Energy optimization in a Flour Milling plant

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Introduction

Primary concern:

- Contribution to energy saving debate
- Global energy prices
- Energy costs up to 5% of total running costs
- Investments for lowering power consumption must pay off
Overview

- Cost structure of a flour mill
- Energy consumption
- Consumption monitoring with WinEnergy control module
- Plant layout of transformer and low tension
- Starting characteristics and quality aspects of motors
- Technology and engineering aspects
- Summary
Cost structure of a Flour Mill

Example from mills in Europe

Raw material: 76 – 80 %
- Grain
- Additives

Profit xx %

Capital costs: 6 - 8 %
- amortization 3-4 %
- interest 3-4 %

Distribution: 7 - 8 %
- packing 2 %
- transport 2 %
- staff 2 %
- marketing 1 %

Production: 7 – 10 %
- Energy 3 – 5 %
- Staff 3 – 5 %
- Maintenance ~ 1 %

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Operating costs

Much attention has been already paid to operating costs in the past:

- Processes were constantly streamlined, reducing labor costs

  the focus now should be on saving energy

  and optimizing power consumption!
Energy Consumption

Total plant 75,2 kWh / to

Intake, pre-cleaning 200 t/h
1st cleaning 40 t/h
2nd cleaning 31.4 t/h
Mill 750 t/24h
Rebolting and bin filling mill
Flour handling mill
Wheat feed, germ, pelleting, screenings
Flour packing / palletizing
Auxiliary (compressor, air make-up)
Warehouse
Infrastructure
Automated Plant control

Power monitoring with WinEnergy

PLC

Profibus-DP

LT-DB 1
Intake / Cleaning

LT-DB 2
Mill / Bin filling

LT-DB 3
Flour handling / By-products

Consumption measuring in each section

Plant operating

Ethernet
Plant control with WinCos

Power monitoring with WinEnergy.
**Power supply / Infrastructure**

**Critical factors:**

- Δ actual power consumption vs. installed kW
- Oversized motors
- Simultaneous factor not considered (machines not running simultaneously)

**Consequences**

- Oversized transformer
- Power factor correction unit on limit
- Enormous loss through reactive power
- Cables, contactors and starters over-dimensioned
Plant layout: transformer and low tension

Transformer / Generator close to low tension-DB

Low tension-DB close to Motor Control Center
Starting characteristics of motors

- Depending on service hours, specific function and rating, the starting mode of drives have an appreciable impact on efficiency and electricity costs.
- Frequency converters (FC) and Softstarters (SS) are interesting alternatives.
- FC and SS are technically improved, moderate prices.
- FC improves power factor and motor efficiency.

This leads to reduction in Energy and costs for power factor correction.
Starting characteristics & Network current

Process:
Direct on Line

Advantages:
- torque straight available
- no extra investment
- simple installation

Disadvantage:
- huge starting current \(7 \times I_N\)
- high transformer load (short)
- voltage dip (short)

direct start \(I_N\) (Motor) = 2.3 A
Starting characteristics & Network current

Process:
- Star / Delta

Advantages:
- moderate investment
- simple installation
- known technology

Disadvantage:
- high starting current (2x $I_N$)
- 5-6x lower torque
- voltage dip (short)

Star / Delta $I_N$ (Motor) = 2,3 A
Starting characteristics & Network current

Process:
- Softstart (SS)

Advantages:
- min. additional cost
- simple installation
- transformer friendly appl.

Disadvantage:
- moderate starting current
- high transformer load (short)

Softstart with a 30% of boost
## Starting characteristics & Network current

**Process:**
- Frequency converter (FC)

**Advantages:**
- low starting current (<2x $I_N$)
- increase Cos $\phi$ (> 0.97)
- no Voltage dip
- energy saving
- great flexibility

**Disadvantage:**
- high initial Investment
- space requirement
- shielded cables (EMC)

Start with a frequency converter

![Graph showing starting characteristics and network current with low starting current and increased Cos $\phi$.]
Quality aspects of Motors

Quality indication of motors ➔ real efficiency $\eta > 0.9$

- **Iron core loss (18%)**
  - optimized steel quality
  - thinner lamination

- **Rotor loss (24%)**
  - optimized steel quality
  - thinner slats

- **Stator copper loss (34%)**
  - optimized grooves
  - larger wiring

- **Loss due to bearing/air friction (10%)**
  - smaller fan

- **Spread loss (14%)**
  - improved design of surface

$\eta > 0.9$
Technology and Engineering aspects.

Compact building concept minimizes conveying distance

- Wheat Silo
- Storage / Bagging
  Byproducts
  Pellet Mill
- Storage / Bagging
  Finished products
- Mill

→ reduction in installation costs
→ saving in power consumption
Engineering aspects:

- 1\textsuperscript{st} and 2\textsuperscript{nd} Break roller mills installed above plansifter (12-18% lower air volume)

- Less pneumatic lifts
  - Energy saving

- Control sifter and weigher in direct flow

- no relift
  - Energy saving
Eight-roller-mill

Twin-Drive with one motor for 2 passages

up to 45kW motors
Eight-roller-mill “Twin-Drive”

- Eight roller MDDO with 4 motors of 37 kW each passage (total 148 kW)
- Eight roller MDDO with 2 motors of 45 kW for two passages (total 90 kW).

Reduction up to 39% of the installed power
Mill pneumatic: ‘Energy saving through air volume reduction’

- 20% reduced air speed (m/s)
- 10% lower negative pressure
- 25% reduced air volume (m³/min)

Previous design

Horizontal conveying incl. elbow Ø 132.5mm

Optimized design

Horizontal conveying incl. elbow Ø 120mm
Mill pneumatic: Summary

Example of a 275to / 24h Wheat flour mill

- 1st BK / 2nd BK Eight Roller mill above plansifter

Power requirement with optimized design of pneumatic system: 76.5 kW (310m³ instead of 360m³)

- motor installed: 90 kW instead of 110 kW

- Mill-Pneumatic fan equipped with a Frequency converter

Power factor improved \( \cos \varphi > 0.97 \)

Energy saving up to 10% possible
Central rinsing air blower with frequency converter

FC operation ➔ 10 - 30% Energy saving

- airflow permanently adjusted to actual need
- no pressure relief into atmosphere
Air compressor with frequency converter

FC operation ➔ - 40% Energy saving

- necessary pressure lower, remaining constant
- airflow permanently adjusted to actual need
**Summary**

- Each motor which can be avoided leads to a power saving
- Use motors with a power factor $\cos \phi > 0.9$
- Evaluate the use of frequency converters

- Optimize mill pneumatic
- Use of Twin-Drive on eight-roller mills
- $1^{st}$ BK / $2^{nd}$ BK roller mills above plansifter can save energy
- In-line flour re-bolting and weighing avoid re-lifting

- Use elevators instead of blow lines where adequate
- Operate sub-processes during off-peak times
  (over night)
Summary continued

- Design transformers only as large as really needed
- Place transformers close to DB and consumers
- Long cable distances mean higher power losses
- Oversizing cables creates high investment costs (copper and steel prices)

- Use automated control systems to improve processes (optimize start-/stop sequences, control controller, adjustment settings)
- Use energy management systems (WinEnergy) (supervision/monitoring of energy consumption)
Thank you for your attention.

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