ENVIRONMENTALLY FRIENDLY WASTE DISPOSAL AT COAL FIRED POWER PLANTS IN HARSH ENVIRONMENTAL CONDITIONS, USING PIPE CONVEYORS

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Waste products produced by coal-fired power plants require environmentally friendly removal and secure storage. During the modernisation of a Russian coal fired power plant, TAKRAF, headquartered in Leipzig – Germany, delivered the complete Dry Ash Removal System (DARS) for this project. At the core of this new residual material removal system is a 4.4 km long pipe conveyor, equipped with a closed Conti® PIPE pipe belt from ContiTech.

A RESIDUAL MATERIAL HANDLING PROJECT FOR A COAL FIRED POWER PLANT IN HARSH ENVIROMENTAL CONDITIONS

In this instance, the Russian power plant in Siberia obtains the majority of its coal from the Ekibastuz Coal Basin (Kazakhstan) via rail.

About 6 million tons of residual material is generated annually, which must be transported from the power plant and stored. Since current Russian environmental protection laws prohibit the use of hydraulic ash conveyor systems, all new coal power plants as well as older coal power plants are being modernised and have to be equipped with “dry” residual material removal systems.

The harsh site conditions faced on this project included:

Temperature	-45 °C to +40 °C
Humidity	72%
Operating time	22 h/d, 7 days/week
Rain load	550 mm/a
Wind speed, max.	22.7 m/s
Snow height, max.	66 cm
Seismic data	Scale MSK64, 7 level

These harsh conditions present a unique challenge for component design and system operation.

TAKRAF received the order for the DARS project requiring the delivery of a residual material removal system that conforms to current Russian standards and laws.

Leveraging the company’s significant experience, an ash handling system boasting a capacity of 2200 t/h, at a bulk density of 1.06 t/m^3, was designed. An approx. 4.4 km long pipe conveyor, which is described below in greater detail, is the first link in a chain of conveyors.

A short movable belt, which either transports waste material for dumping to the disposal site (figure 1) or to an emergency stockpile (figure 2), is located at the head end of the pipe conveyor.

The dumping system consists of a shiftable belt conveyor with a maximum length of 2.6 km, a tripper car on rails, as well as a crawler-mounted spreader with a 50 m discharge boom and a 50 m long intermediate bridge.

To feed the emergency stockpile, a radial stacker is fed by a 100 m long belt conveyor.

Figure 1: Ash being dumped at the disposal site.

Figure 2: Temporary material storage at an emergency stockpile.

This system also makes it possible to disconnect long distance transport from dumping temporarily. Furthermore, the emergency stockpile with belt conveyor and radial stacker (figure 3) also allows for the emptying of the pipe conveyor even if the dumping system is not available.

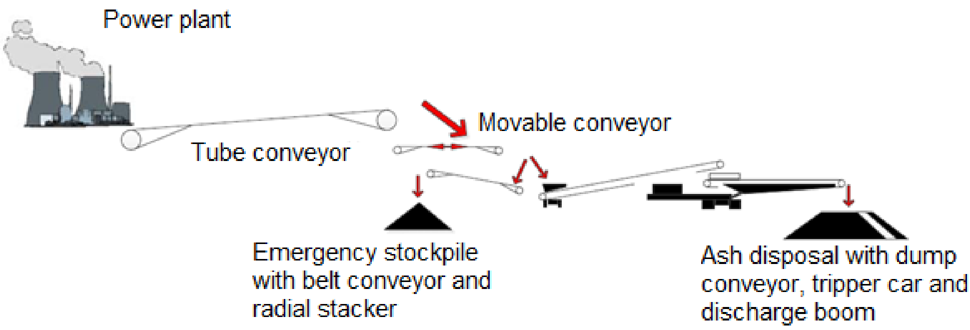

Figure 3: Residual material removal concept at the Russian coal fired power plant in Siberia.

SCOPE OF WORK

The EPS (Engineering, Procurement, Services) scope consisted of:

- Engineering of the entire system including mechanical, structural, as well as electrical components
- Delivery of mechanical components (drives, belts, belt pulleys, idlers, etc.)
- Delivery of electrical components and control system
- Site assistance during assembly and commissioning

The customer was responsible for construction and commissioning, with steel components manufactured locally in Russia.

THE PIPE CONVEYOR

The pipe conveyor connects the power plant with the dumping site approximately 4.4 km away. The transport of up to 90°C of hot ash with an ambient temperature dropping down to - 45°C, as well as difficult curves posed a significant challenge to the design and operation of the system (figure 4).

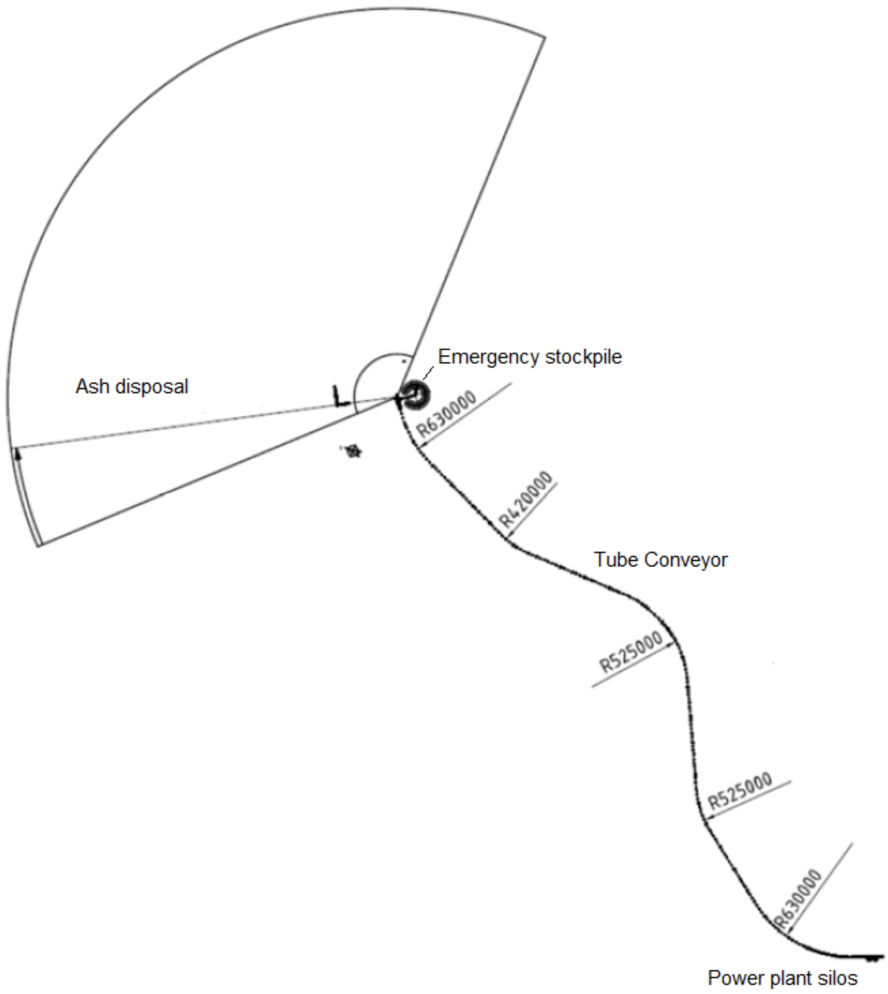

Figure 4: Layout / plan view of the material handling system including pipe conveyor routing.

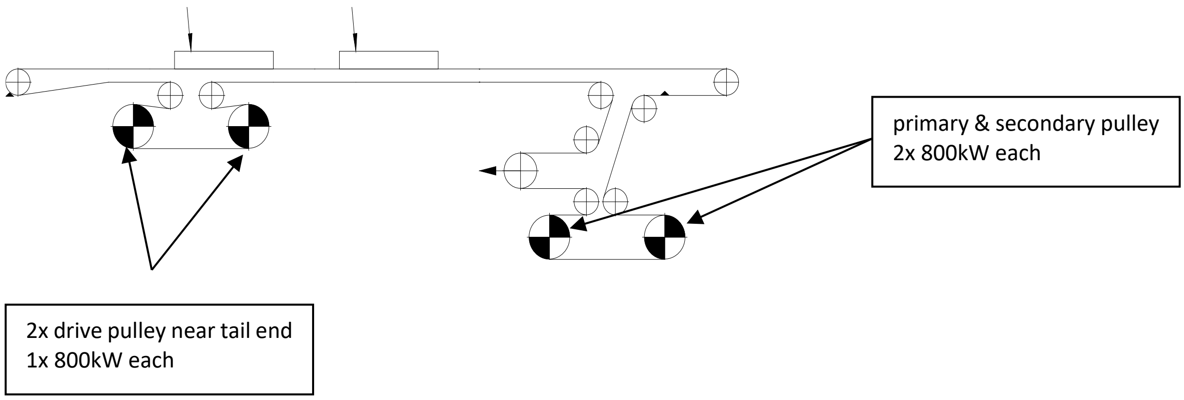

Figure 5: Drive configuration and pulley arrangement

TECHNICAL DATA FOR THE PIPE CONVEYOR

Material:	Hot ash (T_{max} = + 90°C); d_K = 1...8 mm ρ = 1.06 t/m^3; 15% to 40% water content
Pulley centre distance and conveyor lift:	C-C = 4390 m; H = 30 m
Design capacity:	I_m = 2200 t/h
Conveyor speed:	v = 5.2 m/s
Belt width:	B = 2000 mm
Fill level:	$\eta_F \approx 0.55$
Outer pipe diameter:	D_O = Ø 570 mm
5 horizontal curves and 1 vertical curve:	R_{min} = 420 m (min. curve radius)
Idler spacing (straight sections):	l_{TG} = 2.4 m
Idler spacing (curves):	l_{TK} = 2.0 m
Belt type:	Steel cord St 2500 8/7
Drive concept:	Squirrel cage motor with frequency converter
Drive configuration:	Head station: 2 x 800 kW + 2 x 800 kW
	Tail station: 1 x 800 kW + 1 x 800 kW
Take-up device:	Take-up winch at head of system

The conveyor was designed for operation with a design capacity of 2200 t/h at ambient temperatures of between -45°C and +40°C.

Figure 6: View of the pipe conveyor during winter.

Figure 7: View of the pipe conveyor during summer.

With due consideration to the range of climatic conditions faced, the decision was made to enclose the pipe conveyor, along its entire length (figures 6 and 7). Enclosing the system protects the idlers and other important operating components from rain, snow and moisture – which can freeze and turns to ice in winter. In addition, the belt is also protected from the sun and therefore from premature ageing. Furthermore, the nearly constant coefficient of friction between the idlers and belt, is another positive effect of the enclosure that simplifies control of the belt overlap position.

In addition to this and considering the difficult environmental condition, the enclosure also prevents the build up of snow and ice on the belt and idlers, if not in operation. Starting a pipe conveyor in wintertime after a longer stop can be difficult and would require a significant "peak torque" to break the belt loose. Due to the large number of idlers, snow deposits, it would also create a significant amount of additional motion resistance, and therefore increase the technical requirements for all components.

DESIGNING THE PIPE CONVEYOR

There were two main considerations with regard to dimensioning the pipe conveyor:

1. Running resistance of the conveyor in winter (temperature dropping down to -45°C)
2. Curves of the conveyor

Running resistance

Even with a significant number of pipe conveyor references in the history of TAKRAF and other suppliers, there are no reliable power measurements in low ambient temperature environment available. In order to perform a realistic conveyor calculation a reference calculation was performed to superimpose the properties, influenced by the temperature for troughed belts with the characteristics of a pipe conveyor.

Based on previous projects, with troughed belt systems in operation for several years in Canada, Russia and Kazakhstan, measured data for standard belt conveyors was available. If, in this instance, this 4.4 km long pipe conveyor was a troughed belt, TAKRAF would increase the running resistance by 35% to account for the low temperatures in comparison to central European ambient temperatures.

The running resistance (main resistance) of a pipe conveyor is determined by the various resistances illustrated in figure 8. This overview is based on motion resistance on a troughed belt. The additional resistances (red background), which are typical for a pipe conveyor, are considered in the overview.

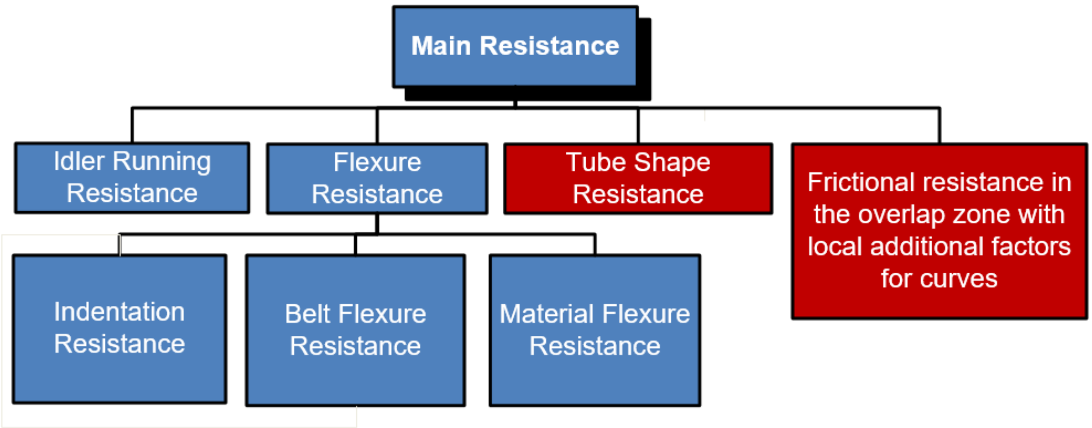

Figure 8: Main resistance on a pipe conveyor with constituent resistances [1].

Based on the assumption that any additional resistances are also temperature-dependent and the temperature-dependent indentation resistance for a pipe conveyor contributes a substantial resistance, an f-value of 0.068 for the nominal throughput was used in the design of the conveyor. Based on an f-value of 0.040, which TAKRAF would use for such systems in a central European climate, the selected coefficient corresponds to an ambient temperature-dependent increase of 70%, i.e. twice as great as the increase for a troughed belt.

Calculations for the pipe conveyor were thus based upon this assumption. The conveyor component selection (specifically belts and drives) was also based upon these results.

Figure 9 depicts belt tension during operation in the upper strand of the conveyor, whilst figure 10 depicts belt tension during operation in the lower strand.

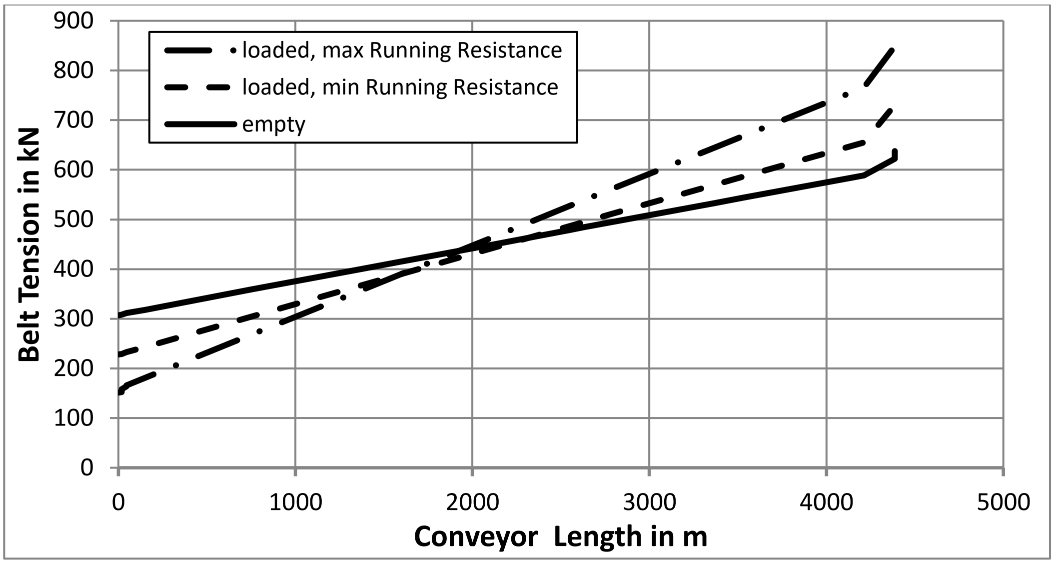

Figure 9 Belt tension during operation in the upper strand.

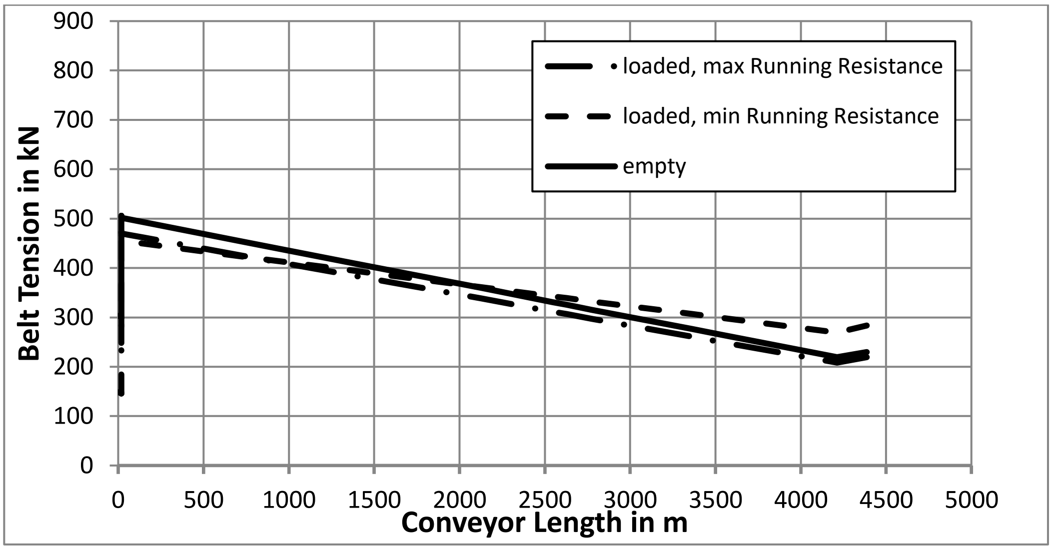

Figure 10: Steady state belt tension in the lower strand.

With a maximum steady state belt tension of 870 kN, belt strength St 2500 was selected, which corresponds to a belt safety factor of S = 5.75.

Curves

As illustrated previously in figure 4, the pipe conveyor runs through numerous curves with radii between 420 m and 630 m.

Local belt tension maximums and minimums had to be determined in order to confirm the curve radii and to prevent the belt from critical stretching on the outer edge of the curves and compressing on the inside of the curves.

The local belt tensions illustrated in figure 11 are based upon the superimposed belt elongation and the local additional elongation. The diagram applies to the tightest curve with a radius of 420 m at the head of the pipe conveyor. As illustrated in the diagram, the belt does not compress on the inside of the curve (minimums depicted by the dotted curve).

The maximum local belt tension (curve outside and maximum belt tension) is 880 kN. This corresponds to a local belt safety factor of S_{local} = 5.7.

Since all values are within the permitted range, critical belt overloads in the curves are not expected.

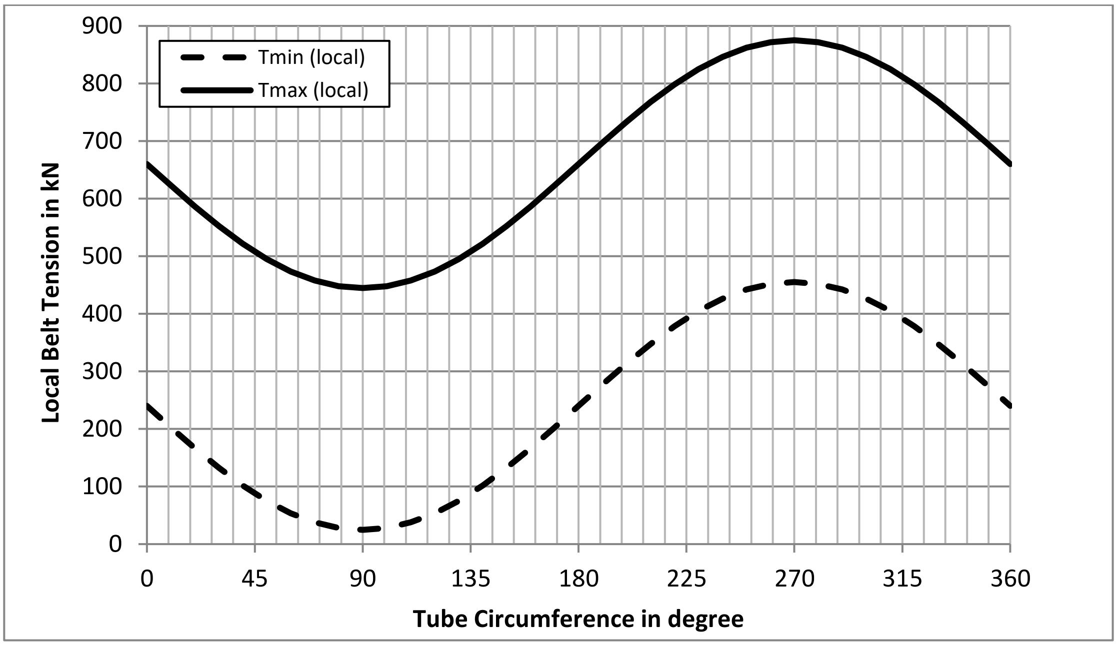

Figure 11: Local belt tensions above the pipe belt circumference at the head of the conveyor with a curve radius of R = 420 m.

MONITORING/CONTROL OF THE BELT OVERLAP POSITION

Belt twisting along the conveyor axis arises as a result of different local belt elongations in curves. In addition, empty pipe belts tend to twist in the upper strand since the upper overlap position moves the centre of gravity above the centreline of the tubular belt shape. The pipe's centre of gravity shifts towards the conveyed material, i.e. downwards, which reduces the tendency of the belt to twist. Belt twisting is not critical for conveyor operation, as long as it does not exceed permitted limits.

However, a precise adjustment of belt overlap is necessary at the point where the pipe belt opens in order to discharge. In order to achieve this criterion for conveyors with particularly difficult routes, TAKRAF recommends the Automatic Belt Training System (ABTS), a patented measurement, control and training device. The current overlap position is determined via ultrasonic sensors. If the overlap exceeds the tolerance limit, servomotors are activated that rotate the pipe profile through individual idlers into the desired position via targeted tilting adjustments (figure 12 and figure 13).

Figure 12: ABTS in operation.

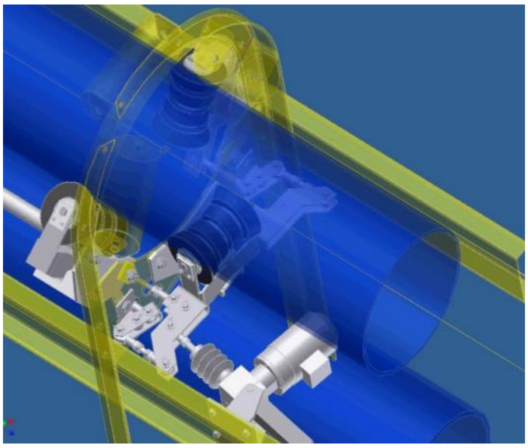

Figure 13: ABTS 3D model.

STEEL FABRICATION AND ASSEMBLY

The entire length of the pipe conveyor is elevated. The minimum bridge elevation above ground is 2 m, with a total of 185 bridge segments having been installed. Maximum bridge span length is 44 m, whilst the majority of bridge spans are 24 m.

The bridges open at the bottom (walkway gratings) and are equipped with electrical lighting.

Various individual components were assembled to produce bridge segments at an assembly site (figure 14) and then lifted onto supports using two mobile cranes each (figure 15).

Figure 14: Assembly site of the bridge segments.

Figure 15: Lifting the pre-assembled bridges.

MEASUREMENTS DURING COMMISSIONING

The first test runs were performed once construction and pre-commissioning was completed. An official 24-hour test was performed as part of an acceptance test by the customer, with the customer providing a conveyed material flow of maximum 1500 t/h at moderate ambient temperatures of -12°C.

This test was successfully passed. Measurement data was recorded to verify the conveyor's dimensioning (figure 16).

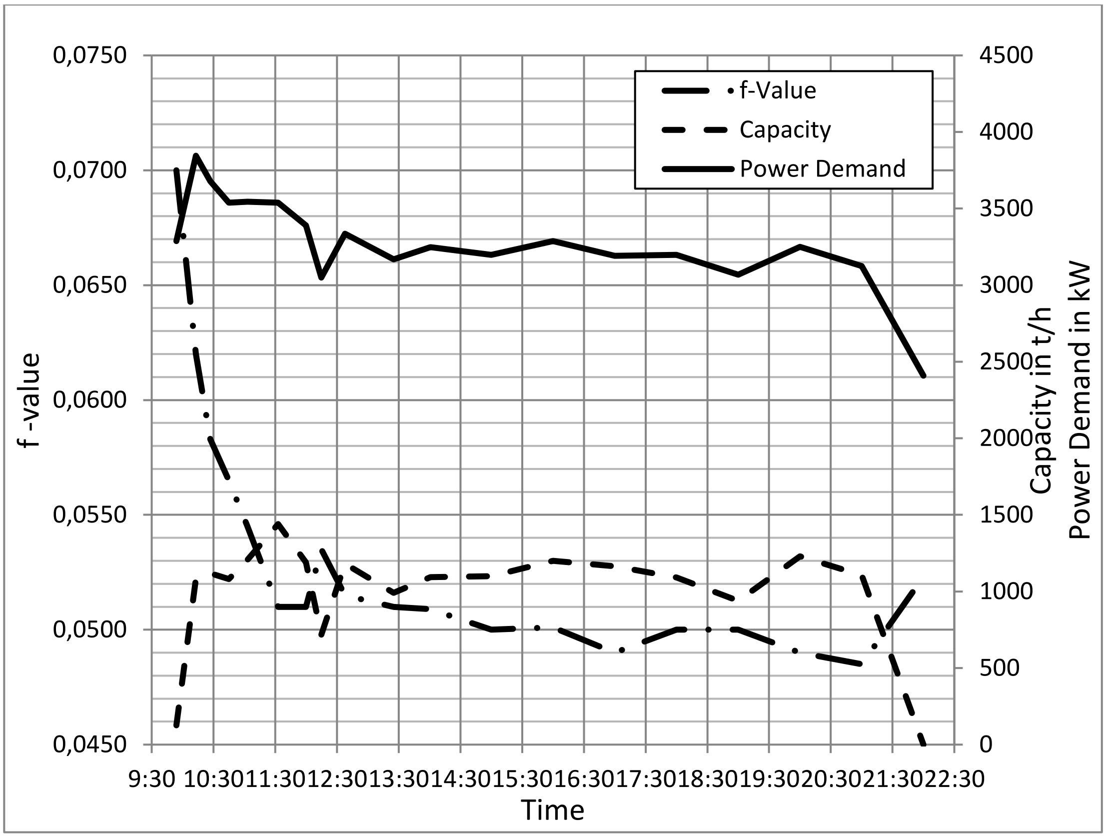

Figure 26: Measurement data recorded during the 24-hour test.

The measurement results show an f-value of 0.050 during operation of the conveyor with an average capacity of 1000 t/h. The system therefore has sufficient reserves for operating at lower temperatures.

Conclusion

The f-value curve in figure 15, in conjunction with the capacity and required power, illustrates that the conveyor and in particular the belt requires 90 minutes to run in. During this period, the f-value decreases from 0.07 down to approx. 0.05. This process will take place whenever the conveyor is restarted after a longer period of time of non operation, especially at low temperatures. The measurement data gathered make it quite clear that increased resistance due to low temperatures cannot solely be compensated by temporarily overloading the motors. Therefore, the consideration of low temperature for the selection of the installed power has a higher influence as the capacity itself.

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TAKRAF, a Tenova company, is an integrated solutions provider to the global mining, bulk material handling, minerals processing and beneficiation industries, offering innovative technological solutions as well as process and commodity knowledge along the industry value chains. With the integration of the well-known DELKOR and Tenova Advanced Technologies (formerly Bateman Advanced Technologies) brand of products into TAKRAF as specialized product lines, our portfolio for the minerals processing and beneficiation sectors has been considerably enhanced.

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