Raising resistance

Dr. O Mielenz, B. Bergmoser, Dr. S. Benito and Prof. Dr. W. Theisen, HEKO, highlight a new development in round steel chain technology that enhances wear resistance and extends service life under challenging operating conditions.

Conveyor chains have a major influence on the efficiency and cost-effectiveness of conveying processes and are subject to high mechanical stress. Accordingly, there is enormous interest in extending service life with increased operational safety and damage tolerance.

In addition to the high dynamic tensile forces acting on the chains, high wear and tear occurs in the contact area at the joints of the chain links, due to high contact pressure with relative movement to one another and the effect of the generally abrasive bulk material. This applies even more to round steel chains, where the joint contact is limited to a small area. Case-hardened steels are therefore often used. These are enriched with carbon in the edge zone through carburisation during the chain manufacturing process and, after subsequent hardening, have a high surface hardness, as well as high toughness and sufficient strength in the core. In recent decades, developments to improve the performance of round steel chains have been particularly

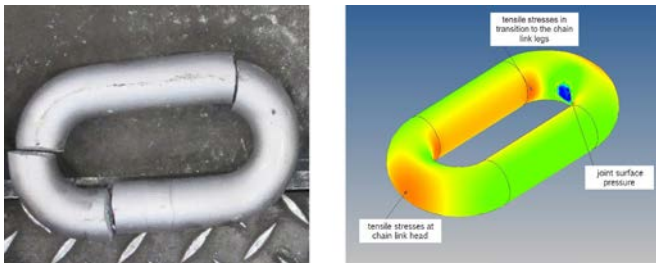


Figure 1. Typical fracture pattern of a torn chain link (left) and normal stresses in a chain link subjected to operational tension calculated using FEM (right).

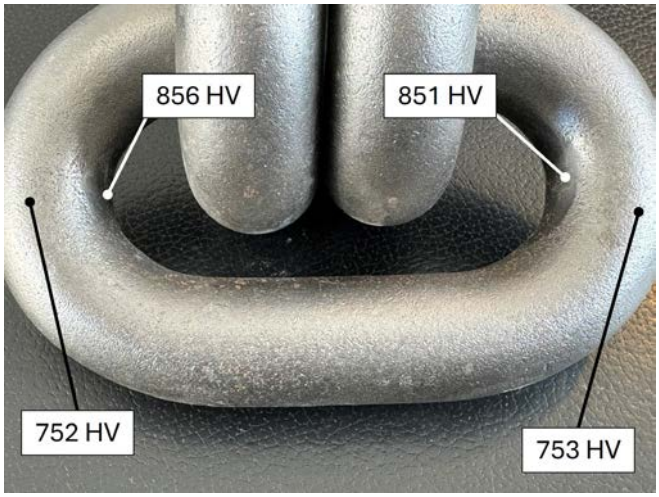


Figure 2. Surface hardness of chain joints and chain link heads of a chain link after experimental use.

Figure 3. Wet sand caking on chain and buckets.

Table 1. Technical data of the new HEKO ultra resistant chain grade UR 400.

Surface hardness in delivery condition	750 HV
Surface hardness under operational stress	850 HV
Carburisation depth	0.18 x D
Case hardening depth (CHD 550)	0.12 x D
Breaking stress	400 N/mm²

aimed at increasing surface hardness and hardness depths while maintaining the ductility of the core. However, these developments often do not consider the fact that most chain breaks are less often due to an insufficiently ductile core than to an insufficiently ductile surface layer in the areas of the chain links in which particularly high tensile stresses are present due to operational forces (Figure 1).

Within a joint R&D project between HEKO and the Chair of Materials Technology at the Ruhr-University Bochum, a new approach was developed to create a highly wear resistant, dynamic, and highly resilient round link chain, which was developed and successfully validated on a laboratory scale and in industrial trials. This project was supported by the Federal Ministry for Economic Affairs and Climate Action (BMWK) based on a decision by the German Bundestag.

Development

The main idea behind this HEKO development was to provide the case-hardened edge zone of the chain links in the areas that are exposed to particularly high tensile stresses with sufficiently high ductility. At the same time, the chain joints, which are subject to increased wear, should be sufficiently wear-resistant during operation. This goal was achieved by a slight modification of the chain material chemical composition targeting grain refinement and by a newly developed case hardening and heat treatment process. The latter results in a slightly lower surface hardness of approximately 750 HV of the new chain in delivery condition, and thus, a significant increase in breaking stresses and improved fatigue strength. The particularly good wear resistance of the newly developed chain grade results from in-situ-hardening in operational use up to approximately 850 HV within the chain joints and contact areas to the sprockets that are subject to high surface pressure and greatest wear (Figure 2). Technical data for the new HEKO chain grade is summarised in Table 1.

The superior properties of this new development have been demonstrated on laboratory scales, industrial trials, and

under operating conditions of a field tests on real conveyors.

Field test

In 2023, HEKO received an inquiry from the Spenner plant in Erwitte for the delivery of new round link chains KE-26x91, chain shackles, and sprocket segments for a sand and gravel bucket elevator with a centre distance of approximately 19 m.

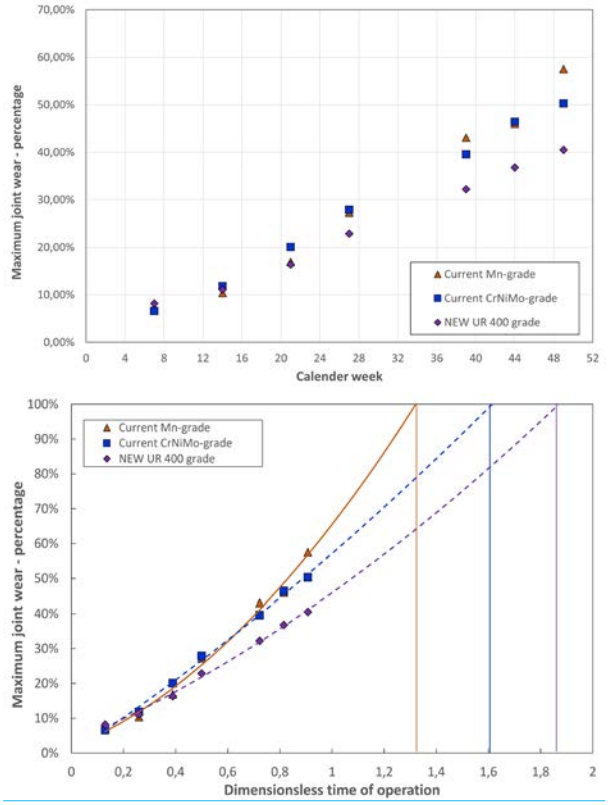
The service life of previous chain grades was limited to approximately one year by extreme wear of the chains due to the abrasiveness of the bulk goods and extreme caking of often wet and sticky sand on the chains and buckets, as shown in Figure 3. Moreover, the relatively small centre distance leads to an increased number of flexures.

It was decided to install the newly developed HEKO chain grade parallel to current Mn- and Cr-Ni-Mo grades. This configuration was possible without any risk of poor chain running and performance due to non-toothed sprockets and return wheels, and it enabled a performance test of the new chain grade in comparison to current chain grades (Table 2).

The chain ends of different chain grades were assembled in fixed sections of the bucket strand and the buckets were marked with welded numbers to allow an easy identification of the respected chain grade afterwards.

After commissioning, the chains were inspected on a regular basis by measuring the chain wear on predetermined chain sections and chain links. The results of these wear measurements are summarised in Figure 5 as the percentage maximum joint wear related to the carburisation depth of the different chain grades. Generally, the chain reaches its maximum allowable wear as soon as the case-hardened surface layer is worn out.

It was found that, in the first weeks of operation, the wear of the new chain grade is slightly higher than the chain wear of current grades, due to its lower surface hardness in delivery status. However, with increasing operation time a lower wear rate was found on the chains of the new ultra resistant grade HEKO UR 400 leading to a 15% extended service life compared to



Figures 4 & 5. Percentage maximum joint wear related to the carburisation depth of the individual chain grade.

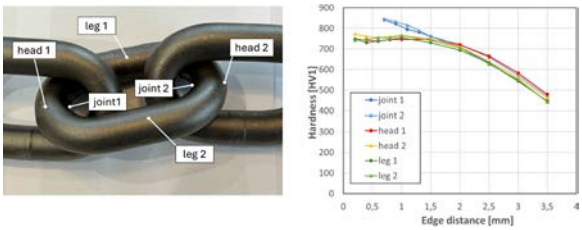


Figure 6. Examined chain link of the new grade after 4 months of use (left) with increased surface hardness in the worn joint areas (right).

Table 2. Technical data of the new ultra resistant HEKO chain grade UR 400 in comparison to current Mn and CrNiMo chain grades.

	NEW UR 400 grade	Current Mn grade	Current CrNiMo grade
Surface hardness in delivery condition	750 HV	825 HV	825 HV
Surface hardness under operational stress	850 HV	825 HV	825 HV
Carburisation depth	0.18 x D	0.14 x D	0.10 x D
Case hardening depth (CHD 550)	0.12 x D	0.09 x D	0.06 x D
Breaking stress	400 N/mm²	350 N/mm²	250 N/mm²

Figure 7. B. Bergmoser in front of the new equipped sand and gravel bucket elevator at the Spenner cement plant in Erwitte.

current CrNiMo chain grade and up to 30% extended service life compared to current Mn chain grade (Figure 5).

The reason for this extension in service life of the new chain grade is due to in-situ-hardening induced by high surface pressure yielding a surface hardness >850 HV in the chain link areas that are normally subject to highest wear (Figure 6).

Conclusion

A new high-performance grade of round link chains has been developed leading to a new benchmark in chain performance and service life. This development is a paradigm shift and is based on a completely redesigned case-hardened surface layer of round steel chains and was only made possible by applying the most modern technology for case hardening under vacuum, which HEKO has been using successfully for more than 15 years. When delivered, the newly designed case-hardened surface layer initially has a lower surface hardness as comparable surface layers of current chain grades. This ensures higher breaking forces and breaking stresses as well as significantly increased durability of the chain. During operational use, the surface within the regions of high surface pressures and increased wear is hardened in-situ to higher levels of hardness. In combination with a significantly increased hardness depth compared to current chain grades, this leads to a significant extension of service life. The results of field tests show that the new ultra resistant chain grade HEKO UR 400 can achieve a service life extension of up to 30% compared to current chain grades, even under extreme operating conditions.

B. Bergmoser (Head of Mechanical Maintenance, Spenner plant Erwitte) said: "The significant extension of service life of the new HEKO 400 UR chain grade under extreme operating conditions has convinced us and will enable us to extend the chain change intervals in the future. This is a significant contribution to reducing maintenance costs and increasing system availability and efficiency." ■

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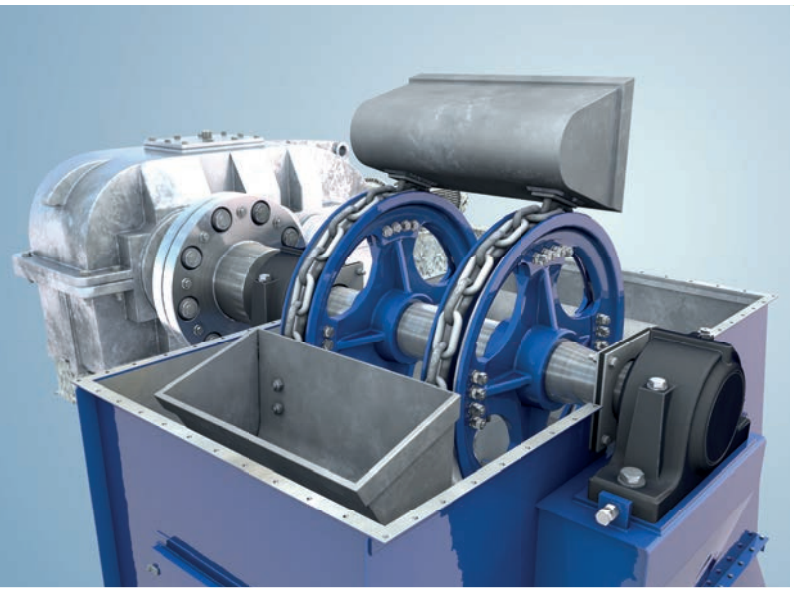

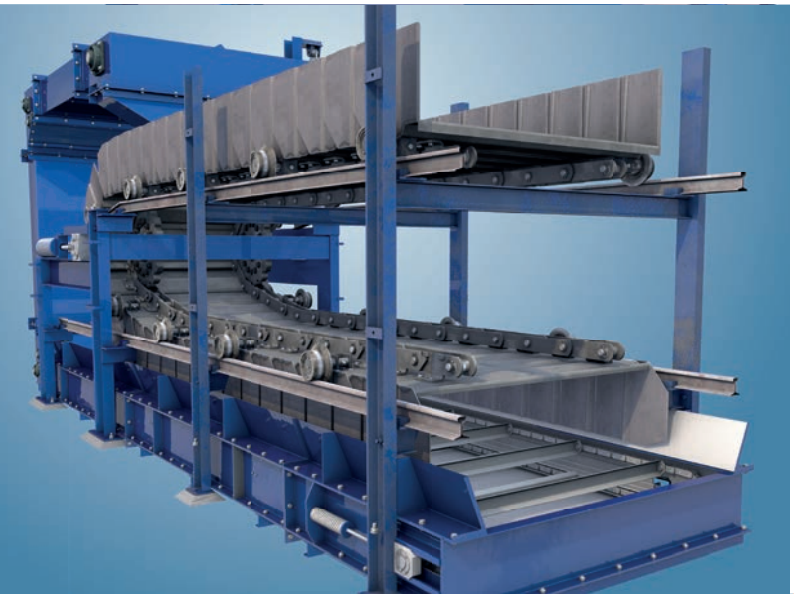

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