Replace V-Belt Drives with Cog Belts (Arc 2.4111)

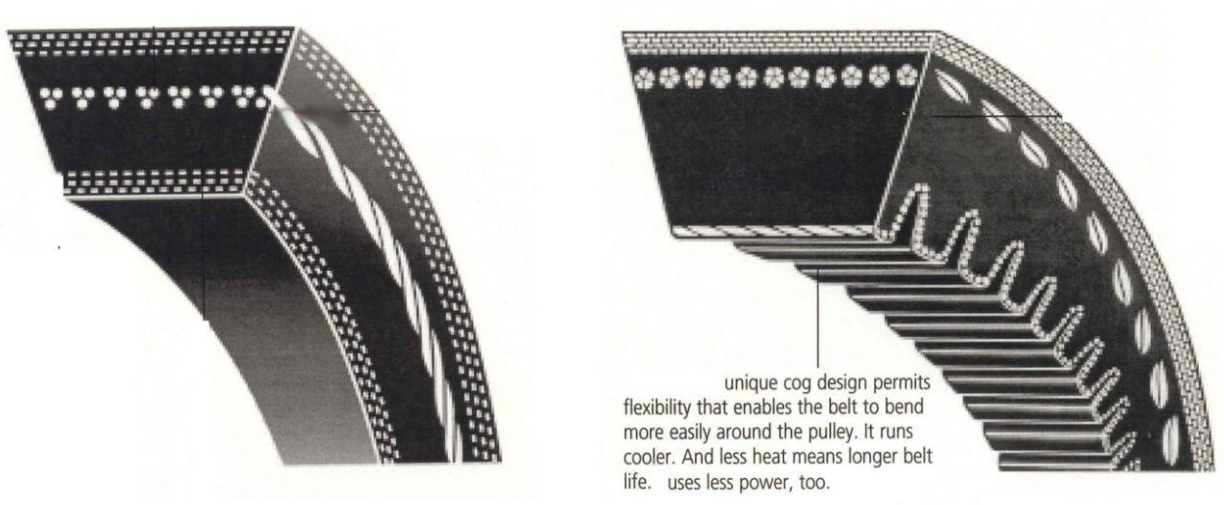
(The analysis below was extracted from one of the assessment reports by the Clemson University Industrial Assessment Center (IAC). This is only an example recommendation and hence, not all the background information and sources for numbers are included here.)

Est. Electric Consumption Savings	= ***188,057.4kWh/yr***
Est. Electric Consumption Cost Savings	= ***$12,492.7/yr***
Est. Electric Demand Savings	= ***501.5kW***
Est. Electric Demand Cost Savings	= ***$2,241.7/yr***
Est. Total Cost Savings	= ***$14,734.4/yr***
Est. Implementation Cost	= ***$3300***
Simple Payback Period	= ***2.7months***

Recommended Action:
It is recommended that all the V-belts on material handling fans and conveyers be replaced with cog-belts to decrease power consumption and increase efficiency.

Background:
The assessment team noticed that several conveyers and fans throughout the facility were utilizing smooth V-belt style drive systems. It is known that by using V-belts a fraction of the work produced by the motor is lost as heat since the belt flexes and slips around the pulleys. Cog-belts are another type of drive belt that have notches on the inner face, flex easier, consume less power for the same type of operations, and thus are more efficient compared to V-belts. Figure 1 illustrates samples of these two types of belts. It is also shown that cog-belts last 50% to 400% longer, reducing downtime and maintenance costs[1]. We recommend replacing the V-belts with cog-belts on all mechanical conveyers and other support equipment motor drives. The equipment is operating two 9-hour shifts, 5 days a week, and 50 weeks annually adding up for a total of 4500 hours. The plant is charged $0.06643/kWh for electric consumption and $4.47/kW for electric demand.

[1]**Carlisle Power Transmission Products,** Energy Loss and Efficiency of Power Transmission Belts, http://www.michaelsenergy.com/PDFs/energy_loss_and_belt_efficiency.pdf Energy Tips: Replace V-Belts with Cogged or Synchronous Belt Drives, DOE/GO-102000-0972, Office of Industrial Technologies, U.S. Department of Energy



V-Belt **Cog-Belt**

Source: Dayco CPT, www.cptbelts.com

Figure 1: Regular V-belt vs. high efficiency Cog-belt

Anticipated Savings:

Before anticipated savings can be calculated, voltage and current readings were taken from multiple v-belt driven machines. The electrical data for those machines are given below in Table 1.

Table 1: Electrical readings for the machines equipped with V-belt Drives

Description	# of Units	Voltage (V)	Current (A)	Power Factor
Material Handling Fan	3	460	282	85%
Conveyer	8	460	112	87%

We provide an example of electricity consumption and demand savings calculations for a single material handling fan. Rest of the calculations for all the equipment mentioned above is done similarly.

The current *power consumption* of a single material handling fan can be calculated as follows:

$$Power = \frac{\sqrt{3} \times Voltage \times Current \times Power\ Factor}{1000\,\frac{W}{kW}}$$

$$\boldsymbol{Power = \frac{\sqrt{3} \times 460V \times 282A \times 85\%}{1000\,\frac{W}{kW}} = 191kW}$$

Based on the previous field studies and peer reviewed publications[2], replacing V-belts with cog-belts would result in an average of 3.5% reduction in power consumption. Thus, the *power reduction* due to using cog-belts can be calculated as:

[2] NREL, *Synchronous and Cogged Fan Belt Performance Assessment*. 2014.

$$Power\ Reduction = Current\ power \times 0.035$$

$$\boldsymbol{Power\ Reduction = 191\ kW \times 0.035 = 6.7\ kW}$$

The annual *electric consumption savings, ECS*, is then the *power reduction* multiplied by the hours of operation.

$$Electric\ Consumption\ Savings\ (ECS) = \ Power\ Reduction * Hours\ of\ Operation$$

$$ECS = 6.7\ kW \times 4{,}500\ hr$$

$$\boldsymbol{ECS = 30{,}079.3\ kWh}$$

The annual *electric consumption cost savings, ECCS*, is the following:

$$Electric\ Consumption\ Cost\ Savings\ (ECCS) = \ ECS * Electric\ Rate$$

$$\boldsymbol{ECCS = 30{,}079.3 kWh \times \frac{\$0.06643}{kWh} = \$1998.2}$$

There will also be an electrical demand decrease as the required power for running the motor will decrease after changing the belts. The annual *electric demand savings, EDS,* is the following:

$$Electric\ Demand\ Savings\ (EDS) = Power\ Reduction * 12\ \frac{mo}{yr}$$

$$\boldsymbol{EDS = 6.7 \frac{kW}{months} \times 12 \frac{months}{year} = 80.2\ kW}$$

The annual *electric demand cost savings, EDCS*, is the following:

$$Electric\ Demand\ Cost\ Savings\ (DCS) = \ EDS \times Demand\ Rate$$

$$\boldsymbol{EDCS = 80.2\ kW \times \frac{\$4.47}{kW} = \$358.5}$$

The annual *total cost savings*, *TCS*, for changing the belts on a single material handling fan can be calculated as follows:

$$Total\ Cost\ Savings\ (TCS) = ECCS + EDCS$$

$$\boldsymbol{TCS = \$1998.2\ +\ \$358.5 = \$2356.7}$$

The summary of electricity consumption and demand savings for all the mentioned machines on Table 1 is presented in the Table 2 below.

Table 2: Annual electricity consumption and demand savings

Description	Electricity consumption saving (kWh)	Electricity consumption cost saving ($)	Electricity demand saving (kW)	Electricity demand cost saving ($)
Material Handling Fans (for # 3 units)	90,237.8	5,994.5	240.6	1,075.6
Conveyers (for # 8 units)	97,819.7	6,498.2	260.9	1,166
Total	**188,057.4**	**12,492.7**	**501.5**	**2,241.7**
		Total Cost Saving ($)		**14,734.4**

Implementation Cost:

The *implementation cost, IC*, can be calculated by multiplying the number of v-belt drives that need to be replaced by the cost of each cog belt drive system. The equipment cost is pulled from a multitude of vendors then averaged for a more accurate cost and doubled for the labor and installation cost. The price of the equipment is $150, so the total cost per machine is $300.

$$IC = \frac{\$300}{belt} \times 11\ belts$$

$$\boldsymbol{IC = \$3,300}$$

Simple Payback Period:

The *simple payback period, SPP*, is the time that must elapse before the anticipated total cost savings equal the implementation cost, and is calculated by:

$$SPP = \frac{IC}{TCS} = \frac{\$3{,}300}{\frac{\$14{,}734.4}{yr}} \times 12\,\frac{months}{year}$$

$$\boldsymbol{SPP = 2.7\ months}$$