Assessment of energy savings

Benefits of mechanical pre-heater and blending silo feeding with bucket elevators

1. Introduction

With ever increasing energy and fuel costs the cement industry, like other energy intensive industrial sectors, is compelled to continuously examine potentials for energy savings. Significant investment in new techniques and plant upgrading have been made in recent years to remain competitive in a tight market. Reduction of energy consumption and productivity of the plant are major issues for all cement plant operators and investors.

New technological developments have made dry process plants very efficient with reduced electrical and thermal energy requirements. Research and development of equipment and technology suppliers to the cement industry has certainly taken a major part in the optimization process and provided tools to improve energy efficiency and avoid waste of energy.

One of these tools with a potential impact on productivity is the use of state-of-the-art bucket elevators instead of pneumatic transport systems to feed the pre-heater and blending silo. Mechanical conveying with bucket elevators has proved to be beneficial in various applications by reducing energy consumption and brought about a more efficient use of available energy in existing plants.

The present article demonstrates the advantages accompanying the use of belt bucket elevators for raw meal feeding of blending silos and pre-heaters versus the use of airlifts.

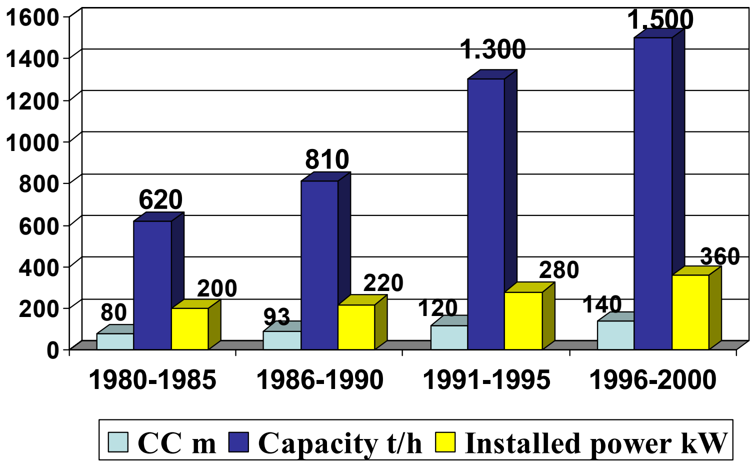
2. Developments

For many years airlifts were the conventional equipment for feeding of blending silos and pre-heaters. Easy operation was regarded as their main advantage. However, pneumatic systems are big energy consumers and with increasing energy and fuel costs, plant operators are more and more inclined to look at alternative solutions.

Development of belt bucket elevators nowadays allows to handle large capacities with lifts up to 140 m and make bucket elevators an economic alternative to pneumatic transport system.

The rapid pace of development in mechanical bulk material handling with bucket elevators is demonstrated with a review of the past 20 years (refer to Chart 1). To satisfy the increasing production output of modern dry process kilns, conveying capacities have more than doubled and lifts have increased by nearly 80% to match the four or five-stage pre-heaters. Considering these substantially increased capacities and lifts, the related power requirements remain remarkably low, an achievement of constant efforts in research and development.

Chart no. 1 - Development of Belt Bucket Elevators over the past 20 years



3. Advantages of bucket elevators over airlifts for raw meal feeding

Comparing bucket elevator feeding of blending silos and pre-heaters with pneumatic feeding, three prominent advantages are evident. Experience has shown that by eliminating the rotary piston blower required with the pneumatic transport system :

- 2/3 of the electrical energy can be saved
- the dedusting volume is substantially reduced
- the noise level is considerably reduced

With a bucket elevator the power required to remove the air introduced into the process by the airlift, can be saved.
In addition, in existing installations, always depending on the individual kiln process and operation, the thermal energy provided by the spare hot gas volume of the ID fan may be used for other sections in the process resulting in increased drying efficiency and thus higher productivity.

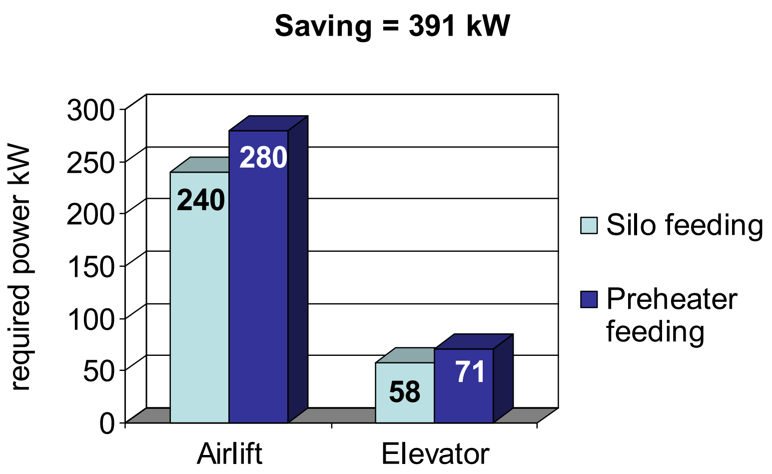
4. Savings achieved with Bucket Elevators

Looking at the financial incentive, we take the example of a clinker production line with a capacity of 3.000 / 3.300 t/d representing an average pre-heater feeding rate of 225 t/h and a blending silo feeding rate of 300 t/h. The lift for silo feeding is assumed with 60 m and the lift for pre-heater feeding is assumed with 100 m.

4.1 Savings on electric power required for the airlift

Considerable savings are achieved by eliminating the rotary piston blower required to drive the airlift. Based on the present example, the power required to lift the raw material to the top of the blending silo and the pre-heater tower amounts to 520 kW with the airlift and to 129 kW with the bucket elevator resulting in a total saving of 391 kW as shown in chart no. 2.

Chart no. 2 - Power Savings on conveying

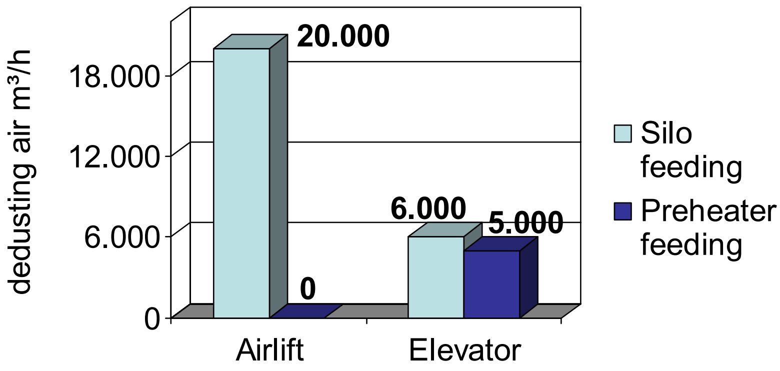


4.2 Savings on dedusting volume and related power

The savings on dedusting volume and the related electric power is shown in chart no. 3, providing a further 9 kW resulting from 20.000 m³/h or 20 kW with the airlift vs. 11.000 m³/h or 11 kW with the bucket elevator.

Chart no. 3 - Power savings on dedusting

Saving = 9.000 m³ or 9 kW

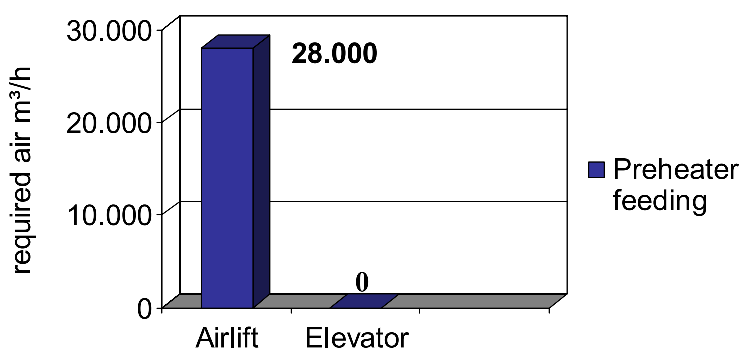


4.3 Savings on ID fan

A major item are the savings on the ID fan. An additional 56 kW can be added to the total amount of savings by taking into account the exhaust air volume of 28,000 m³/h produced by the airlift (Chart no. 4).

Chart no. 4 - Power saving on Exhaust fan

Saving = 28.000 m³/h or 56 kW



4.4 Additional power required with bucket elevators

While the pneumatic transport system is one independent unit, the bucket elevator requires additional subsequent conveying equipment such as an air slide and a screw and valve. The power required to drive these additional items with the present example amounts to 24 kW and will be deducted from the summary of savings.

5. Summary of power savings

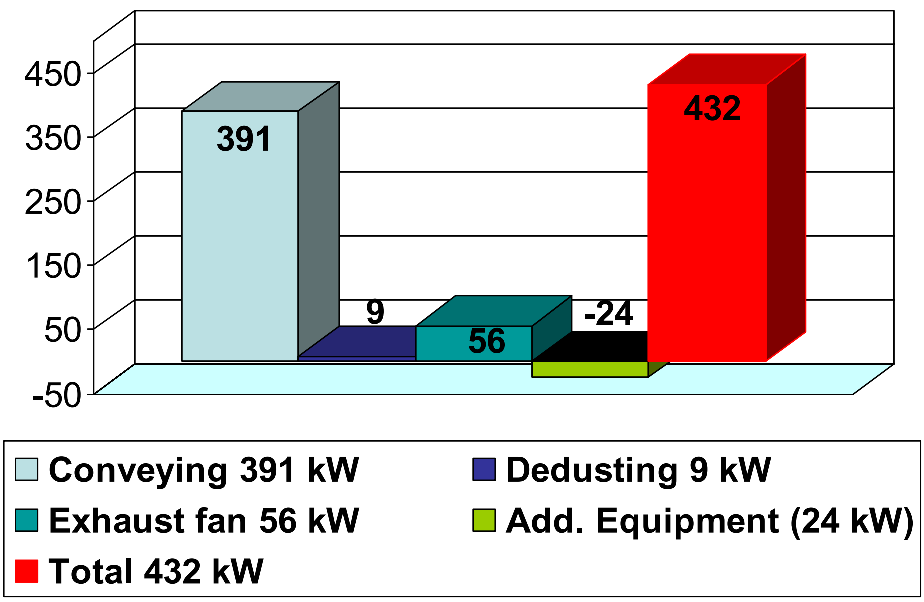
5.1 – Case 1

Based on the savings as listed in chart no. 5 and which result from the reduced power consumption, i.e. a total of 432 kW, the financial incentive may be summarized as follows :

<u>Assuming :</u>

7.200 operating hours x 432 kW	-	**3.110.400 kWh per year**
x USD 0.1 / kWh		
(depending on country of installation)	-	**USD 311.040,-**

Chart no. 5 – Summary of power savings including exhaust fan



5.2 – Case 2

In case of upgrading of an existing installation it may be interesting to look at the possible increase in productivity by using the fan's available power of 56 kW. With this solution, the savings of electric power are reduced to 376 kW as shown in chart no. 6, the 56 kW of the fan are however available for other purposes. The possible result is summarized as follows :

a) Savings due to reduced power consumption

<u>Assuming :</u>

7.200 operating hours x 376 kW	-	**2.707.200 kWh / year**
x USD 0.1 / kWh (depending on country of installation)	-	**USD 270.720,-**

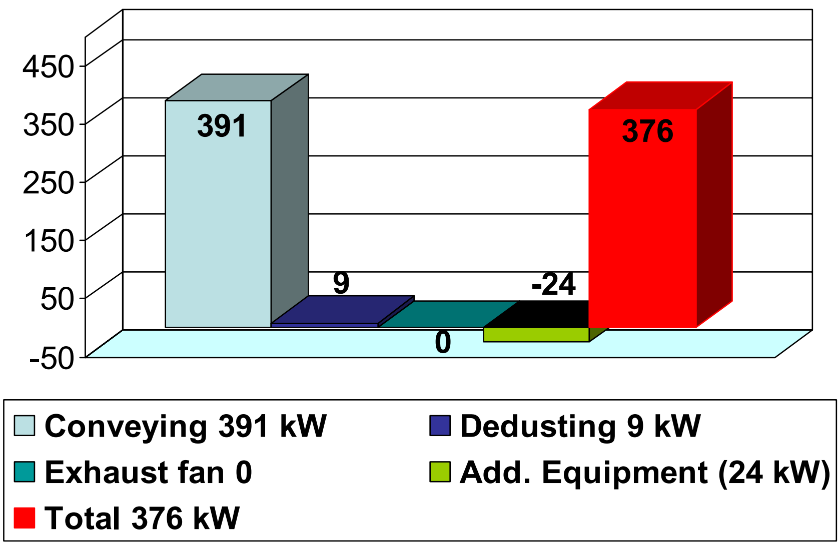
b) Possible capacity increase when upgrading existing plants

<u>Assuming :</u>

a 3% capacity increase, i.e., based on the present example of a 3.000 t/d kiln and 300 days of operation, 3.000 t/h x 0.03 % x 300 d/y	-	**27,000 t / year**
with 7,00 USD / t (depending on country of installation) the profit increase represents	-	**USD 189.000,-**

With the above figures – a) plus b), the total financial incentive represents **USD 459.720,-**

Chart no. 6 – Summary of power savings without exhaust fan



6. Investment costs and assessment of ROI

Taking into account the investment costs as per chart no. 7, i.e. USD 884.000,- the return on investment – without considering financial costs such as interest etc. – can be figured as follows :

Case 1 :

Investment	884.000 USD	=	~ **3 years**
Savings per year	311.040 USD		

Case 2 :

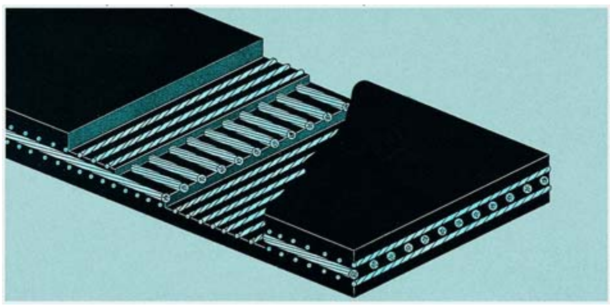
Investment	884.000 USD	=	~ **2 years**
Savings per year	459.720 USD		

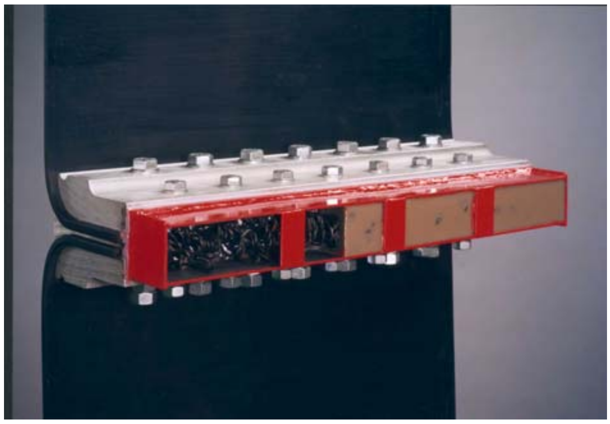
Chart no. 7 - Investment Costs for plant upgrading

	Silo feeding		**Preheater feeding**	
	Weight	**USD**	**Weight**	**USD**
Supplies and services	13 t	180,000	15 t	230,000
Local part	34 t	68,000	47 t	94,000
Additional equipment		38,000		58,000
Field assembly	47 t	60,000	62 t	80,000
Civil work		13,000		15,000
Electrical installation		23,000		25,000
Total		**382,000**		**502,000**
Investment costs	**USD 884,000**			

7. Special features and design criteria

Nowadays, new plants with a high production capacity use belt bucket elevators instead of air lifts on account of the above advantages and the proven reliability of belt bucket elevators. Aumund high-capacity bucket elevators installed in the cement industry are designed to achieve a high degree of availability and a long service live of the traction element .





The design calculation in accordance with VDI standard no. 2324 stipulates the nominal strength as the most important value for determination of the safety factor. The nominal strength has to be calculated under consideration of the that the areas where the rope mesh leaves free zones, i.e.

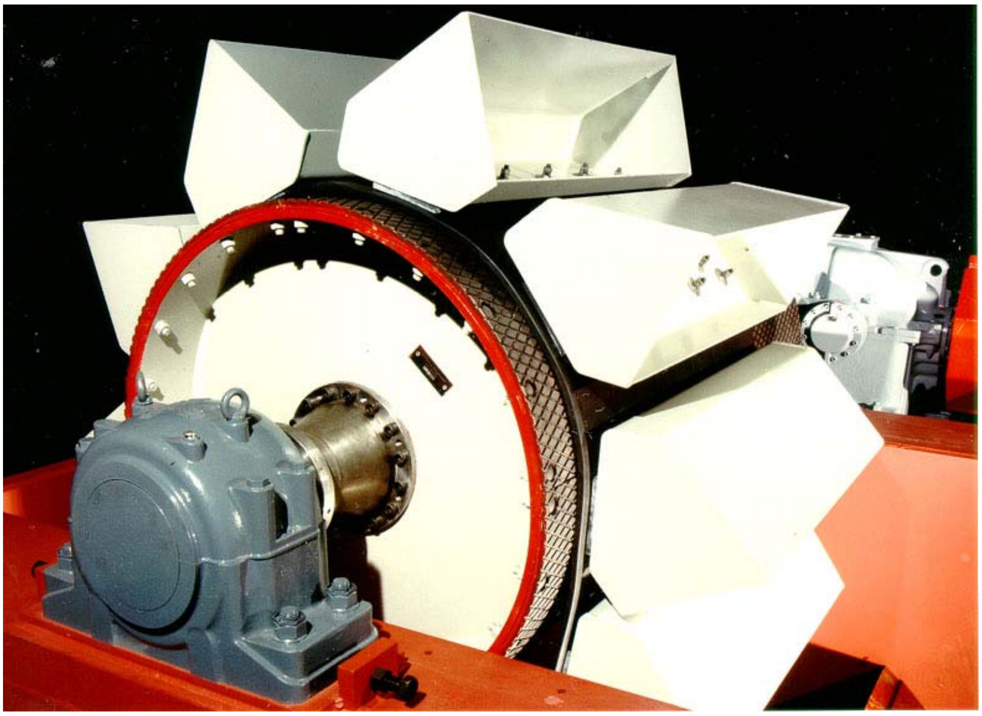
- border area
- bucket fixing
- bolt holes of the clamping connection

as the belt's tensile strength depends on the supporting steel ropes. The given tensile strength is a gross nominal value confirmed by quality tests and takes into account the rope-free areas on both belt edges.

The rope sections which are taken from the mesh by punching for the bucket fixing are deducted from the belt width in order to determine the net nominal strength. The specified safety factor always refers to this net nominal strength of a belt. A safety factor of min. 8 is always applied for the traction element used with bucket elevators. These very high safety factors result from influences which cannot be determined with accuracy, such as

- dynamics
- temperature
- motion
- variations of the bulk density, etc.

Experience has demonstrated that these safety factors are largely sufficient and we can assume that they are considerably overestimated in most cases. Continuous development is a main issue in order to keep up with the increasing capacities.



Conclusion - Present and Future Trends

The trend for large belt bucket elevators for raw-meal silo and pre-heater feeding is ever increasing since the kiln capacities are nowadays very often in the range of 5,000 - 7,500 tpd or even up to 10,000 tpd. Moreover, the centre distance is also continuously increasing due to the introduction of 5 and 6-stage pre-heater/pre-calcination systems.
In general, for "green field" projects can be said that belt bucket elevators for vertical transport are considered to be the ideal choice in the vast majority of these projects. The initial higher capital investment costs of the equipment are offset within very short time by the considerable advantage in lower operating costs due to reduced energy consumption.

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