https://doi.org/10.36375/prepare_u.iei.a237

Experience of Belt Jump and Sway in a Short Belt Conveyor

Bhaskar Dutta[1] and Anirban Datta[2]

[1]Vice President (Retd.) – ThyssenKrupp Industries
[2]Chief Technology Officer – MESCIA Engineers
(FD-217/7, Sector-3, Salt Lake City, Kolkata, West Bengal, India, Pin Code – 700106)

ani_dat@yahoo.co.in

Abstract – A limestone handling belt conveyor intended to carry 200 Metric Tonnes per hour met challenges during the start of operation. Simple conveyor, simple design parameters and rather simple layout yet engineers were rather struggling to tame the running of the conveyor.

This paper intends to provide the problems faced, analysis/diagnosis of the problem & remedial measures suggested. It is really an eye opener for young bulk material handling engineers working in the industry. It is also lesson learning for experienced engineers of the industry to create checks and balances in the working system to eliminate any lapse that can creep in but could be avoided.

Keywords – *Conveyor; Material handling; Belt; Troughability; Sway; Jump.*

INTRODUCTION

Bulk Material Handling Industry can't be thought of without Belt Conveyors. A Belt Conveyor consists of Idler, Pulley, Belt, Scrappers, Skirt Boards, Take Up, Protection & Safety switches, Couplings, Gear boxes, Motors, Drive options like Drive without soft start, Drive with soft start, Hydraulic Drive, VVFD drive, CST Drive, Gearless Drives and Supporting Structures. Experience would give us the clue that there is inherent and intrinsic tendency of Business Managers to make it too simplistic for short conveyors with small capacities thinking it to be too simple and trying to intrude in the design & operational features of Belt Conveyors sometimes unknowingly and unintended intrusion as well.

Associated with the above parts or components, some technical terms are Belt Speed, Troughing angle, Tensions (allowable, running, starting, empty belt), $e^{\mu\varnothing}$, μ, TIR (total indicated runout) of an idler, troughability of the conveyor belt, allowable material cross sectional area of belt, cosine correction and some more.

There are number of established books, codes and standards available in the archives to enable the engineer to get into the design aspects of Bulk Material Handling Industry at large and belt conveyor in particular. While high capacity, high speed, long belt conveyors in complex layout feature with/without curvatures in vertical and/or horizontal plane with multiple drives with/without regeneration receives due attention from experienced engineers, the smaller ones are left to younger engineers and allowed to be released from designer table to site for installation. However, the intended example that is presented here shows that the industry engineers ought to exercise caution to obtain desired results of operations even for small conveyors like the one presented in this article.

BELT CONVEYOR IN DISCUSSION – ITS PARAMETERS

- Material handled – Limestone
- Lump Size – 50 mm and down
- Bulk density – 1360 kg/m^3
- Angle of repose – 38^O
- Angle of surcharge – 20^O
- Rated Capacity – 200 MTPH
- Design Capacity – 230 MTPH
- Belt conveyor c/c – 180000 mm approx.
- Lift – 35 m (approx.)
- No of feed points – 2 (Two)
- Type of take up – Vertical Gravity
- Troughing angle – 35^O
- Drive margin – 1.36 at rated MTPH & 1.21 at design MTPH
- Type of Drive – Direct if selected motor is 75 KW or below
- Other stipulation – Top & bottom cover thickness of Belt shall not be less than 7 & 3.5 mm respectively.

LAYOUT DRAWING OF THE CONVEYOR

Following Fig. 1 indicates the layout (plan & profile) of the conveyor in discussion.

https://doi.org/10.36375/prepare_u.iei.a237

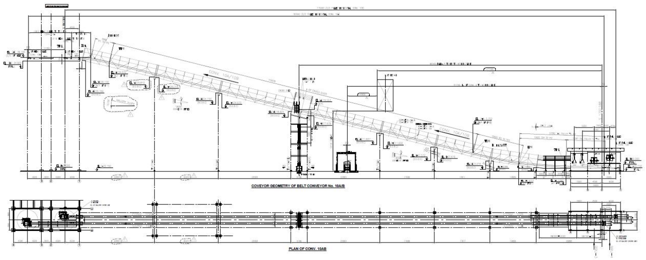

Fig. 1 Conveyor Layout.

Fig. 2 Belt jump.

Fig. 3 Belt sway.

DESIGNED PARAMETERS

- Belt – 600 mm wide, 35^{O} troughed, 630/4 with 7 mm top & 3.5 mm bottom EP belt
- 127 mm toughed equal roll idlers
- Drive – Snub drive with 45 kW Sq. Cage Induction Motor (with no soft start), Bevel Helical Drive, matching Pin Bush Coupling between Motor & Gearbox & Gearbox & Drive Pulley
- Take up – Vertical Gravity

WHAT WAS THE PROBLEM?

When the plant was taken up for operation, “no load” trials were being taken; the project site team noticed that:

- The belt is not touching the central idler. And the gap between belt and roller is uneven throughout the length of the belt conveyor.
- At the curvature zone, belt jumped quite a bit during no load trial.
- When the conveyor was taken for no load trial, the belt jumped & swayed too much on one side. There was no consistency in such sway i.e. sometimes it swayed on one side and in another time it swayed on opposite side. And the sway in carrying run was on one side where as the sway on return run was on the opposite side.
- During no load start, it appeared that the belt slipped a while and then the belt started running. Apparently, this introduced lagging wear rate more.

And ironically, the problems listed above were visible at two Project sites where two separate site teams were working.
Since the problems were repetitive at both sites, installation errors were practically ruled out.
Fig. 2 & Fig. 3 showing the ‘jump’ and ‘sway’ of the belt are given for the comprehension of the problem and visual understanding.
Design team studied the problem in detail and their findings are outlined below.

ANALYSIS OF THE PROBLEM

Careful scrutiny of the design revealed the following:
Empty belt power is hardly around double-digit mark. Whereas the motor selected was 45 kW. And the starting torque of motor of the selected vendor was 260% of full load torque (FLT) at rated voltage and rated frequency. Since Pin bush Coupling was installed between Motor & Gearbox, the starting torque of 260% of FLT was being witnessed by the belt resulting in abnormal jump of belt from the alignment.
And once belt jumped, the return of the belt was getting largely influenced by weight of the

https://doi.org/10.36375/prepare_u.iei.a237

belt, behaviour of the belt in free fall condition and such other.

That explained the unpredictable sway of belt conveyor and the reason of the abnormal jump at curvature zone.

Layout of the belt conveyor would give a geometrical calculation of the maximum radius of curvature and that worked out as 309 m (when the belt is partially loaded up to the start of concave curve) though there are other conditions also that need checks.

Could the layout engineer have increased the radius of curvature feasibility at least geometrically without compromising the engineering norms of such layout engineering? Answer is yes. Then why was it not done? Apparently, the engineer designed the conveyor preliminarily and did not refresh it with the actual equipment procured. May be it was too late to introduce any geometrical change in layout of the conveyor since the structural works proceeded much ahead without a room for trace back even if the plant engineer wanted to effect any change.

This is where the experience would have played a role. And that is why, this paper intends to bring it to the notice of the industry that small conveyors, be it small belt width, small capacity, short length and little height also deserve attention of experienced engineers.

The problem got complex since the base document stipulated direct drive for drives below 75 kW. And the young engineers who were a bit of inexperienced relied heavily on such stipulation and preferred not to raise the flag on the mother stipulation. One has to reckon the fact that the mother stipulation in the base document might have been done to cover most of the drives where such a stipulation might have proved to more than logical. That same needed a closer scrutiny is best realised by experienced engineers only. And that is why this deliberation stresses the need for checks & balances.

Second problem of troughability was looked at as follows:

Catalogues from reputed belt manufacturers provides recommendation for troughability purely on the bulk density (range given by belt manufacturer) and belt width (TABLE I). From that consideration, the designer, due to his/her lack of experience, found it to be okay for troughability of 600 mm conveyor belt at 35^{O} for a bulk density of 1.36 t/m^3, and abnormal cover thickness was not given credence that ought to have been given.

TABLE I

(TITLE: CONVEYOR BELT LOAD SUPPORT TABLE)[1]

Belt Rating	Minimum belt width for satisfactory troughing		Max. width for satisfactory load support		
	35^{O}	45^{O}	Upto 1 ton/m^3	Over 1 to 1.6 ton/m^3	Over 1.6 to 2.5 ton/m^3
kN/m			mm	mm	mm
315/3	500	600	1200	1000	800
400/3	500	600	1200	1050	900
500/3	500	600	1400	1200	900
500/4	500	600	1400	1200	900
630/3	600	650	1400	1200	1050
630/4	600	650	1600	1400	1200
800/4	650	800	1800	1600	1400
800/5	750	800	1800	1600	1400
1000/4	650	800	1800	1600	1400
1000/5	800	1000	2000	1600	1400
1250/4	800	1000	2000	1800	1600
1250/5	900	1050	2000	1800	1800
1400/4	1000	1200	2000	1800	1800
1600/4	800	1050	2000	2000	2000
1600/5	1000	1200	2200	2000	2000
2000/4	1050	1200	2000	2000	2000

Result: The practical experience showed that the belt is not touching the central idler. Some opinion was expressed that the belt would trough once the belt receives load and the troughability recommendation in the belt catalogue is with load.

GEOMETRICAL DIMENSIONS

Resilience of the conveyor geometry with respect to its behaviour to radius of curvature was checked for below conditions for young engineers to take note of.

Radius of curvature

- With direct drive considering the selected motor and its torque – speed characteristic curve:
  - ✓ At no load belt
  - ✓ At partially loaded belt up to the start of the curvature with design tonnage
  - ✓ At fully loaded belt at design tonnage
  - ✓ All the above conditions with 105% of rated frequency
  - ✓ All the above conditions with 95% of rated frequency

- With soft start introduced between Motor & Gear box:

https://doi.org/10.36375/prepare_u.iei.a237

This soft start shall be considered as 150% of FLT irrespective of motor torque with 4% slip (an average of 3 to 5% slip recommended by Hydraulic Coupling manufacturer)

- ✓ At no load belt
- ✓ At partially loaded belt up to the start of the curvature with design tonnage
- ✓ At fully loaded belt at design tonnage
- ✓ All the above conditions with 105% of rated frequency
- ✓ All the above conditions with 95% of rated frequency

One can also calculate the radii of curvatures with 3% slip and 5% slip. This slip largely depends on the Fluid Coupling model selected for a specific supplier

Loading cycle calculation for top cover thickness

TABLE II
(TITLE: RECOMMENDATIONS FOR COLD BULK MATERIALS WITH NORMAL LOADING CONDITIONS)[2]

Frequency Factor	Cover Grade (RMA)	Non Abrasive — Material such as lime, charcoal, wood chips, bituminous coal, grain — Material Class 5 (CEMA) — Lump size, inch				Abrasive — Material such as salt, anthracite, coal, phosphate rock, limestone, fullers earth — Material Class 6 (CEMA) — Lump size, inch				Very Abrasive — Material such as slag, copper ore, sinter, coke, sand, fine dust — Material Class 7 (CEMA) — Lump size, inch				Very Sharp Abrasive — Material such as quartz, some ore, foundry refuse, glass batch, iron borings — Material Class 8 (CEMA) — Lump size, inch			
		Dust to 1/4	1/2 to 1 1/3	2 to 5	6 and over	Dus tto 1/4	1/2 to 1 1/3	2 to 5	6 and over	Dust to 1/4	1/2 to 1 1/3	2 to 5	6 and over	Dust to 1/4	1/2 to 1 1/3	2 to 5	6 and over
0.2	2	3/32	3/16	3/16	3/8	3/16	3/8	-	-	3/16	-	-	-	3/8	-	-	-
	1	1/16	1/8	1/4	5/16	1/8	1/4	3/8	3/8	7/32	3/8	3/8	3/8	5/16	3/8	3/8	3/8
0.4	2	1/16	3/32	3/16	1/4	3/32	1/16	3/8	-	3/16	3/16	-	-	7/32	3/8	-	-
	1	1/16	3/32	1/8	3/16	3/32	1/8	1/4	3/8	1/8	1/4	3/8	3/8	3/32	5/16	3/8	3/8
0.6	2	1/16	3/32	1/8	3/16	3/32	1/8	1/4	3/8	1/8	7/32	3/8	-	3/16	3/16	-	-
	1	1/16	3/32	1/8	3/16	3/32	1/8	3/16	1/4	1/8	3/32	1/4	3/8	1/8	7/32	3/8	3/8
0.8	2	1/16	3/32	1/8	3/16	3/32	1/8	3/16	9/32	1/8	3/32	3/16	-	1/8	7/32	3/8	-
	1	1/16	3/32	1/8	3/16	3/32	1/8	3/32	3/16	1/8	1/8	7/32	3/8	1/8	3/32	5/16	3/8
1.0	2	1/16	3/32	1/8	3/16	3/32	1/8	3/32	7/32	1/8	1/8	1/4	3/8	1/8	3/16	3/8	-
	1	1/16	3/32	1/8	3/16	3/32	1/8	3/32	3/16	1/8	1/8	3/16	1/4	1/8	1/8	1/4	3/8
1.5	2	1/16	3/32	1/8	3/16	3/32	1/8	5/32	3/16	1/8	1/8	3/16	1/4	1/8	1/8	1/4	3/8
	1	1/16	3/32	1/8	3/16	3/32	1/8	5/32	3/16	1/8	1/8	3/16	7/32	1/8	1/8	3/16	1/4
2.0	2	1/16	3/32	1/8	3/16	3/32	1/8	3/32	3/16	1/8	1/8	3/16	7/32	1/8	1/8	3/16	3/8
	1	1/16	3/32	1/8	3/16	3/32	1/8	3/32	3/16	1/8	1/8	3/32	3/16	1/8	1/8	3/16	1/4
3.0	2	1/16	3/32	1/8	3/16	3/32	1/8	3/32	3/16	1/8	1/8	3/16	7/32	1/8	1/8	3/16	1/4
	1	1/16	3/32	1/8	3/16	3/32	1/8	3/32	3/16	1/8	1/8	3/32	3/16	1/8	1/8	3/16	1/4
4.0 and over	2	1/16	3/32	1/8	3/16	3/32	1/8	3/32	3/16	1/8	1/8	3/16	7/32	1/8	1/8	3/16	1/4
	1	1/16	3/32	1/8	3/16	3/32	1/8	3/32	3/16	1/8	1/8	3/32	3/16	1/8	1/8	3/16	1/4

NOTE: THE FREQUENCY FACTOR INDICATES THE NUMBER OF MINUTES FOR THE BELT TO MAKE ONE COMPLETE TURN ON REVOLUTION

TABLE II indicate that:

- 600 mm width is non-standard belt width in Indian context. Standard width is 650 mm
- 35^{O} troughing for such small width was a question mark. Designers relied too much on the customer requirement.
- Tension mandated that 630 kN/m shall have to be provided by the belt selected. Designer had the option of selecting 630/3 but designer selected 630/4 from other consideration that magnified the troughability issue of the belt not touching the central idler.
- Selection of EP belt instead of NN for the fabric of the belt also added stiffness.
- Loading cycle calculation indicated that 5 mm top cover would have been more than adequate. But customer stipulation of minimum top cover thickness indicated it to be 7 mm. That made the belt to be procured with top cover of 7 mm. And corresponding bottom cover though could have been made to be 3 mm to maintain the engineering practice of 1:3 between bottom & top cover but was selected as 3.5 mm based on customer requirement. Extra thickness also added stiffness to the belt for the flexural rigidity and thereby making trough further complex.
- Drive was stipulated as direct. That means the torque vs. speed in the transient period of the motor was being witnessed by the belt resulting lifting of the belt in no load condition. Procured motor was producing 260% of FLT at rated voltage and frequency. Torque speed characteristics curve of the motor is referred to.
- Critical look back of the conveyor calculation indicated that empty belt power was close to single digit and the loaded belt power with margin was close to 30 kW. But the designer selected a 45 kW drive presumably insisted upon by customer to make the selection extra safe.

Above would give the clue that the conveyor though small, in terms of layout parameters, width, capacity, belt speed and material conveyance, was installed with rather loaded parameters than required and without a soft start provision.
Design team of customer, contractor, component supplier and all other stakeholders have contributed in varying proportions to the parameters in building such over margin in the system.

MODIFICATION RECOMMENDATION

1. To introduce a fluid coupling of adequate rating to have smooth start with due checks for the space, ease of maintenance, finer parameters of bore checks of shaft (input & output) including tolerances
2. To reduce the trough angle of idlers to 20^{O}.

3. To introduce Guide roller in zigzag manner on both side of the conveyor at the cost of some additional wear at an interval of 20 m on carrying side and 40 m on return side

These modifications though not simple during commissioning phase because of time pressure were carried out successfully and the conveyors were running satisfactorily.

Conclusion

This paper is presented for young engineers to take cognizance of the inherent checks that they need to provide as also it is an eye opener for experienced belt conveyor specialists to properly guide young engineers to be aware of such complexities and raise flag at appropriate stage of execution so amends are possible avoiding loss of precious time of execution especially during end phase of a project when schedule is crashed.

Acknowledgement

The authors sincerely acknowledge the guidance and support provided by Mr. Amit Bhaduri, Former General Manager, Development Consultants Private Limited and Former Senior Consultant, ThyssenKrupp Industries, and convey thanks to the complete project team (Owner, Owner’s consultant, contracting company, equipment & component manufacturers & suppliers) of the subject case study with experts providing their valued comments for rectification.

References

[1] *Belt Conveyors for Bulk Materials*, 6th Ed., 2nd printing, published by Conveyor Equipment Manufacturers Association (CEMA), pp. 208
[2] *Selecting the Proper Conveyor Belt*, Fenner Dunlop – Conveyor Belting Americas, pp. 13