

Chain drives: quiet-running and with long service life

Chains and chain sprockets in conveyor systems are subject to constant wear and tear that does not only make necessary the periodic replacement of the chain and chain sprocket but also causes additional costs. Another weak point of chain drives is the sometimes high noise generation. Both problems can be significantly reduced by the “self-adjusting chain sprocket”.

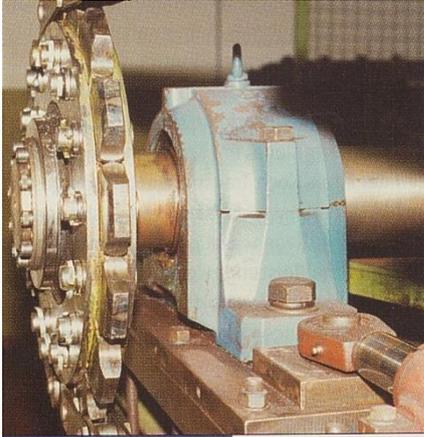


Fig.1

Self-adjusting chain sprocket in the test field:
the individual tooth segments of the chain sprocket can be clearly seen

Chains and chain sprockets, which in many applications are exposed to extreme loads, require periodic reviews of their condition. Due to wear, a frequent replacement is necessary, particularly of the chains but also of the chain sprocket. As a consequence, the operator of the machine or plant will suffer high costs. Once, the wear of chain and chain sprocket have reached a critical level, the process will start accelerating. Towards the end it will even be increasing exponentially. Wear is essentially caused by:

- the force transmission from the chain sprocket to the chain,
- longitudinal forces that act on the chain with the resulting elongation of the chain which, in turn, prevents the exact meshing of the chain with the teeth of the chain sprocket,
- irregular pitch tolerances due to manufacturing inaccuracies,
- meshing shocks of the chains (polygon effect, shock acceleration)

with the biggest source of wear, of course, in the area of contact between the chain and the drive wheel. In the case of a conventional chain drive, only a few teeth of the chain sprocket bear the lion's share of the tensile forces. The other meshing teeth rather serve as a chain guide. And it is this circumstance that leads to excessive strain and fast wear and tear.

It is exactly this aspect that differentiates the patented „self-adjusting chain wheel“ from conventional chain sprockets. In the case of this innovative product which has a good chance of taking hold in the market, the forces are absorbed uniformly across all the teeth. This leads to much more favourable load conditions for the chain and the chain sprocket. The principle of the self-adjusting chain wheel: contrary to the conventional chain wheel, which is manufactured „of one piece“, the self-adjusting chain wheel consists of many

individual segments or elements, respectively, with each element representing a tooth. Every tooth element is equipped with a pivot bearing allowing the tooth element to move. Both ends of the tooth element provide indentations which in conjunction with the neighbouring tooth elements accommodate an elastic spiral spring. The so arranged tooth elements form a radial and solid sprocket with, in itself, flexible tooth elements which are able to execute small „tilting movements“ and transmit these to the neighbouring teeth. Now, if a force acts on any of the teeth, the flexible arrangement generates a torque on the tooth element which is transmitted by means of the elastic spiral springs to all subsequent teeth – all the way around to the first tooth element under load. It is the „endless balance“ principle where all tooth elements participate in the force transmission.

Thanks to the flexibility of the tooth elements, the chain sprocket can, in a way, adjust to the chain conditions.

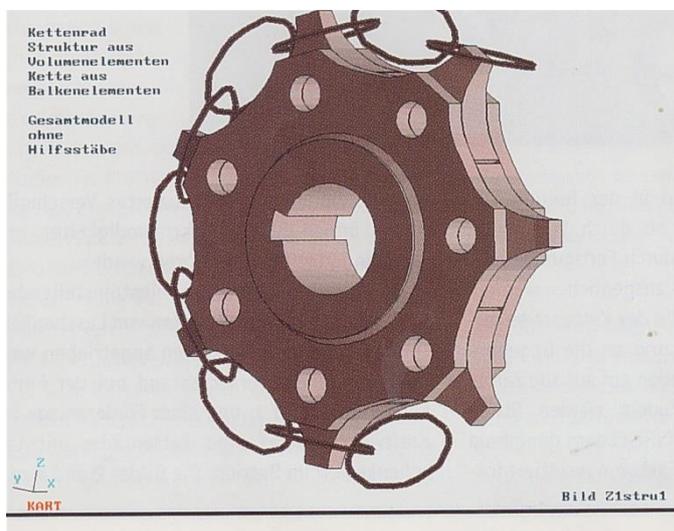


Fig. 2 Structure of the self-adjusting chain sprocket (made of volume elements) with chain

Chain sprocket structure of volume elements
Chain of beam elements

Overall model without auxiliary members

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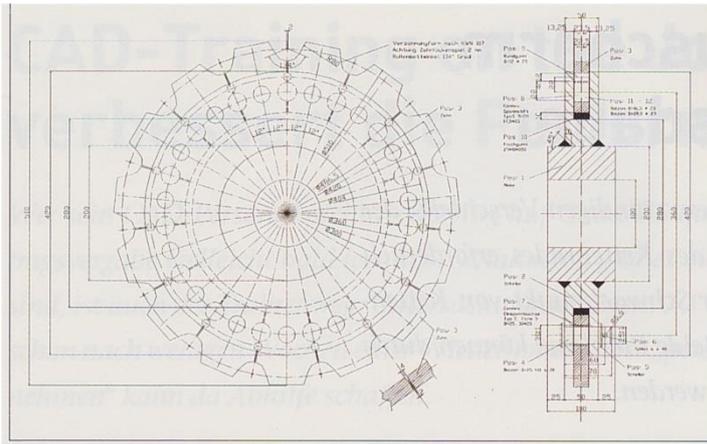


Fig. 3 Drawing of the self-adjusting chain sprocket in the test field

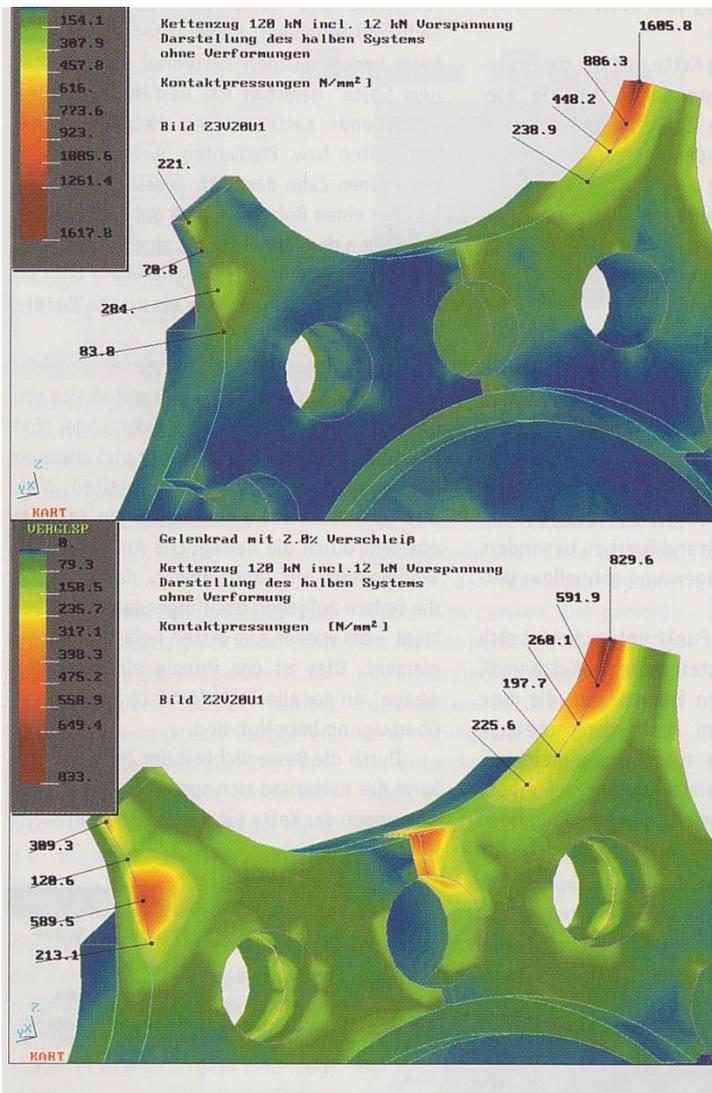


Fig. 4 FEM load analysis for a wear rate of 2 % (pitch extension). Above: rigid chain sprocket; (Data see diagram); below: self-adjusting chain sprocket; (Data see diagram)

Rigid wheel with a wear rate of 2 %

Chain load 120 kN incl. 12 kN pre-tensioning

illustration of half the system without deformation

Contact pressure (N/mm²)

Fig.

Articulated wheel with a wear rate of 2 %

Chain load 120 kN incl. 12 kN pre-tensioning

illustration of half the system without deformation

Contact pressure (N/mm²)

For instance, pitch inaccuracies of the chain and chain sprocket – no matter if due to wear, chain elongation or manufacturing inaccuracies – can be offset. The flexible segments of the chain sprocket achieve the adaptation to the conditions, and the forces are evenly distributed across all teeth. Impacts (e. g. meshing shocks) are absorbed by the cushioning effect of the springs. All these factors attribute to a considerably reduced wear rate, and the system can be run at a higher speed and without any modifications to the chain.

The system of the self-adjusting chain sprocket can be applied to all types of bush roller chain drives as well as round link chain drives. Chain sprockets with bush roller chains are in operation on a test rig operated by the company Ketten Wulf, Fig. 1, and on a conveyor system at the Ensdorf power station. Fig. 2 and 4 show a calculation of the chain sprocket for a round link chain. Fig. 4 shows a comparison between a rigid and an articulated chain sprocket with a pitch extension of 2 % due to wear. As we can see, the peak loads that act on the self-adjusting chain sprocket are considerably lower.

According to Karl Herkenrath, the inventor and patent owner of the self-adjusting chain wheel, the only disadvantage of the chain wheel known so far is the fact that, owing to its design, it is more expensive than a conventional chain wheel. However, cost savings can be achieved from the fact that it is also possible to replace individual defective teeth, if necessary. This can be done without disassembly of the chain wheel, and without unmeshing the chain from the sprocket.

The first use of the self-adjusting chain sprocket under practical conditions was started in the beginning of 2000 on a conveyor system at the Ensdorf power station which had been manufactured by the company Koch Transporttechnik. This application was subject to strict requirements set by the authorities with respect to the maximum noise level allowed in order to avoid any disturbance of local residents. The sound measurements carried out by the technical control

board TÜV showed that the noise level stayed below the allowed limit values (by 8 dB).

This would not have been possible with a conventional chain drive or only a the cost of substantial additional sound insulating measures. The chain conveyor system at the Ensdorf power station has, meanwhile, been operating for more than a year without problems.

For the company Ketten Wulf in Eslohe-Kückelheim in Sauerland, one of the bigger German manufacturers of chains and chain drives, the expectations placed upon reduced noise generation and lower wear through the innovative chain wheel were promising. This is why they decided to enter into a cooperation with the inventor and patent owner Karl Herkenrath and start to offer the new system on the market. The aim is to significantly increase the effectiveness of the system chain-chain wheel. Hermann Wilke, Technical and Commercial Manager in Ketten Wulf: "With our customers requesting shorter maintenance intervals and longer service life, this system, of course, comes in handy as a unique selling point." Plant construction firms account for 80 % of the Wulf customers and, eventually, it is the plant construction firms that more and more demand maintenance-free systems. The machinery and plant engineering companies have to position themselves if they want to survive in business.

Ketten Wulf has been testing the self-adjusting chain wheel on their in-house test bed for approx. nine months. Hermann Wilke: "It seems that our expectations will be met. First of all, we notice a noise level reduction by approx. 50 %. Apart from that wear was reduced significantly compared to the conventional type of drive." In fact, it is too early for accurate and quantitative evaluations due to the high complexity and long duration of tests but still, Wilke is convinced that the system will be highly welcomed by the customers.

For Wilke, the argument does not hold that chain manufacturers who offer extremely hardwearing chain systems might be pulling the rug from under their own business. "After all, it is a product that the market wants. Today, you win clients through quality thinking, and this includes a long service life. We are problem solvers for our clients; if you think this way, the odds are strong that you will get more business and further tasks." Anyway, Wilke thinks that due to the current cost structures the odds are rather against German companies in the market for standard chains: "The main part of the chain business is done abroad. We benefit from providing technical advice. 95 % of our sales come from specialty chains, i. e. customer-specific designs."

Wilke sees important technical trends for chains first of all in service life extensions and, in the second place, in maintenance-free conveyor chains. As to the latter, the main concern is to reduce customer service work and prevent pollution caused by the still-common total loss lubrication systems. Companies with the respective know-how will find themselves well positioned in a growing market. Here, the company Ketten Wulf claims the position as technology leader on the international level.

Of course, the company also places high expectations upon the self-adjusting chain wheel. It is rather difficult to forecast, if and to what extent self-adjusting chain wheels will actually be able to gain acceptance in the field. However, for the operators of conveyor systems the advantages are quite obvious. For instance, simpler and more cost-effective chains can be used without negative effects on the service life of the system chain-chain sprocket. Nowadays, the

argument of reduced spare parts and maintenance costs is just as important as the possibility to operate chain drives at a reduced noise level.

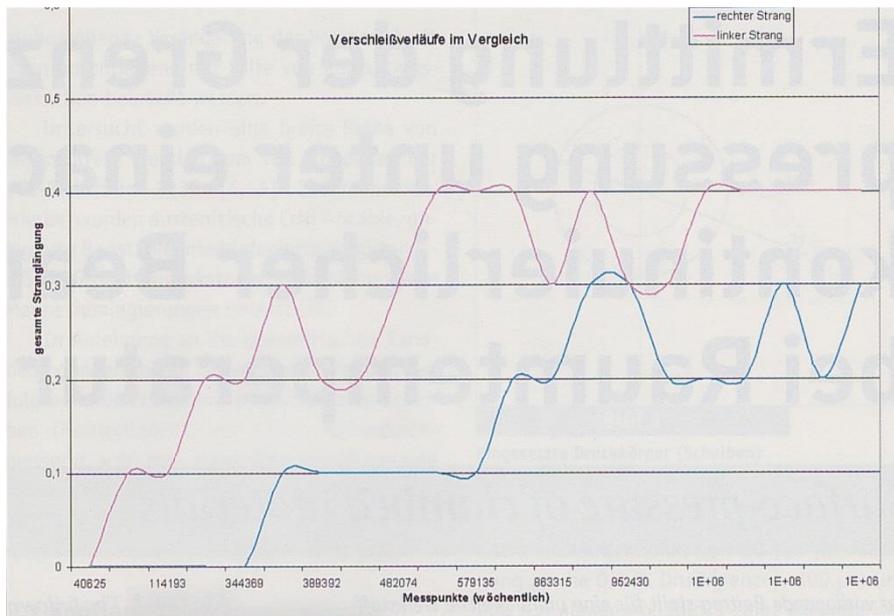
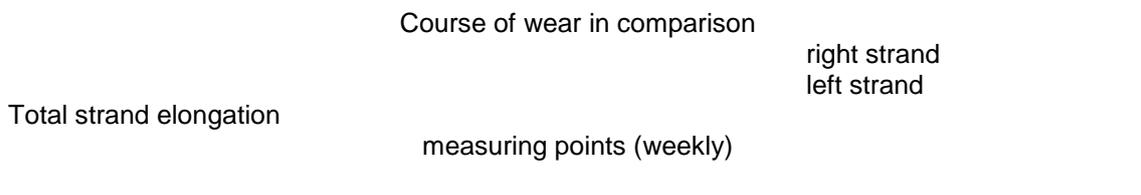


Fig. 5 Example of a wear measurement: the experiment with the self-adjusting chain wheel (lower curve) shows substantially less strand elongation than the conventional chain sprocket



Experience of an inventor

Karl Herkenrath is the inventor of the self-adjusting chain wheel. The idea was born in 1992 when we used to work as a design engineer with Krupp Fördertechnik in St. Ingbert. Initially, the patent application was filed by Krupp Fördertechnik. However, as the company was not a manufacturer of chain sprockets, the patent was assigned to Karl Herkenrath. Since 1995, Herkenrath has tried to find a manufacturer to duly promote the system. Herkenrath: "I travelled vom Hamburg to Munich and tried to give the chain producers an understanding of the system. Though I received some offers, none of the companies was really interested in manufacturing the system or sign a license agreement with me."

In fact, many chain manufacturers were apparently not interested in reducing the wear of chains. After all, they realize up to 90 % of their sales volume with chains; chain sprockets, on the other hand, account for a very much smaller percentage. They simply did not want the spare parts business with worn chains to suffer.

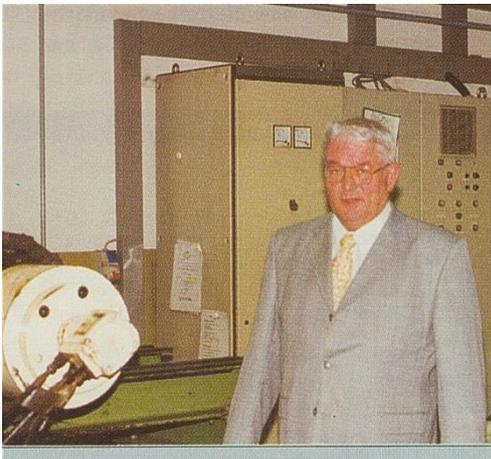
Of course, Herkenrath did not want his invention to be tucked away in the desk drawer of one of the big manufacturers. All the same, in 2000 he was almost

ready to give up hope and drop the patent. For years, he had been paying patent annuities of several thousand DM per year without any visible success. If he had given up, any chain manufacturer could have copied his invention.

However, in October 2000, there was a flicker of hope. The company Koch Transporttechnik GmbH showed interest in the chain wheel in connection with the construction of a conveyor belt at the Ensdorf power station. Koch took on the patent annuities and ordered the manufacture of one single piece of the chain sprocket. So far, it has been operating without any problems at all.

Shortly after, a second genuinely interested party appeared on the scene. The company Ketten Wulf from the Sauerland signed a license agreement with Karl Herkenrath and they are now at the ready to bring the system to the market.

Karl Herkenrath thinks that the reason for his difficulties are also related to the aversion to take risks and the bureaucracy getting out of hand in German companies. In his opinion, innovations are more likely to happen in owner-managed businesses where the owners are used to taking risks and to think long-term.



Karl Herkenrath, the inventor of the self-adjusting chain wheel kept his spirit up and believed in his invention