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REFINING CONVEYOR SPECIFICATIONS AND OPERATING PROCEDURES TO CUT RUNNING COSTS AND DOWNTIME.

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SYNOPSIS

This paper puts forward three related proposals:

- To modify existing design specifications on conveyor drives.
- To verify conveyor performance during commission.
- To monitor the conveyor performance during its life cycle, and implement the monitoring into preventative maintenance and trouble-shooting procedures.

These proposals will benefit the user significantly by improving conveyor availability and reducing operating costs.

The proposal will also be beneficial to conveyor designers, manufacturers and equipment suppliers.

CONTENTS

1. INTRODUCTION

During the past twelve years, Surtees Conveyor Test Division has been active in the performance measurement of over 100 conveyor installations.

A wide range of conveyors with varying parameters have been measured, including belt centres up to 6 km, belt lifts up to 250 metres, installed powers up to 2,5 MW and tonnages up to 12000 tons per hour.

The decade of measurements and findings are reviewed to identify general problems being experienced in the industry.

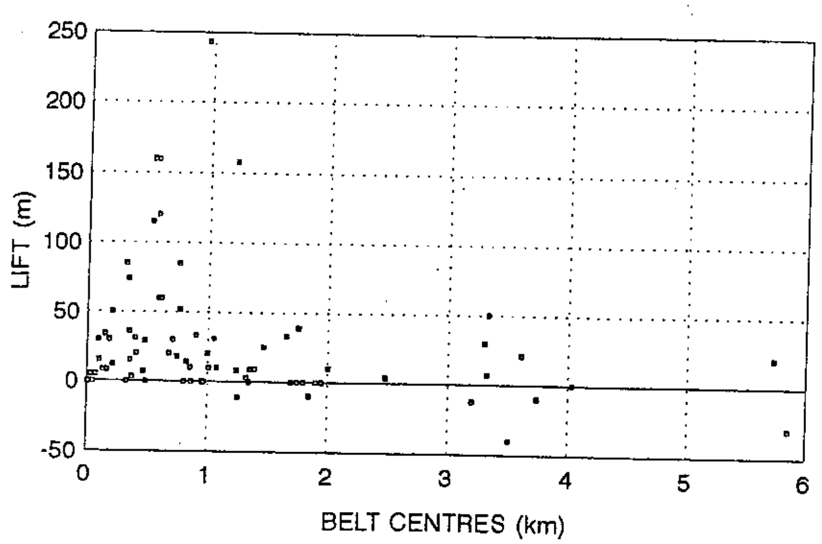
These problems can certainly be overcome in the next decade by paying more attention to design specifications, design verification during commissioning, and monitoring/preventative maintenance during operation.

Proposals covering these issues are put forward for consideration.

2. REVIEW OF CONVEYOR PERFORMANCES MEASURED

The basic length and lift parameters for each conveyor tested are shown in graph no. 1.

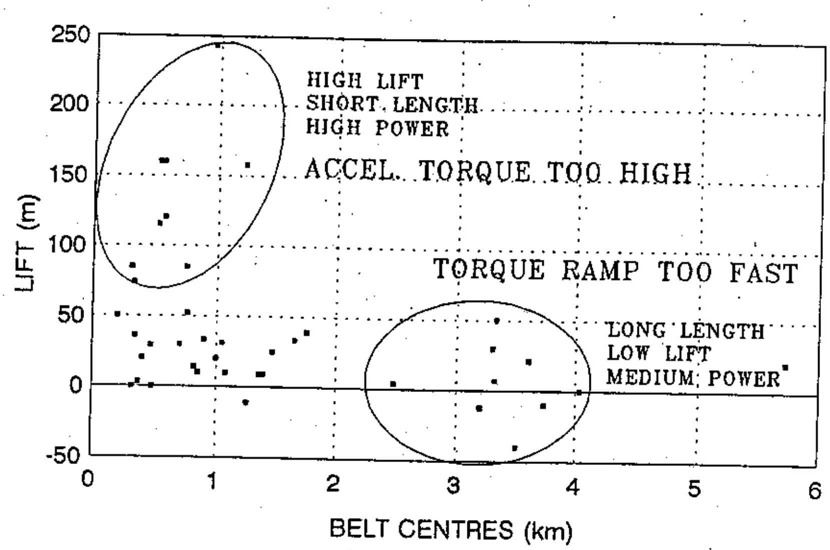
GRAPH 1;ALL BELTS TESTED



By separating the conveyors by belt construction, problematic trends become more apparent.

Graph no. 2 shows all steel cord belts tested. Two main problematic areas are evident:

GRAPH 2;STEEL CORD BELTS TESTED



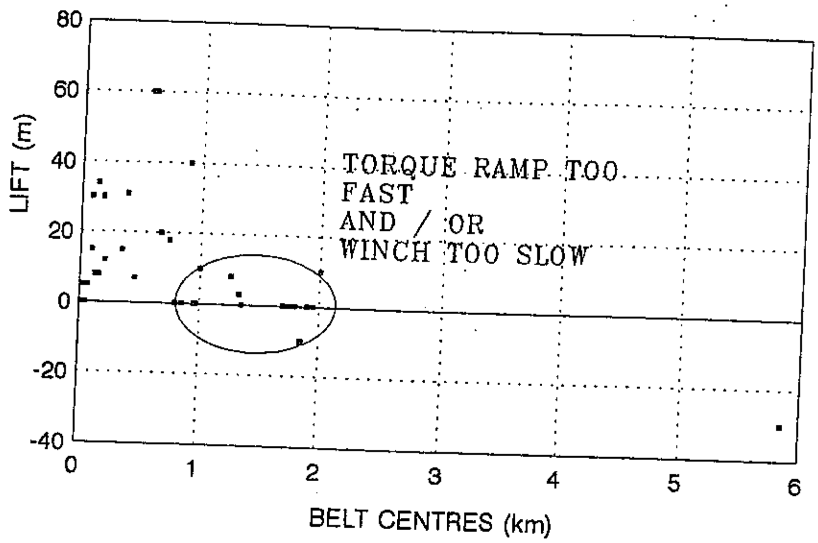
The first area occurs with high power, relatively short length and high lift conveyors. In all these cases, the acceleration torque exceeds those values allowed for in the design. Rapid acceleration during starting results in excessive forces being experienced in the belting, structures, pulleys and drive elements.

The second area occurs with medium power, long length and relatively low lift conveyors. In this area, the general problem is one of too much torque being introduced by the drives into the system too quickly. i.e. Torque ramp too fast. High speed transient waves are excited in the belt which impose high forces in the belting, structures, pulleys and drive elements.

Graph no. 3 shows all fabric or solid woven belts tested.

The general problematic area occurs with relatively long, low lift conveyors - The problem is one of the torque ramp being too fast and/or the tensioning device being unable to maintain sufficient tension. Problems occur mostly on underground trunk and section conveyors.

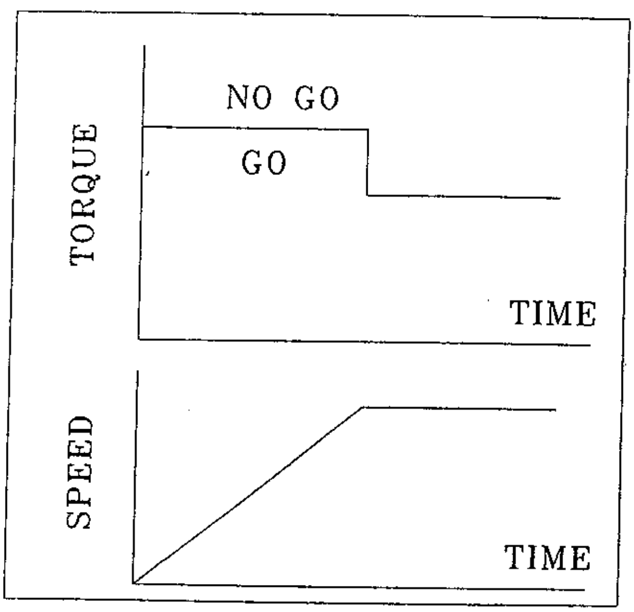
GRAPH 3;FABRIC/SOLID WOVEN BELTS



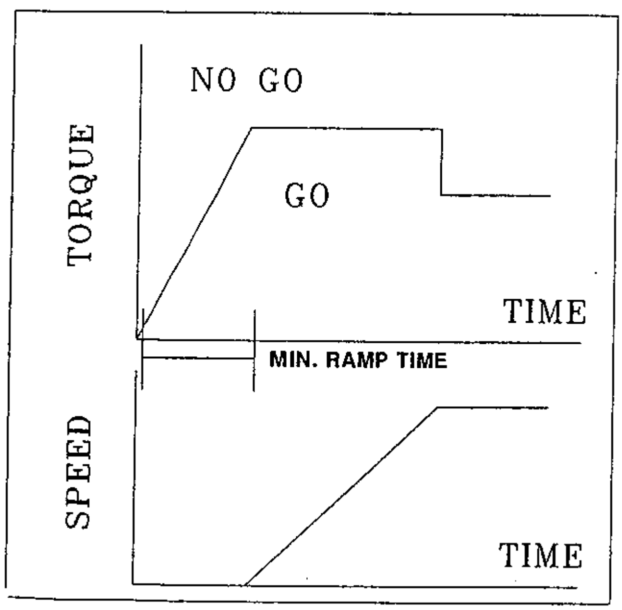
3. PROPOSAL 1 : TO MODIFY EXISTING DESIGN SPECIFICATIONS ON CONVEYOR DRIVES

Most users and mining houses do call for some maximum allowable value to accelerate the conveyor not to be exceeded. However, no stipulation is made on how this maximum value should be introduced into the system (refer to graph no. 4).

GRAPH 4; EXISTING SPEC.

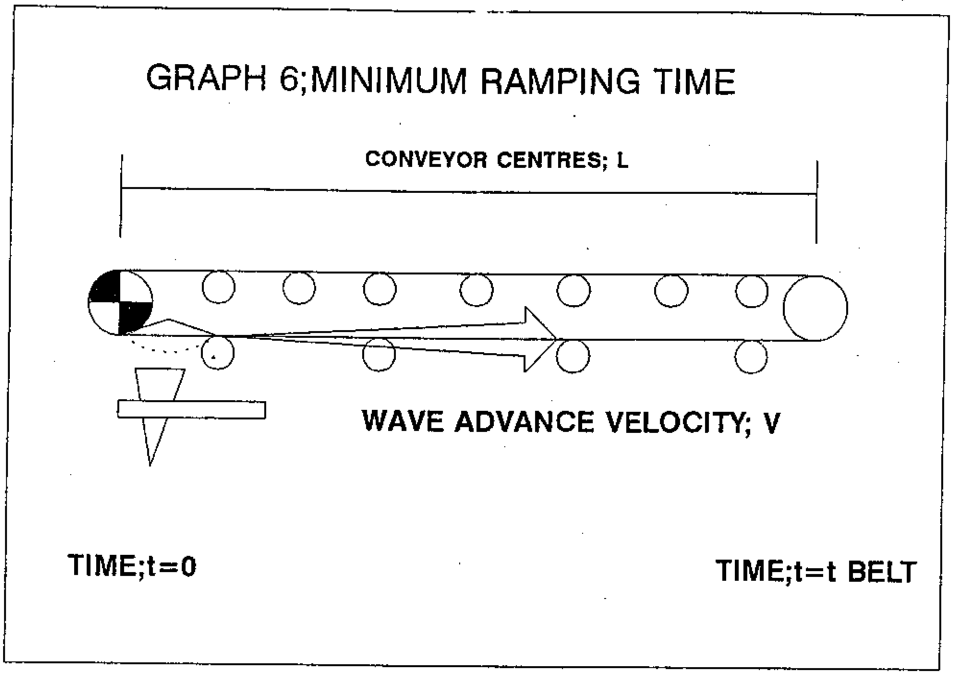


GRAPH 5;PROPOSED SPEC.



To ensure that high amplitude travelling waves are not excited in the belt, specification should be changed to allow for a minimum ramping time to reach the maximum allowable value, in order to accelerate the belt (refer to graph no. 5).

The minimum ramping time can easily be defined for any conveyor, given its belt centres and belt construction (refer to graph no. 6).



This proposal is based on findings published by The Institute of Conveyor Technology, Hannover University (Funke, H - The dynamic stress of conveyor belt systems when starting and stopping, Braunkohle n3 v26 p64-73 1974, translation).

<u>The simple rule is</u>: The ramping time from zero accelerating torque to maximum accelerating torque must be at least 5 x the time it takes for a disturbance to travel from the head to the tail in the return belt.

i.e. $t_{RAMP} > 5 \times t_{BELT}$

WHERE $t_{BELT} = \dfrac{\text{CONVEYOR CENTRES} \quad (L)}{\text{WAVE ADVANCE VELOCITY} \ (v/s)}$

Values for the wave advance velocity v are dependent on the belt construction and formulae to calculate them are available in various publications. (Funke, Harrison, Nordell et al.)

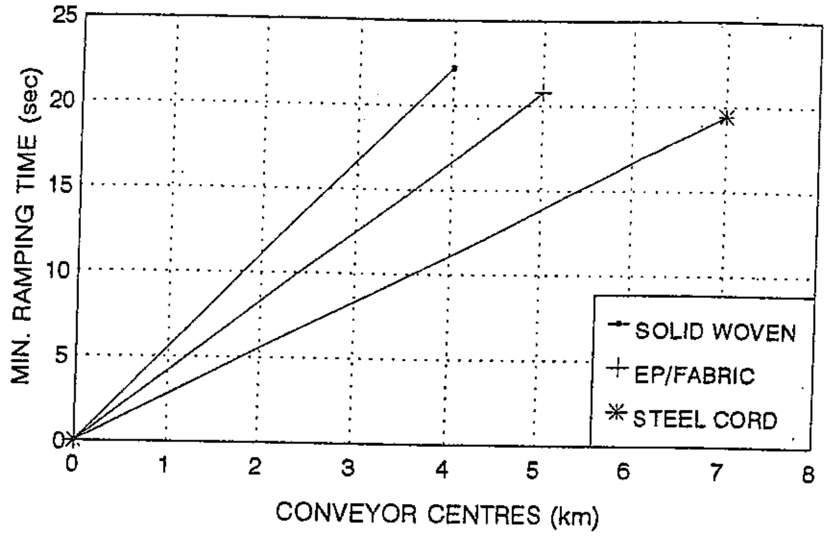
To allow ease of calculation (without losing too much accuracy), the following values may be used.

Steel cord belts:	1800 m/s
EP/fabric belts:	1200 m/s
Solid woven belts	900 m/s

Where this simple rule has been applied, measurements have verified, in all instances, that no high amplitude transient stresses occur in the systems during starting.

Graph no. 7 gives a simple selection procedure for minimum ramping time based on conveyor centres and type of belt used.

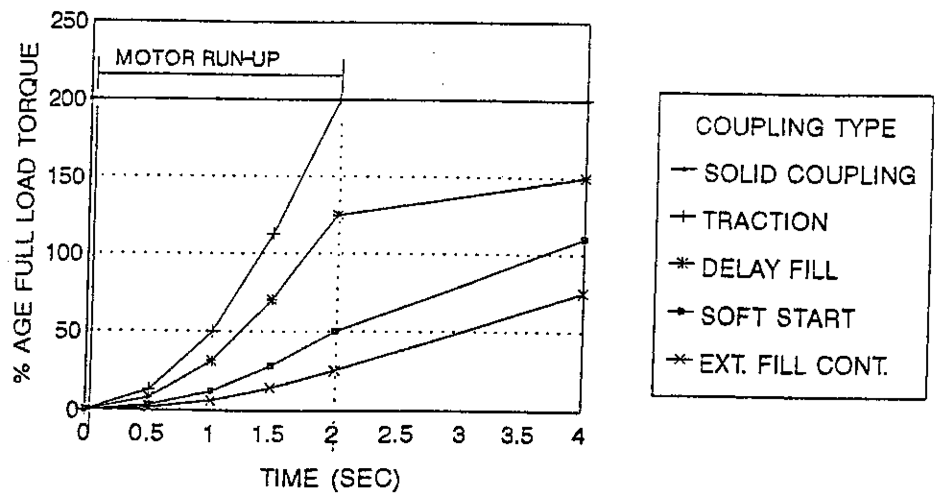
GRAPH 7;MIN. RAMPING TIME VS CONV. LENGTH



Squirrel cage induction motors combined with constant fill fluid couplings are the most widely used devices for driving and starting belt conveyors. Their only limitation is fixed heat capacity which may be exceeded for high inertia conveyor systems, such as long overland conveyors. Where this is the case, variable fill couplings are normally used.

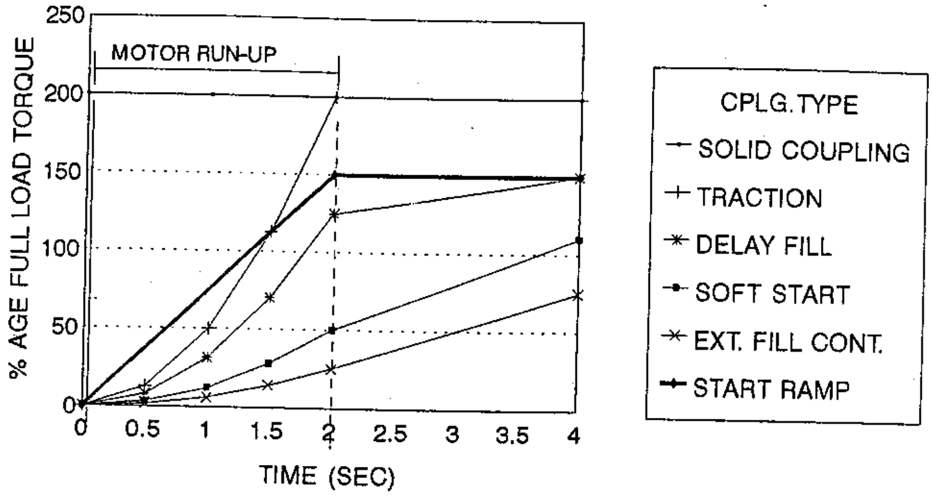
Graph no. 8 shows how different types of couplings build up torque on motor run-up (2 seconds start up used as example).

GRAPH 8; DIFFERENT DRIVE OPTIONS



Graph no. 9 shows an example of a 720 m. long steelcord conveyor with minimum ramping time of 2 seconds. Note that a delay fill coupling is suitable as its run-up torque falls below the minimum ramp line.

GRAPH 9; EXAMPLE 1; STEEL CORD 720 m BELT

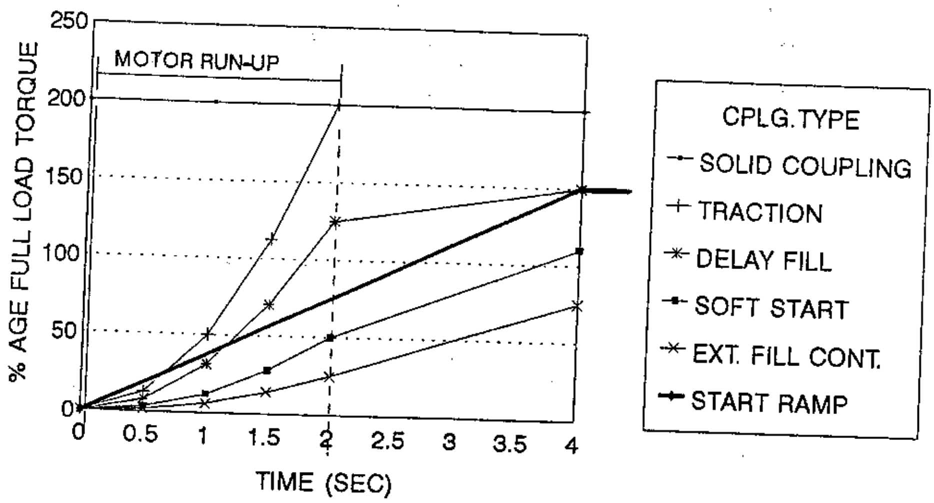


MIN. RAMP TIME;2 sec 150 % TORQUE LIMIT

Graph no. 10 shows a similar length belt, but using a solid woven belt. The minimum ramping time is now 4 seconds (twice the value for a steel cord belt, because the wave advance velocity is halved).

A delay fill coupling is not suitable for this application as its run-up torque is above the minimum ramp line. A superior coupling must be used.

GRAPH 10; EXAMPLE 2; SOLID WOVEN 720 m BELT



MIN. RAMP TIME;4 sec 150 % TORQUE LIMIT

The majority of larger conveyors employ multiple motor drives. In such cases the drives may be step started with sufficient time intervals to ensure that the minimum ramping line is not exceeded. The longer the time delays the more likely the first drive energized will overheat before the conveyor reaches full speed.

Graphs no.'s 11A, B and C show the effect of changing the time delays between energizing motors and type of coupling used. The application example is a 4,7 km steel cord overland conveyor with a peak torque limitation of 150%. From graph no. 7, the minimum ramping time is calculated to be 13 seconds. The go and no-go areas are thus defined.

Graph no. 11A shows the power build-up versus time, using delay fill couplings with 3 seconds between energizing each drive. The power build-up falls on the minimum ramping line and may thus lead to dynamic problems being experienced.

To ensure that the power build-up falls below the minimum ramp line, the time delays could be increased from 3 seconds to 5 seconds. This power build-up is shown in graph no. 11B.

No dynamic problems will be experienced with this sequence but another problem is introduced. i.e. The thermal heat capacity of the first drive coupling becomes critical.

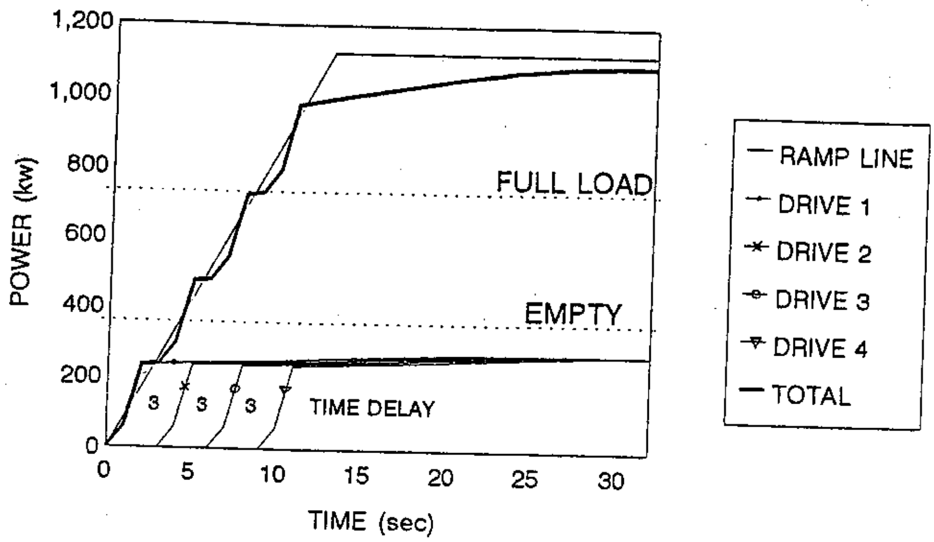
Note that the theoretical break-away for the conveyor would only occur, for a fully loaded belt, after approximately 15 seconds. Up to this time the first coupling is generating 250 kW continuously in the 100% slip position. All the heat generated during these 15 seconds must be dissipated by the coupling.

Graph no. 11C shows the final optimum solution: By using soft start couplings, the peak power after energizing each motor is only 180 kW (compared to 250 kW with the delay fill coupling).

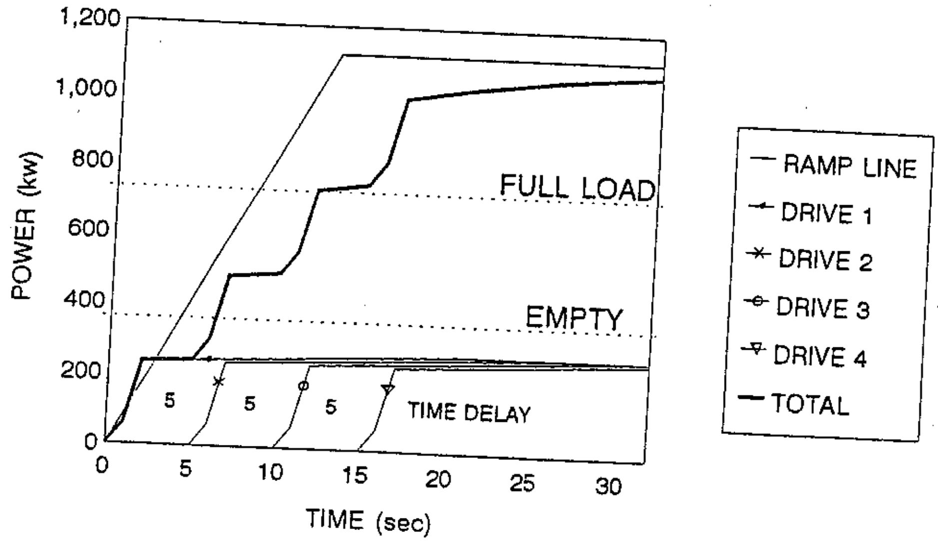
Hence the motors may be energized with a 3 second time delay and still ensure that the power build-up falls below the minimum ramp line as well as reducing the heat build-up in the couplings during starting.

Breakaway occurs after only 10 seconds (compared to 15 seconds with delay fill couplings).

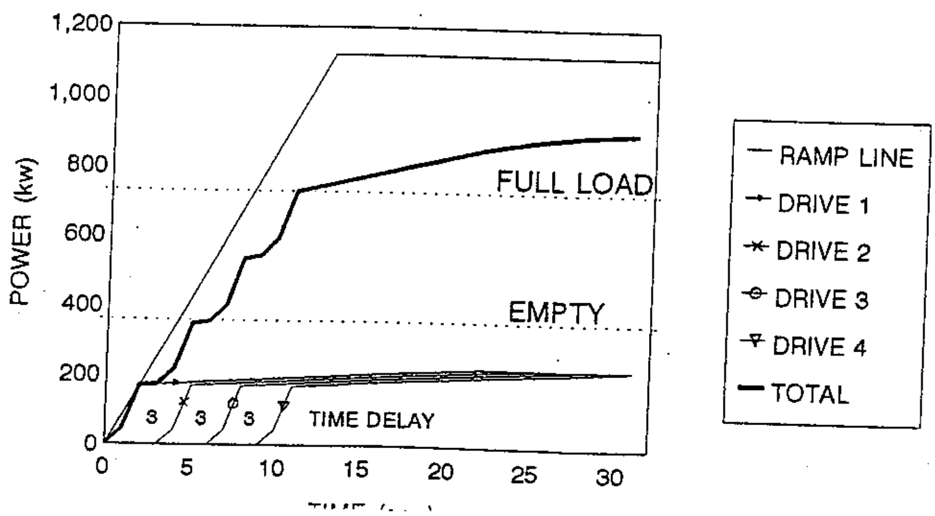
GRAPH 11A;STEP START USING DELAY FILL CPLGS.



GRAPH 11B;STEP START WITH 5 SEC. TIME DELAYS



GRAPH 11C;STEP START USING SOFT START CPLGS.

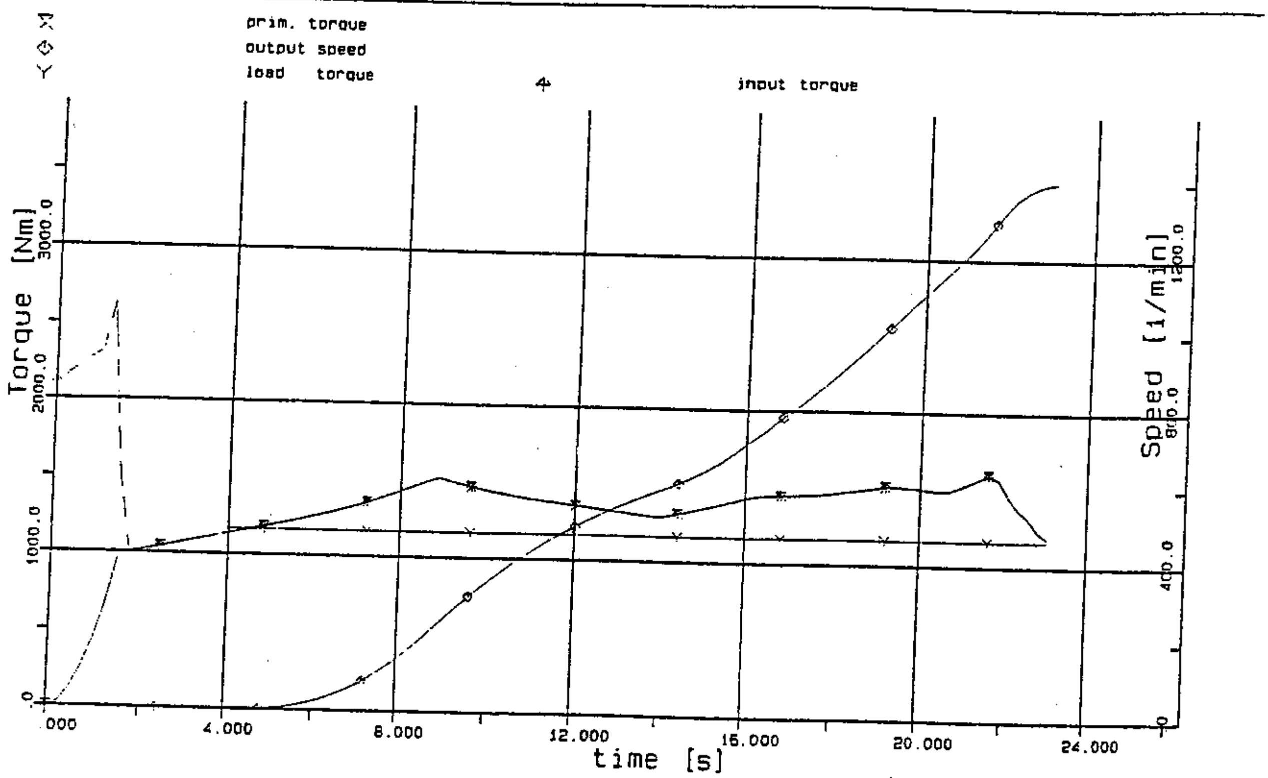


With modern computer aids, it is simple to model the suitability of a fluid coupling with respect to heat capacity.

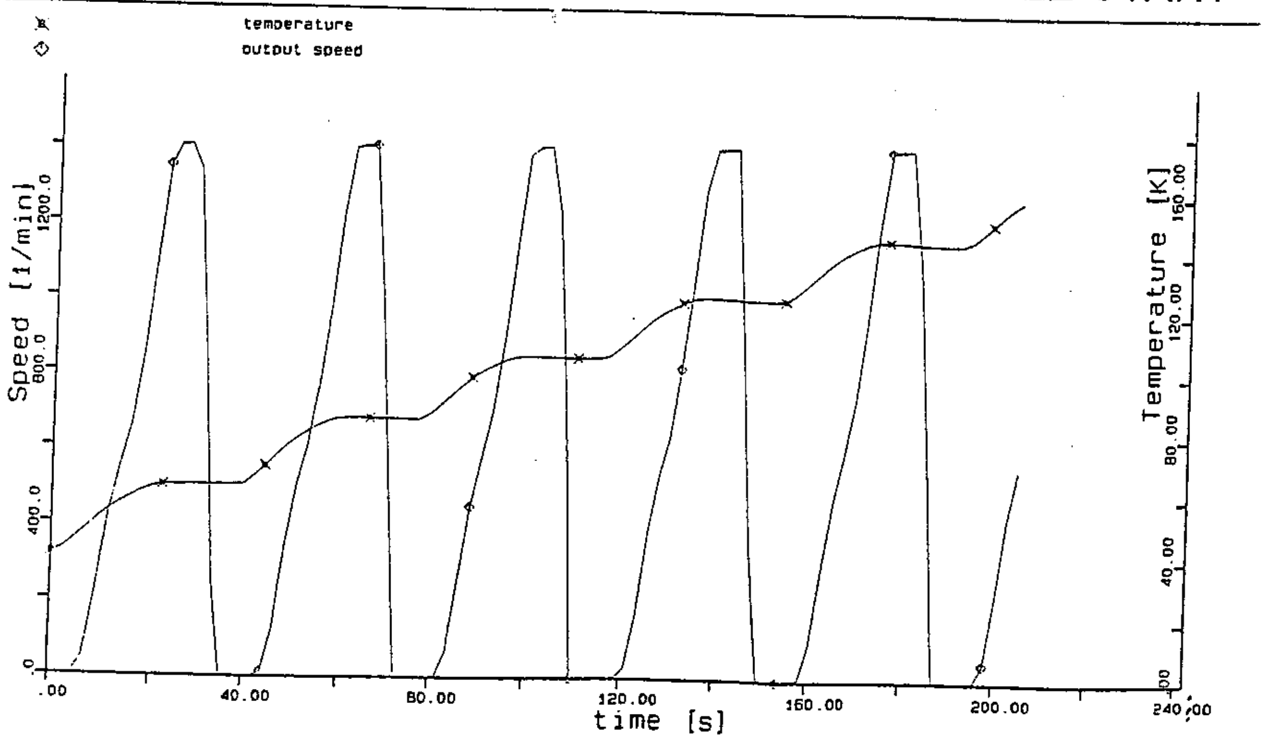
Graph no. 12A shows a typical example of acceleration and maximum torque limitation expected during one start.

Graph no. 12B shows the temperature rise expected after six consecutive starts.

GRAPH 12A;COMPUTER SIMULATION:SINGLE START-UP



GRAPH 12B;COMPUTER SIMULATION:MULTIPLE START



4. PROPOSAL 2 : TO VERIFY CONVEYOR PERFORMANCE DURING COMMISSIONING

In the past, little effort was made to verify the conveyor design in the field (mainly due to the high expense and sophistication of electronic measuring systems).

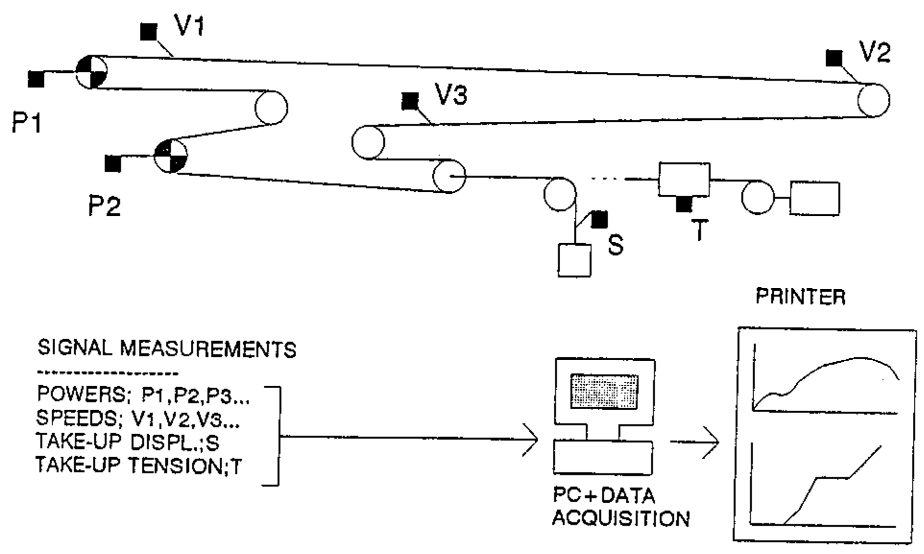
If the conveyor would not start, the contractor "made" it start by changing something from the original design (example: increasing take-up mass). This normally resulted in excessive forces somewhere in the system. During the hand-over period, these forces generally went unnoticed as no damage was evident. The client accepted the system in good faith and problems only began to occur thereafter.

To verify the conveyor performance, the following measurements should be made during starting and running conditions:

- Power consumption of all drives.
- Belt speeds at head, tail and take-up.
- Take-up displacement or winch tension and displacement.

Refer to graph no. 15.

GRAPH 15;MEASUREMENTS DURING COMMISSIONING



These measurements should be made for both empty and fully loaded conditions. They can be referred to as the "Signature" of the conveyor. The Signature verifies that all design conditions are met. The starting parameters and theoretical friction co-efficient factors would be verified.

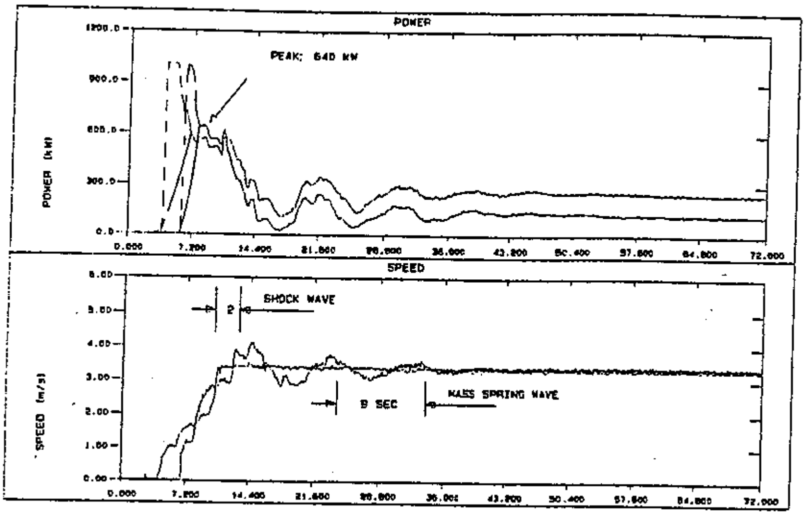
The following comparison highlights the need to verify the conveyor design thoroughly during the commissioning stage.

Graph no.'s 13A + B show a loaded and empty start for a problematic conveyor. This conveyor had been running for over a decade with low availability and high operating/maintenance costs.

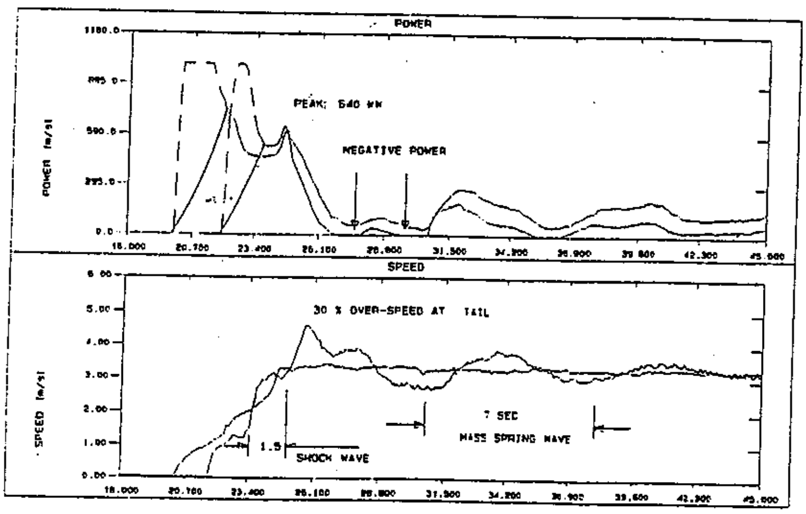
Graph no. 13C indicates the cause of the problem:

- The torque build-up exceeds the ramping line.
- The maximum allowable acceleration value exceeds that originally allowed for in the design.

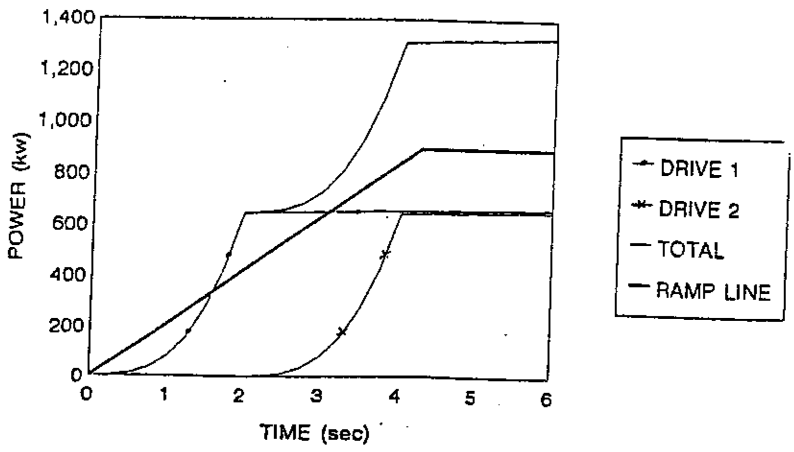
GRAPH 13A;LOADED START



GRAPH 13B;EMPTY START

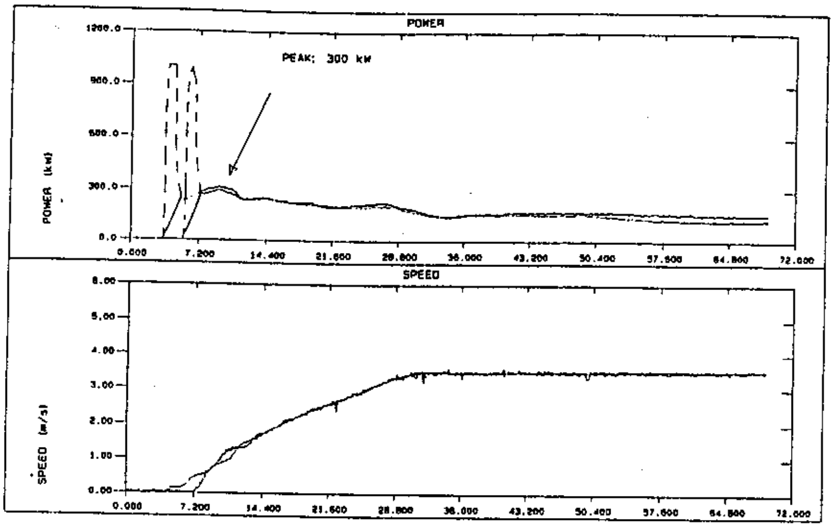


GRAPH 13C;0RIGINAL SINGLE DELAY CPLGS

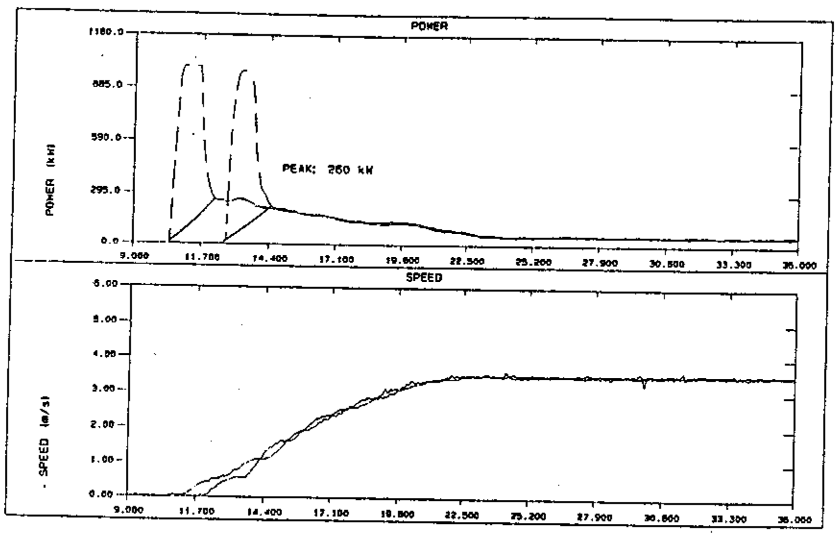


A decade later, the drives were upgraded with improved starting couplings (refer to graphs 14A + B). All transients (high speed and mass spring) disappeared. This may be credited to the torque build-up remaining below the minimum ramp line and the maximum allowable torque value not being exceeded (refer to graph no. 14C).

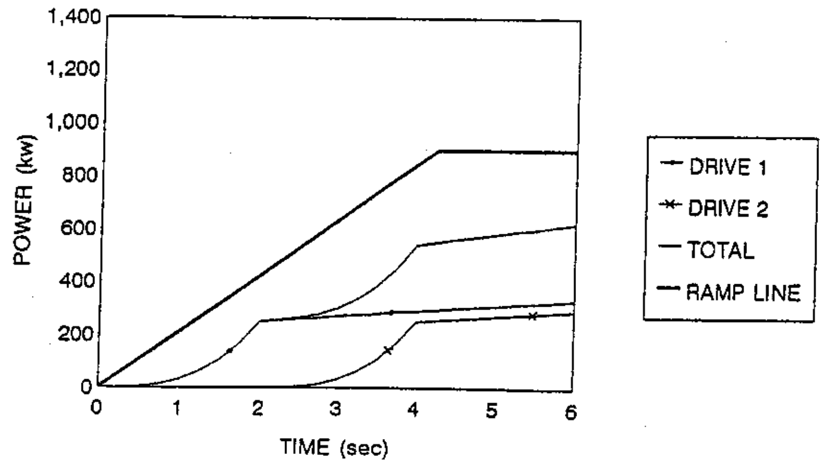
GRAPH 14A;LOADED START UPGRADE



GRAPH 14B;EMPTY START UPGRADE



GRAPH 14C; SOFT START CPLGS.



5. PROPOSAL 3 : TO MONITOR THE CONVEYOR PERFORMANCE AND IMPLEMENT THE MONITORING INTO PREVENTATIVE MAINTENANCE AND TROUBLE-SHOOTING PROCEDURES

Should problems be experienced with a conveyor after commissioning, the problem could be easily identified by re-measuring the conveyor performance and comparing these measurements to the original Signature.

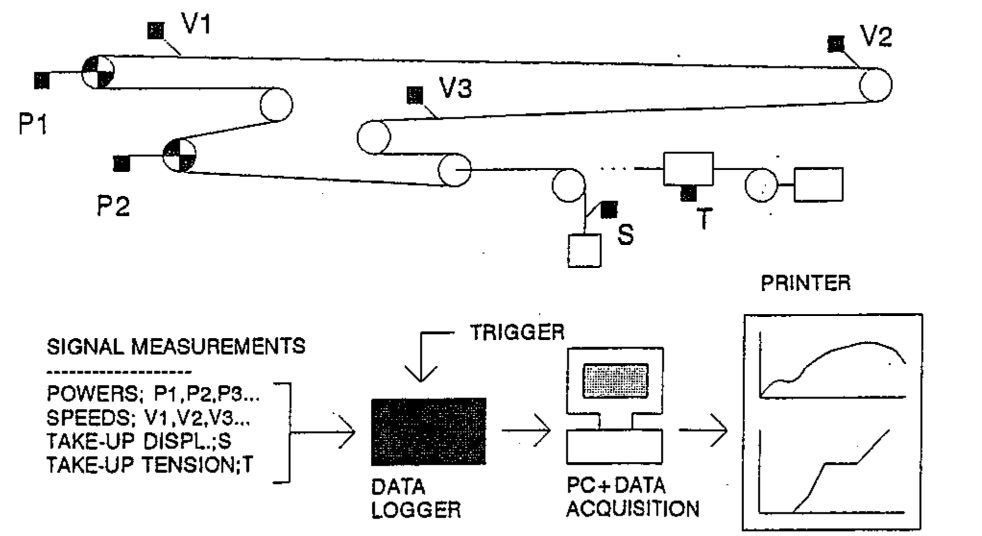
This proposal would also protect the designer and the equipment supplier if the user made modifications to the conveyor system outside the original design parameters.

Regular monitoring (say yearly) and comparison to the original Signature would identify any deteriorating aspects such as increasing friction co-efficients indicating idler deterioration.

For existing conveyor installations, the measuring equipment can be retrofitted temporarily or permanently. For new, medium-to-high-power conveyor installations, power, belt speed, and take-up displacement/tension transducers should be fitted permanently.

Measurements can be stored on a data logger system with triggers to activate measurement during desired operating conditions. The measurements can then be down-loaded onto a computer at any stage for further analysis (refer to graph no. 16).

GRAPH 16;SIGNATURE MEASUREMENT/MONITORING



The capital outlay for such a measuring system is negligible considering the benefits to be gained.

6. CONCLUSIONS

By implementing the three proposals put forward, significant savings in increased conveyor availability and decreased operating costs are obvious.

The proposals will benefit the conveyor users, designers, manufacturers and equipment suppliers. The image of belt conveyors in the material handling industry will be further enhanced.