
Variable Frequency Drives in Dairy Vacuum Milking Systems

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USING VARIABLE FREQUENCY DRIVES IN DAIRY VACUUM MILKING SYSTEMS

INTRODUCTION

To maintain the stable vacuum needed for milking cows, air must be removed from the system at the same rate at which air enters the system through the pulsators, claws, leaks, unit fall-off and other equipment such as milk meters when present. Air does not enter the milking system at a uniform rate, but is rather erratic due mainly to units being attached and falling off the cows. Conventional vacuum control is accomplished by having a vacuum pump, sized to the largest possible air flow into the milking system, running a full speed. The difference between the pump capacity and the actual air entering the system is made up by allowing air to enter the system through a regulator. The concept of this new vacuum control system is to adjust the speed and capacity of the vacuum pump such that the air removed equals the air entering the milking system. No conventional controller or regulator is needed during milking

PROJECTS IN CALIFORNIA

The new vacuum control system was demonstrated on two California dairy farms; one in the Tulare/Hanford area and the second near Chino.

The Cross Creek Dairy is located at 15528 Fifth Ave, Hanford. The dairy has two double 20 parlors, each milking about 1,600 cows twice each day. The original vacuum pumps were 30 hp water ring, one for each parlor. Following a regulator efficiency test, which showed a rather poor efficiency, the regulator was relocated and a 20 hp lobe/blower pump was installed on the east parlor. In early February 1997 the variable frequency drive with direct vacuum feedback system was installed. The conventional controller was set at one inch above milking vacuum. The vacuum stability with the new vacuum control system is equal or better than the conventional regulator.

The following table presents information about the energy use and savings for this farm resulting from the changes. At \$0.08 per kWh, about \$4,000 was saved by each change. Because water ring vacuum pumps do not perform well at low speeds (less than one half), the pump would have to be changed before the variable frequency drive could be installed. The horsepower of the pump for this double 20 parlor, based on ASAE S518.2, could be 15. A 20 hp lobe pump was installed. With the variable frequency drive, the motor is developing about 10 hp during milking. The controller would not have to be relocated in order for the variable frequency drive to operate satisfactorily. Thus the savings over the next five years due to downsizing the pump horsepower and adding the variable frequency drive would be at least \$40,000.

<u>Cross Creek Dairy System</u>	Pump Type	Pump Hp	Energy kWh/day	Power kW	Hp/unit	EUI*	Savings kWh/yr
Original pump & controller	Water ring	30	470	25	0.75	54	n/a
Relocated controller	Lobe	20	330	18	0.50	38	51,000
VFD with Feedback	Lobe	20	170	9	0.25	20	57,000

The second dairy chosen was the Corona Dairy Ranch, 6313 Archibald Ave., Corona. On this farm 830 cows were milked three times a day in a double 16 parlor with two 15 hp vane (oil lubricated) vacuum pumps. Originally this farm used both pumps for milking and for pipeline washing. Following a regulator efficiency test, the regulator was relocated and one pump was used for milking and two pumps for washing. The vacuum pumps operate about 23 hours per day.

A variable frequency drive was installed on a new 15 hp lobe pump in November 1997. Operating data for this milking system is presented in the following table. Based on measurements made, the new control system, when properly tuned, was capable of maintaining vacuum stability equal to the original regulator.

<u>Corona Dairy System</u>	Pump Type	Pump Hp	Energy kWh/day	Power kW	Hp/unit	EUI	Savings kWh/yr
Original pump & controller	Vane	2 - 15	590	26	0.93	88	n/a
Relocated controller	Vane	15	290	13	0.46	43	110,600
VFD with Feedback	Lobe	15	107	5.3	0.16	16	66,800

The energy savings at Corona Dairy Ranch are significant. Less than one-fifth of the power is now used with the variable frequency drive compared with the original system.

PROJECTS IN OTHER STATES

Eight other farms in New York, Vermont and Hawaii were studied by the Cornell Agricultural Energy Program (CAEP) for energy savings using the variable frequency drive. The results of these tests are presented in the following table.

When pumps are too large for the number of milking units and/or the system has minimum air leaks, the pump may run too slow while maintaining milking vacuum. For rotary vane pumps, this can cause the vanes to clatter and for lobe pumps they may over heat. When this happens, an intentional air leak must be provided. This obviously reduces energy savings but the pumps must be protected.

Farm	Cows	Milk/day	Milking Units	Pump hp	Installed hp/unit	Pump Type	EUI* Before	EUI* After	Savings kWh/yr
A	190	3	16	7.5	0.47	Vane	43	20	13,100
B	105	3	10	5	0.50	Lobe	56	22	10,700
C	613	3	28	15	0.54	Vane	56	21	64,360
D	950	3	2 - 16	2 - 20	1.25	Vane	68	28**	111,000
E	240	2	8	9.5	1.19	Vane	71	22**	23,500
F	410	3	24	10	0.42	Lobe	73	13	73,800
G	470	3	24	10	0.42	Lobe	86	17	97,300
H	200	3	16	7.5	0.47	Vane	89	24**	39,000

** With an intentional air leak

* To compare the effectiveness of various energy conservation systems, the term EUI (Energy Utilization Indices) was established. This term appears in these tables. The units of this EUI are kWh per year-cow-milking each day. For example, the energy saved annually at Cross Creek Dairy is kWh/yr = (38 - 20) x 1,600 x 2 = 57,600.

Tests have been run on water ring vacuum pumps to assess their performance with variable frequency drives. The performance of the pump tested deteriorated below half speed. Unfortunately, this limitation restricts the reserve capacity of the pump and also the potential energy savings. At this time variable frequency drives are not recommended for water ring vacuum pump.

About eight years ago 26 New York dairy farms with conventional vacuum control systems were monitored by CAEP for energy use by the vacuum pump motor. Combining these with the 10 farms described here, the average EUI was 67 kWh/cow-yr-milking with a range of 41 to 91. For the group of 10, the average energy use after installing the variable frequency drive was 20, including the three farms where an intentional air leak was necessary. The savings average 70 percent.

The suggested retail prices from one manufacturer for a new vacuum control system ranges from \$1,500 for a 5 hp unit to about \$8,000 for a 30 hp unit. The installation costs vary considerably from farm to farm depending somewhat on whether the pump has to be replaced. Reviewing the energy savings listed in the tables above and assuming energy costs \$0.08 per kWh, the annual dollar savings ranged from \$800 for the 5 hp vacuum pump to nearly \$9,000 for the 20 hp pump reduced from 30 hp. The simple pay back can range from less than one year to several years.

Today there are at least 200 milking systems working, from Vermont to Hawaii, where vacuum is being controlled by direct vacuum feedback to a variable frequency drives on the vacuum pump. Some of these systems have been operating for over 3 years on

both rotary vane (oil lubricated) and lobe/blower pumps. Today, there are 10 units operating California. Currently there are at least four companies marketing these systems.

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