Mastering challenges in aluminium extrusion through the use of premium steels

By Werner Hähnel*

Tool costs and tool life are decisive for the performance of an extrusion line. The pure tool costs are always put in relation to the service life achieved. Furthermore, the use of premium tool steels increases the product quality because the premium grade has a higher strength and toughness. The use of premium tool steel is also more economical because fewer tools have to be changed and thus there is a higher availability of the extrusion press. In addition, premium tool steels enable the production of particularly critical profile geometries.

Tool costs of the extrusion tools are determined by the following groups:

1. Extrusion die and mandrel
2. Stem and fixed dummy block
3. Container, inner and intermediate liner as wear parts.

For all tool groups, the specific load and, based on this, the desired material properties for the component are derived in this article. Very often premium tool steels from Kind&Co with precisely tailored property profiles that solve the task best and most economically. All premium steels listed here have been developed by Kind&Co and optimised for the respective application.

Extrusion dies and mandrels

Driven by the electrification of vehicles, there is an increasing trend to use ever lighter aluminium profiles. This trend towards thinner-walled profiles requires higher stability for the die, because higher pressures and temperatures occur in the forming process. This also increases the loads on the die package, which in turn has a negative effect on the service life of the dies and thus increases production costs. To break this negative spiral, Kind&Co has developed premium tool steels especially for these applications. The well-known premium steels TQ1 and HP1 from Kind&Co have been used successfully for years.

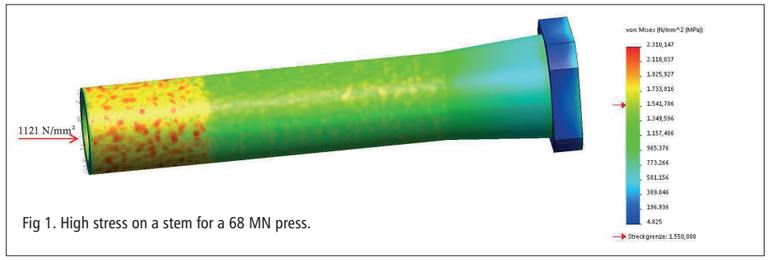

Fig 1. High stress on a stem for a 68 MN press.

Well-known aluminium extruders are increasingly using premium steels for dies in the following product groups:

- Filigree aluminium profiles (e.g. cooling fin profiles),
- Large batches as frequently known from the automotive industry (e.g. bumpers, sills),
- Project business, depending on the size and difficulty of the project (e.g. train profiles for the railway).

As a result, the extruder achieves twice the tool life at 15-20% higher tool costs by using TQ1 premium steel. A coordinated nitriding cycle also leads to an even better die service life. Premium tool steels can be nitrided together with standard steels. The nitrided layer on premium tool steels provides a much longer tool life than standard steels. As a rule, the service life of the nitrided layer on TQ1 is twice as long as on good standard steels. Kind&Co has assisted many customers in optimising the nitriding process of premium tool steels to the existing plant technology.

Stems and fixed dummy blocks

Increased extrusion pressures in aluminium extrusion also pose a challenge for extrusion stems and dies. Kind&Co recommends the premium grade CS1 with higher hardness (54-56 HRc). Due to the toughness of this material despite its high hardness, the stem can work longer in the elastic range. The same applies to dummy blocks, which, from a pressure of above 800 MPa, are made of TQ1 (50-52 HRc). Above a press pressure of 1100 MPa, Kind&Co recommends using stems made of CS1 (54-56 HRc). We observe a trend towards longer stems, which have higher risk of buckling. This must be taken into account when selecting the material. Therefore, we always recommend premium steels from a critical buckling ratio of 1:6 (diameter/length) or higher. (**Fig 1**).

Container, inner and intermediate liners

Containers are exposed to the billet temperature and the extrusion pressure. The materials used must have a high heat resistance in order to cope with the high extrusion pressures. A long service life of containers with a consistently good product quality is supported by a temperature management of the recipient that is matched to the product (profile, aluminium alloy).

The temperature management of a container consists of heating and cooling (air) and it is the goal to provide a uniform temperature distribution in the extrusion direction. As a result, the bore remains as cylindrical as possible, the dummy block leaves a uniformly good "shirt" and stable production conditions prevail in the extrusion line. Temperature peaks in the centre of the container can be positively influenced by modified heating zones with different heating powers. Intensive temperature differences lead to unstable conditions and to unwanted dimensional changes, e.g. at the shrink fit of each liner.

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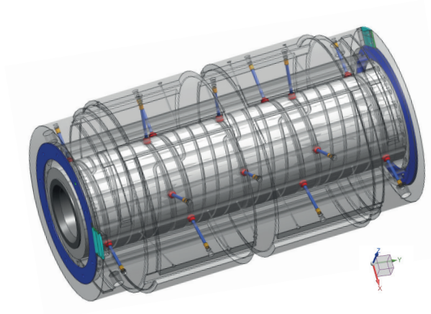

Fig 2. Modern design for 3-piece container incl. 3-zone cooling system

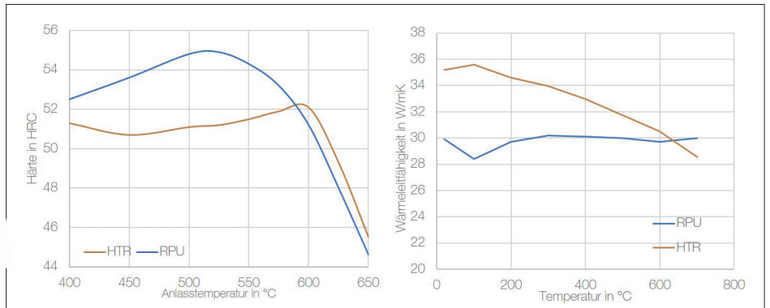

Fig 4 & 5. Premium grade HTR for intermediate liner offers higher tempering resistance and thermal conductivity compared to the standard material 1.2367/RPU.

If modified heating zones are not sufficient, additional air cooling can be installed on the outer diameter of the intermediate liner. (**Fig 2** & **Fig 3**)

Different cooling zones in spiral design are aligned in axial direction and fed with cold and dry pressurised air. The greatest cooling effect should be achieved locally where the highest temperature peak is to be expected. By separating the cooling zones from each other, the maximum cooling capacity is applied at this point. Shock-like cooling should be avoided in order to protect the steel of the mantle from cracks. The constructive design of a cooled container involves a certain risk due to the cooling holes to be inserted. This should be consideredagainst the advantages for temperature distribution in each individual case. However, slanted bores must be avoided in any case: Holes should be drilled perpendicular to the container axis to minimise stresses.

Kind&Co has developed the premium grade HTR as the carrier material for the air cooling used mainly on the outer diameter of the intermediate liner. This grade has a significantly higher tempering resistance and thermal conductivity compared to standard steels. Both properties extend the service life of the intermediate liner.

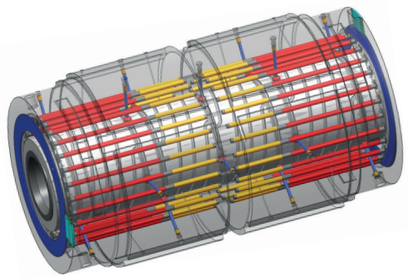

Fig 3. Optimal temperature management with 4-zone heating system.

(**Fig 4** & **Fig 5**).

Kind&Co recommends the premium steel Q10 for inner liners in aluminium extrusion, which is now established in over 50% of all new inner liners. Its very good toughness enables a hardness of 50-53 HRc. This keeps sealing surfaces more stable and minimises liner wear on the bore.

Generally, the design of the tools is optimised with the help of an FEM analysis. Kind&Co has experience from the many investigations carried out in its own materials laboratory as well as from more than 300 relining services per year. This interaction of theoretical calculations, long time experience and dialogue with extruders leads to an improved service life of containers in the long term.

Conclusion

Due to the use of increasingly lighter aluminium profiles, the demand on the quality of materials and tooling technology is growing. In many cases, the standard materials USN/1.2343 or USD/1.2344 are no longer sufficient to meet the demands of the market. For this reason, the use of premium tool steels such as TQ1 for dies is more economical because of its longer service life and better product quality.

The demand on quality of the materials for the production of extrusion dies also increases due to higher extrusion pressures. For this reason, Kind&Co recommends the premium tool steel CS1 for extrusion stems.

The premium steel HTR is particularly suitable for intermediate liners to achieve better heat resistance and thermal conductivity.

Inner liner consisting of the premium steel Q10 have become established in the market because of a better service life. ■