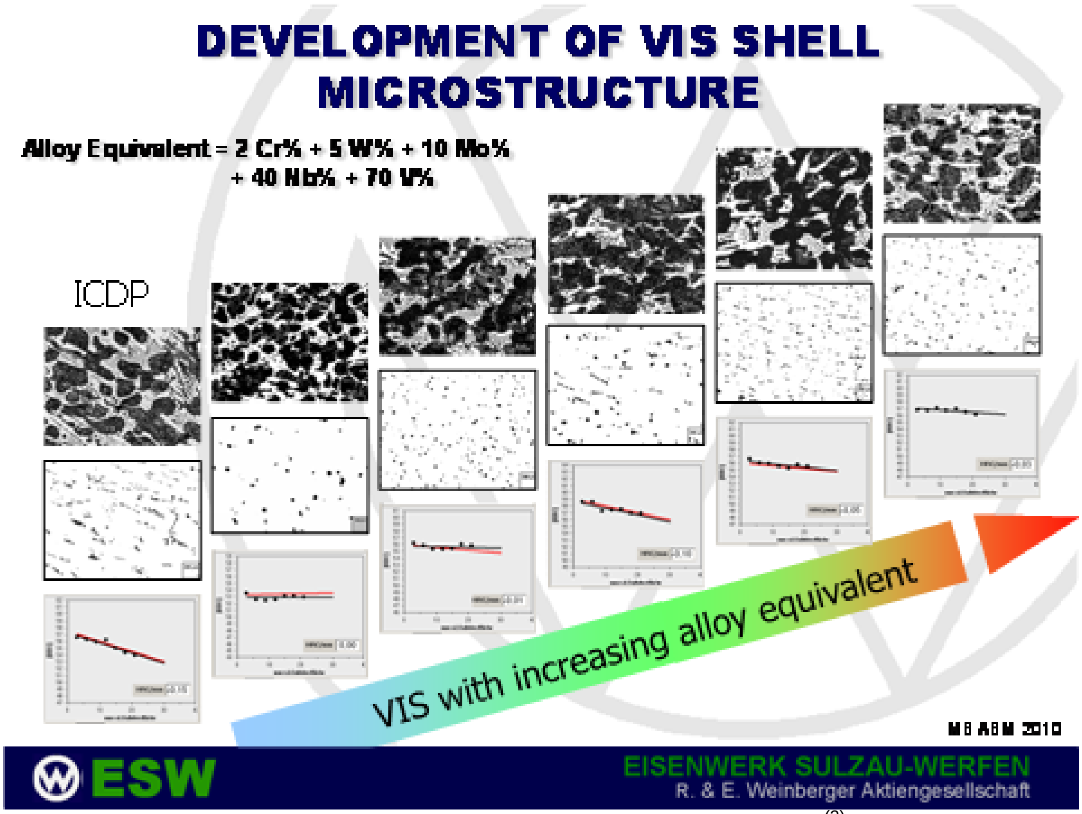

Figure 5. AE values for different VIS generations.[(2)]

The graphite shape is more round and the graphite amount can be precisely determined with the pre calculated inoculation.
The amount and the distribution of graphite are very homogenous and in addition the amount of graphite particles per square mm is much higher in VANIS compared to the last generations.
The microstructure is dominated by special carbides and carbide precipitations in connection to the graphite particles. The graphite shape and amount are the guarantee for the good behaviour in the mill.

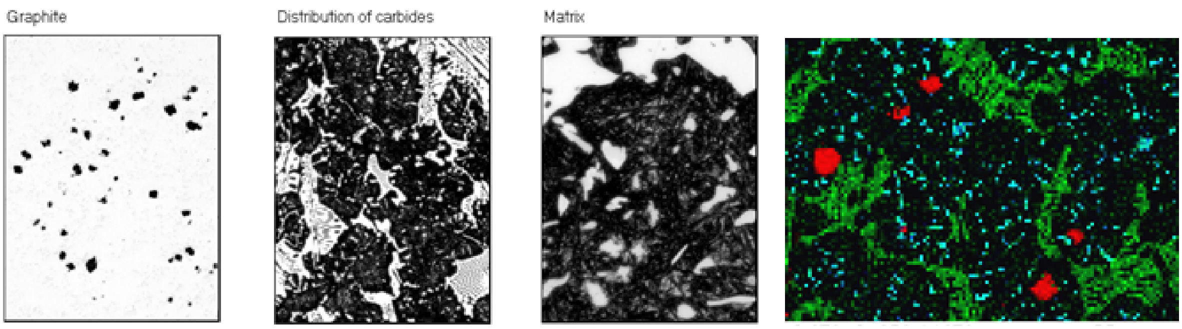

Figure 6. Microstructure of the Vanis roll material.

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3.2 Results of Vanis In The Mill

Due to the new morphology of the microstructure and the new formation of the graphite, the performance in the mill is much better than the earlier VIS types. The Figure below shows the performance results in the last finishing stands of a 6 stand HSM.

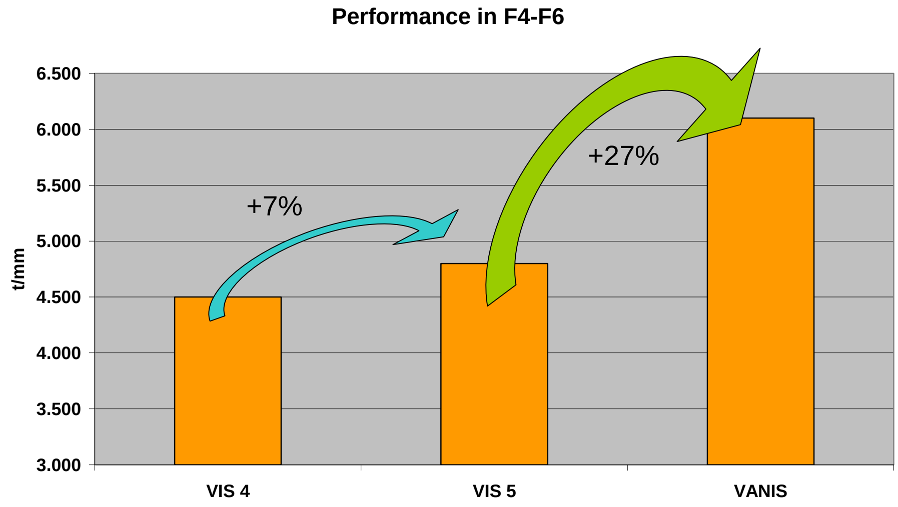

Figure 7. Example of performance of Vanis.(2)

4 SOME POSSIBLE FUTURE ROLL MATERIALS AND MANUFACTURING ROUTES

4.1 New Materials

4.1.1 Cemented carbide

At least when it comes to hot rolling of wide flat steel the use of Cemented Carbide rolls is at this point not known. Cemented Carbide rolls have been used for more than 20 years though in rolling of long products. Reported values of performance increases could sometimes range from 30 to 50 times.

4.1.2 Ceramic systems

Today the use of Ceramics as roll material is very limited due to the size requirements. The only material known to be used is Sialon and this is a man made Ceramic alloy.

4.2 Alternative Production Methods

There are at least 4 obvious reasons for introducing new or modified production technologies when it comes to roll production in order to increase the value in use:

- cost of production;
- possibility to modify the structure in existing alloying systems;
- possibility for new material combinations (compound rolls);
- possibility to introduce completely new materials and alloying systems.

In the following some examples will be given on some of the technologies that are at the edge of being used and also what might come in a longer perspective (10 to 15 years).

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4.2.1 Cladding technology

The use of cladding technologies (Figure 8) is one example from Japan offers compared to Spin Casting technology a somewhat higher cooling rate and thus some structure improvements are to be expected. In this technology the cooling rate during solidification is primarily controlled by induction technology (the heating system of the mould).

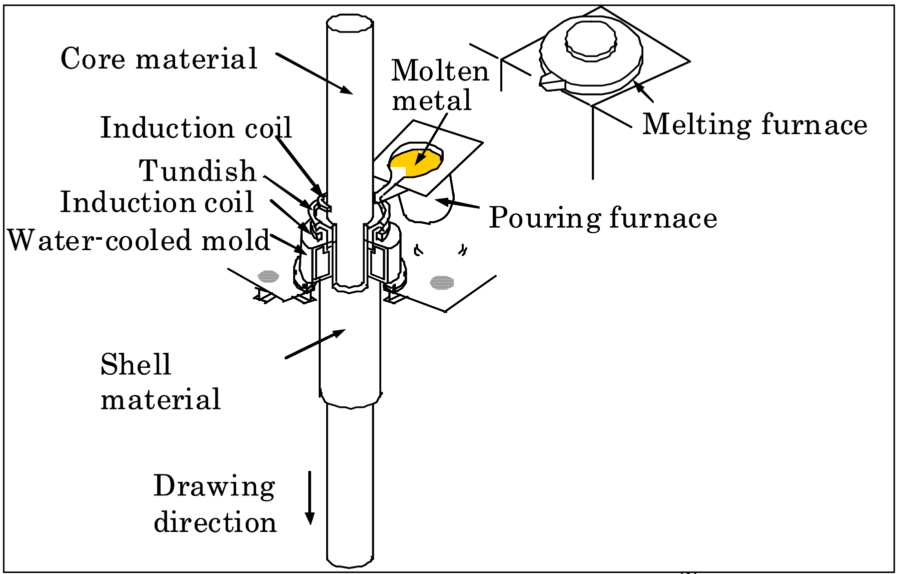

Figure 8. Example of a CPC installation.[1]

4.2.2 Powder metallurgy

The most efficient way to reduce carbide size is by using PM (Powder Metallurgy). The melt is atomized (Figure 9) and solidified in the form of very small droplets (typically ∅ < 500 microns) giving a very high cooling rate during solidification.

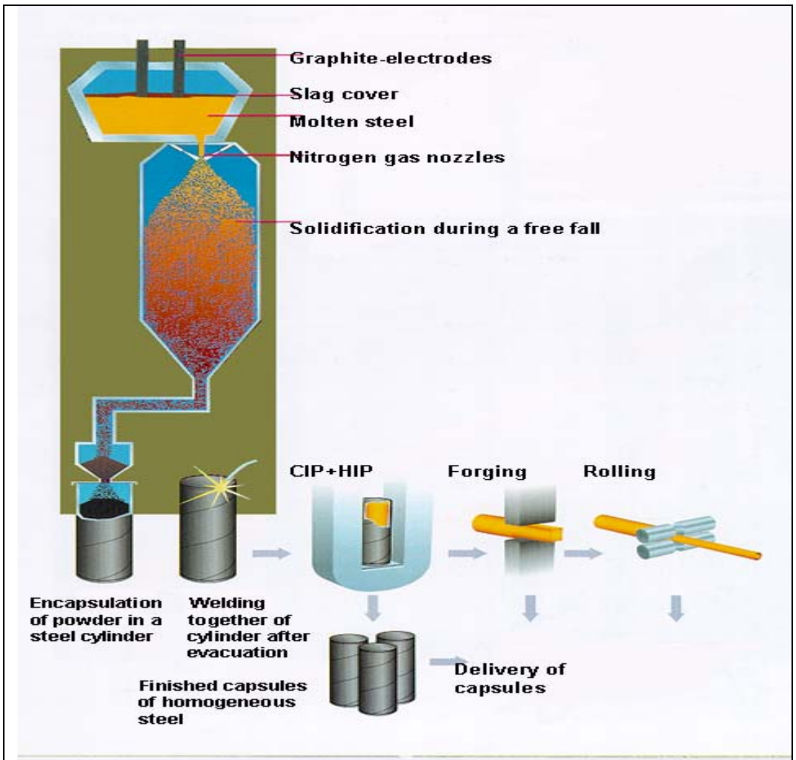

Figure 9. Erasteel PM production route.[3]

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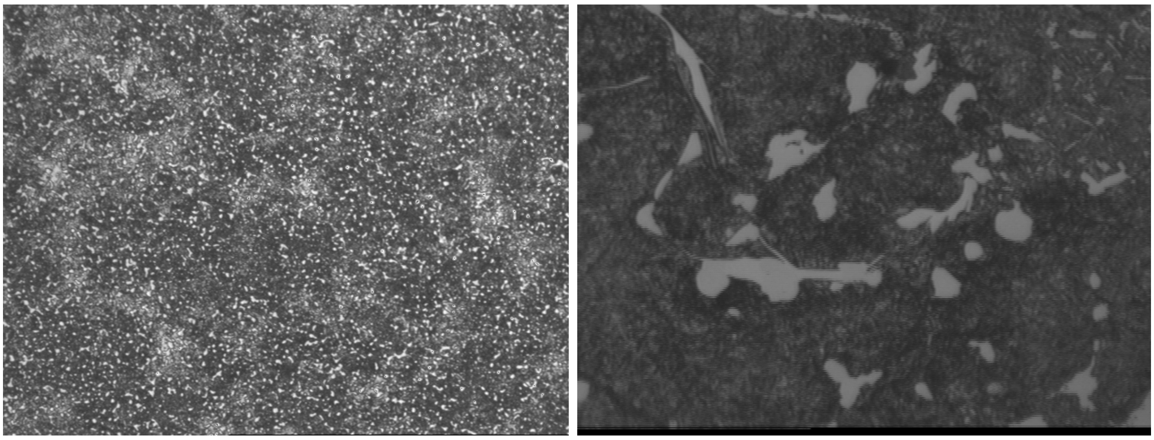

PM **Spin casting**

Figure 10. HSS material produced by PM and Spin Casting (x500).[1]

4.2.3 Spray forming

Another technology based on the PM technology is Spray Forming that is producing in this case a monoblock material directly from molten droplets. This technology has the advantage of not demanding the hipping operation that is a costly operation. The process is shown in Figure 11 and also indicating some size limitation of the technology as of today.

Figure 11. Sprayforming technology.[1]

5 CONCLUSION

ESW is using a well defined and transparent R&D process in combination with skilled technical staff and necessary R&D equipment in close interaction with leading Universities and Technical Institutes. In addition we keep a close contact with our customers thus enabling us to be always reactive and proactive and to be regarded as one of the leading roll makers in the world.

ESW is constantly trying to be at the leading edge both in terms of roll material developments but also in general technical support to be considered as the total solution provider.

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