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Paul-Gerd Voigt

Computerized calculations and drawings

Progress in the production of steel wire ropes

Modern requirements in respect of wire ropes could not be fulfilled without computers. Even the most careful rope construction cannot exclude adjustments during production if the rope is to turn out optimally for the application concerned. Thus computer technology also supplied substantial impulses for wire rope manufacturing. Important machine engineering requirements for reproducible accuracy in stranding and closing include disc braking with constant strand tension, adjustable back- and forturn of the bobbins and strictly controlled production sequences.

Paul-Gerd Voigt is Works Manager in a wire rope factory in Gelsenkirchen, Federal Republic of Germany.

The evolution of the wire rope is reflected in the development of wire rope machines. Requirements regarding the ropes were always accompanied by demands on the machine makers.

It is approximately 150 years since the wire rope made its appearance. It was invented and further developed as mine hoist rope by senior inspector Albert for the mining industry in Germany. In those days ropes of this kind were urgently required because the conventional chains and hemp ropes no longer withstood the heavier loads and the constantly increasing shaft depths.

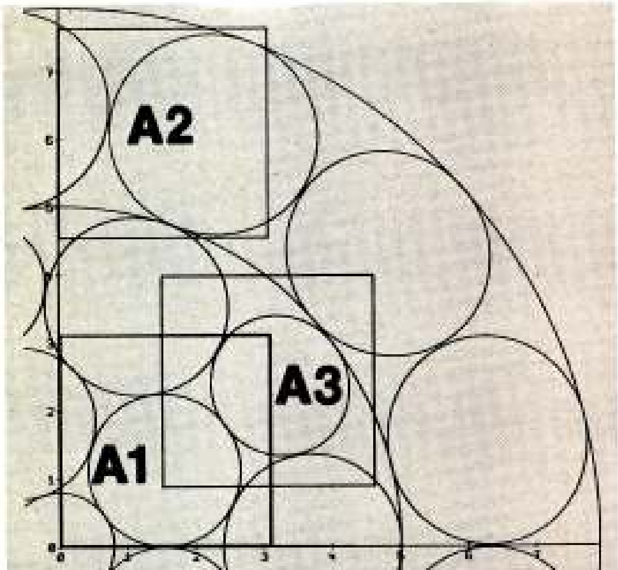
Although the wire rope is such an old "machine element" many problems concerning its condition have still not been explained; the investigation and further development of the wire rope are far from concluded.

Of all the numerous single elements of the rope—the wires—, which move over a pulley when the rope is running, even the smallest detail in their design and production has to be carefully checked. The aim is always the attainment of the best form of rope.

Clearances calculated by computers

The greater the stressing of a rope, the more accurately the wire diameter, the construction of the rope and finally the production have to be adjusted to one another. With less severely stressed ropes the quality requirements of the rope are not always so strict as those of the highly stressed grades. In laboratory tests and in practice however quality differences can be clearly detected both in the fatigue bending test and also by the service life.

The construction of the rope was previously calculated by approximation formulae or by determination of the geometrical cross-section of the strand by drawing. Accurate mathematical calcu-



layer	No. of wires		wire diameter	clearances		strand diameter		angle of lay	length of lay
00 K	1		1.600						
01 T	6		2.726	0.005		6.053		8.96	76.20
02 W	5+5	1.900	2.005	0.018	10.020	10.020	10.33	17.00	
03 T	13		2.946	0.035		15.920		16.00	135.00

Fig. 1: Strand geometry calculated and plotted by electronic data processing system

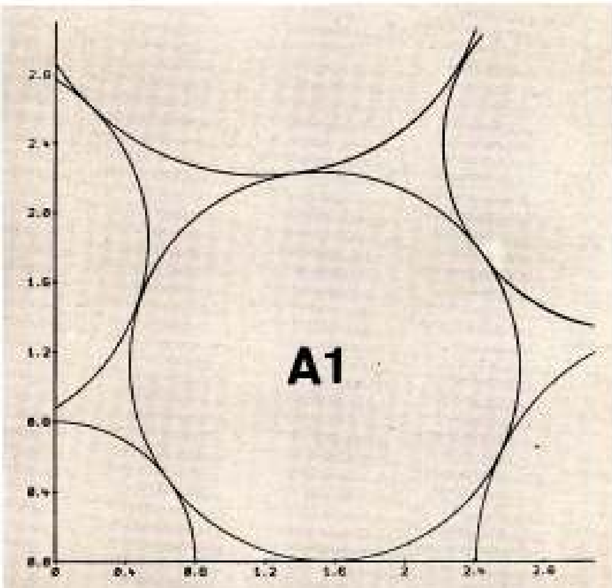


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Fig. 2: Section A1 of strand geometry in Fig. 1

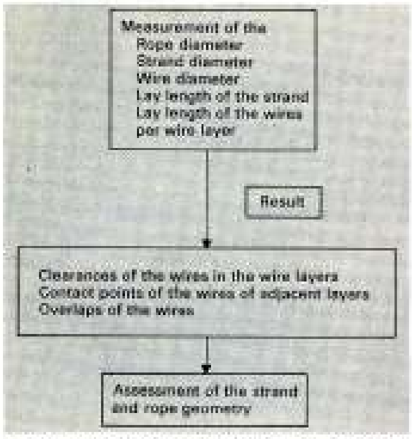
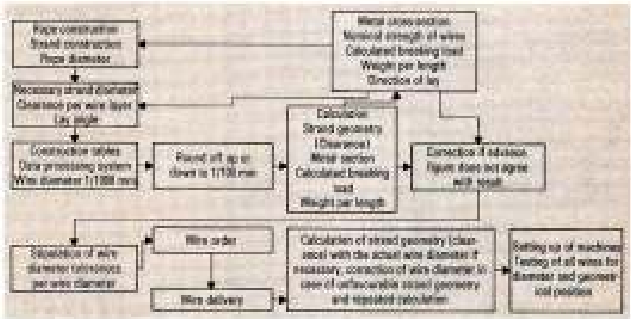


Fig. 3: Checking a rope construction on the finished rope to obtain an expert opinion

Fig. 4: Calculation of a wire rope construction before production of rope



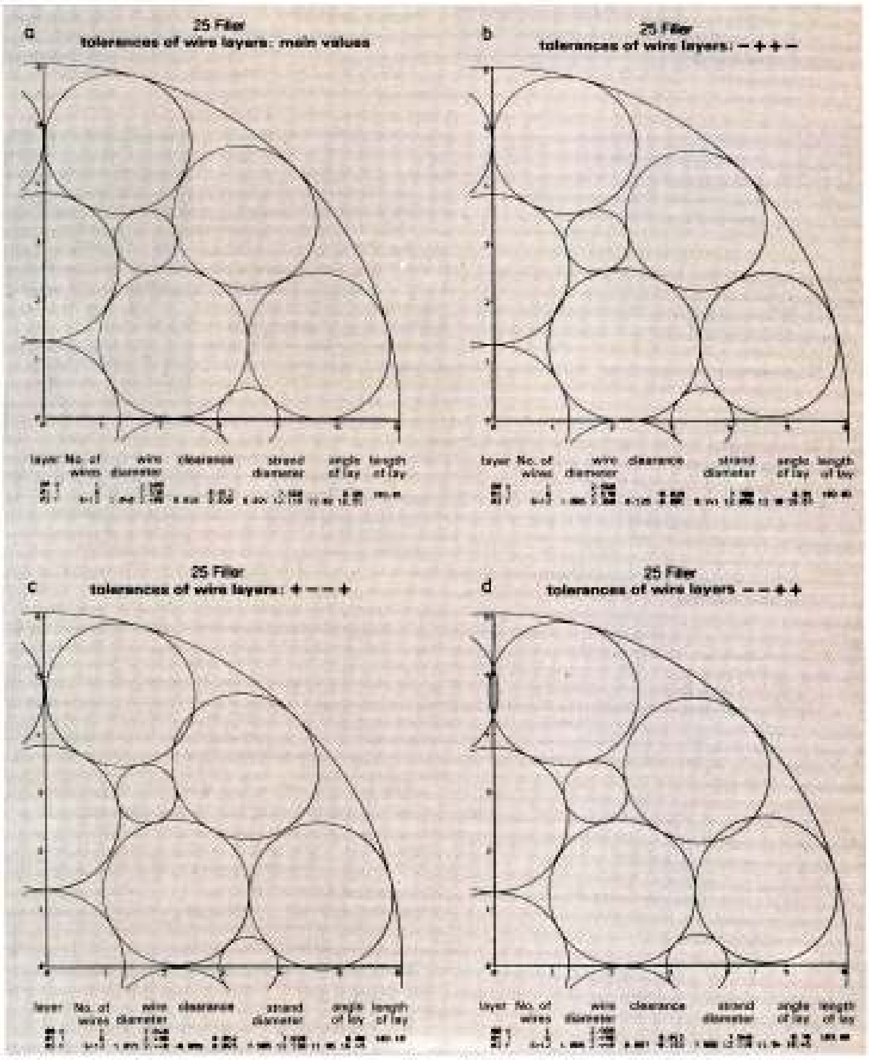


Fig. 5: Strand construction, calculated by electronic data processing system
a with nominal wire diameter, b to d by use of the wire diameter tolerances to DIN 2078

lation was extremely time-consuming. Consideration of the contact points of the wires for example involved difficulties.

Nowadays even the most complicated calculations can be carried out very rapidly by data processing systems. It is thus possible to check the construction of the rope, i.e. the actual clearances between wires and strands, during rope manufacture without long periods of machine shutdown. Whithout data processing systems such calculations or drawings of the strand cross-sections would be so complicated that subsequent checking with the actual wire diameters would be impossible for reasons of time.

The total strand cross-section can be shown. But only one quadrant of the section need be plotted (Fig. 1) since this is sufficient to show all the details. To supply a better view, enlarged sections may also be shown (Fig. 2).

When a rope is bent, its wires are displaced and slide against one another. It would thus be ideal if the clearance between the wires in the layers of wire would only be as large to ensure that the wires did not touch when they move. The clearance of the wires in each layer should increase from the outside to the inside. A somewhat greater clearance in the outer layer is not necessarily a disadvantage. The effect of unfavourable clearances is more pronounced in the bent rope than in the straight rope.

Wire tolerances affect strand geometry

In order to check a rope construction, wires and lay lengths from the finished rope are measured, the strand construction is established and thus the geometry, the layer of the wires and the clearances, are calculated and plotted (Fig. 3). The rope diameter or the computed breaking load (breaking load) and the strand construction are prescribed for calculation of the rope. From this value the necessary strand diameter is then calculated (Fig. 4).

The data processing system then permits calculation of the wire diameter, the layer diameters, the clearances and the relevant lay lengths on the basis of the stipulated lay angle. The strand may also be plotted in order to illustrate the position more clearly.

The wire diameter tolerances may act so that the strand geometry does not come out correctly in spite of accurately prescribed values (Fig. 5). The method of initially selecting larger clearances in order to prevent wire reinforcement (overlaps or crossovers in the illustration), has a negative effect on rope life, as has been shown in practice and also by laboratory tests. In order to obtain acceptable clearances, above all in the inner layers, the wires concerned have to be exchanged.

Accuracy of rope manufacturing is reproducible

The manufacture of high-grade ropes requires stranding and closing machinery

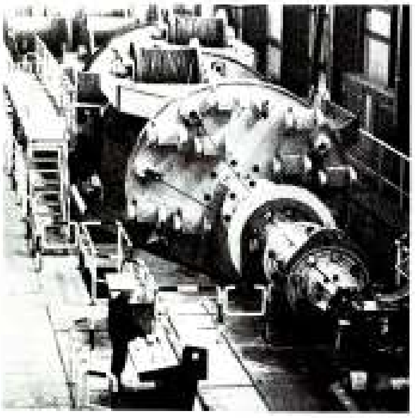


Fig. 6: Adequate bobbin capacity permits the production of ropes in one length for multiple hoisting rope installations

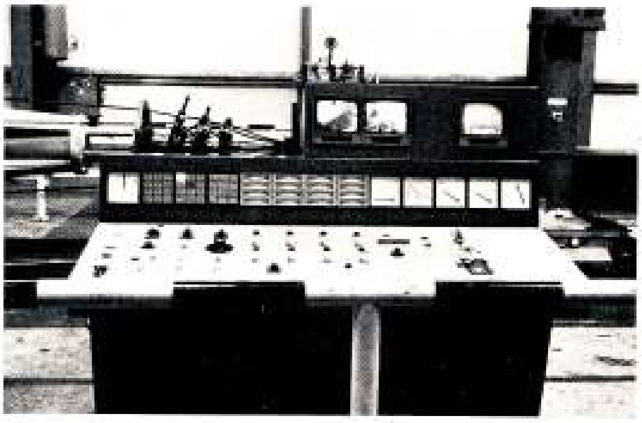


Fig. 7: Die pressure and strand tensions regulated and adjusted at control console

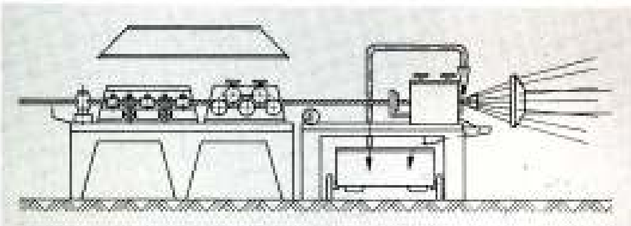


Fig. 8: Measured application of basic lubrication of rope

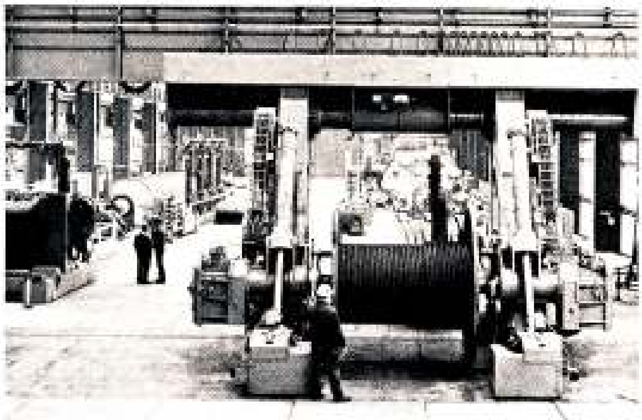


Fig. 9: Rotary pay-off stands and traversing take-ups

of the highest technology, i.e. machines and tools designed to withstand the stresses and strains of production and to permit the sufficiently accurate manufacture of strand and ropes of optimal dimensions and shape calculated by data processing systems.

Modern wire ropes machines, which can be provided with all important manufacturing data and are also equipped with the necessary pre-forming, postforming and calibrating devices, turn out high-quality ropes with reproducible accuracy. On account of their adequate bobbin capacity these machines will also produce ropes in one length for multiple hoisting rope installations. Uniformity in all ropes is thus guaranteed (Fig. 6).

Reproducible accuracy is a deciding quality feature for ropes. Important constructional and production engineering requirements in the stranding and closing machines are:

- Disc braking with constant strand tension,
- High pull-off forces and twin haul-off capstans which ensure uniform clearances between the strands and an effective rope setting with steplessly adjustable lay lengths,
- Back- and forturning of the bobbins during loading time or in operation, corrected singly or jointly from the control console,
- Controlled die pressure (Fig. 7),
- Optimal guiding of wires and strands,
- Measured application of basic lubrication which surrounds every single wire (Fig. 8),
- Rotary pay-off stands and traversing take-ups (Fig. 9),
- Strictly controlled production sequences,
- Constant monitoring of quality based on checking for example of the number of fatigue cycles of a rope.

Although it is approximately 150 years since the introduction of the wire rope, further developments in its design are still proceeding. New techniques for calculation of the rope construction and manufacture are leading to improvements in quality.

The use of computers permits the optimal determination of rope geometry and enables the wire diameters to be accurately aligned during manufacture. The greater the anticipated stressing of the rope, the more accurate this essential alignment but at the same time the greater the expense.

The purchase price of modern stranding and closing machines which comply with requirements regarding maximal reproducible accuracy and high productivity is many times that of conventional machines and their operating costes are also appreciably higher. The extra outlay of course pays for itself.

Pictures of courtesy: Thyssen