Use Multiple Speed Motors or AFD for Variable Pump, Blower, and Compressor Loads (Arc 2.4141)

(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	= ***230,825 kWh/yr***
Est. Electric Consumption Cost Savings	= ***$17,312/yr***
Est. Electric Demand Savings	= ***632 kW/yr***
Est. Electric Demand Cost Savings	= ***$5,675/yr***
Est. Total Cost Savings	= ***$22,987/yr***
Est. Implementation Cost	= ***$32,413***
Simple Payback Period	= ***16.9 months***

Recommended Action:
It is recommended to update the existing compressors and pumps running on part load with variable frequency drives (VFD). VFDs have a lower energy requirement for the same amount of work done.

Background:
The plant uses a full load capacity compressors, pumps and motors. However, a few of them run at part-load. We suggest the use of variable frequency drive for these components to increase the efficiency of the plant. Upon careful analysis, it is recommended that variable frequency drives be used on recirculation pumps and the bubble cannon mixing compressor. Variable frequency driven compressors will have higher part load efficiency than modulating compressors, meaning they will use less energy at fractional loads than modulating compressors.

Anticipated Savings:
Generally, the power consumed by a pump in its functioning is calculated as the product of voltage, ampere and the hours of usage of the compressor.

(i) The plant currently runs a 15 hp recirculation pump at 230V/41A/0.85 power factor.
The power consumed by this compressor is given by:

$$\textbf{\textit{Power consumed} = 230 \times 41 \times 0.85 \times 3 = 24.05kW}$$

For this calculation, an estimate of 50% reduction in power consumed is used. Note that this value may be higher or lower based on many variables:

$$\textbf{Reduction in power consumption (50\%) (}\textbf{\textit{RPC}}\textbf{) = (½) } \times \textbf{\textit{ Power Consumed = 12.03 kW}}$$

The annual *electricity consumption saving* for the pump can be calculated as the product of kW saved and the hours of operation of the unit.

$$\textit{Electrical consumption saving (ECS) = RPC} \times \textit{Operation hours}$$

= 12.03kW × 4380 hour/yr

= 52,691 kWh/yr

Finally, the estimated annual electric consumption cost savings can be determined based on the unit electricity consumption charge as:

Electric consumption cost savings (ECCS) = ECS × ($0.075/kWh)

ECCS = 52,691 kWh/yr. × (*$0.075kWh*) = $3,952/yr

(ii) The plant currently runs a 60 hp recirculation pump at 230V/139A/0.85 power factor.
The power consumed by this compressor is given by:

Power consumed = 230 × 139 × 0.85 × 2 = 54.35 kW

For this calculation, an estimate of 50% reduction in power consumed is used. Note that this value may be higher or lower based on many variables:

Reduction in power consumption (50%) (*RPC*) = (½) × *Power Consumed = 27.18 kW*

The annual *electricity consumption saving* for the pump can be calculated as the product of kW saved and the hours of operation of the unit:

Electrical consumption saving (ECS) = RPC × Operation hours

= 27.18 kW × 4380 hour/yr

= 119,048 kWh/yr

Finally, the estimated annual electric consumption cost savings can be determined based on the unit electricity consumption charge as:

Electric consumption cost savings (ECCS) = ECS × ($0.075kWh*)*

ECCS =119,048 kWh/yr. × ($0.075kWh) = $8,929/yr

(iii) And, the estimated cost saving for compressor is calculated as follows:

The plant currently runs 30 hp (x2) compressor at 230V/69A/0.85 power factor.
The power consumed by this compressor is given by:

Power consumed = 230 × 2 × 0.85 × 69 = 26.98 kW

For this calculation, an estimate of 50% reduction in power consumed is used. Note that this value may be higher or lower based on many variables:

Reduction in power consumption (50%) (*RPC*) = (½) × *Power Consumed = 13.49 kW*

The annual *electricity consumption saving* for the compressor can be calculated as the product of kW saved and the hours of operation of the unit:

Electrical consumption saving (ECS) = RPC × Operation hours

= 13.49kW × 4380 hour/yr.

= 59,086 kWh/yr.

Finally, the estimated annual electric consumption cost savings can be determined based on the unit electricity consumption charge as:

Electric consumption cost savings (ECCS) = ECS × ($0.075kWh*)*

ECCS = 59,086 kWh/yr. × (*$0.075/kWh*) = $4,431/yr

The estimated demand savings (*EDS)* by installing the VFD's on the compressor and the pumps is:

EDS = (RPC (compressor) + RPC (15 hp pump) + RPC (60 hp pump)) × 12 mos/yr

EDS = (13.49 kW + 12.03 kW + 27.18 kW) × 12 mos/yr

EDS = 632 kW/yr

The estimated demand cost savings (*EDCS*) is calculated as follows:

EDCS = EDS × Electric Demand Rate

EDCS = 632 kW/yr × $8.98/kW

EDCS = $5,675/yr

The total cost savings (*TCS)* by installing the VFD's on the compressor and Pumps is:

TCS = ECCS (compressor) + ECCS (15 hp pump) + ECCS (60 hp pump) + EDCS

= $4,431 + $3,952+ $8,929 + $5,675

TCS = $22,987

<u>Implementation Cost</u>:

The installation cost to update the pumps and compressor is as follows. The installation cost is estimated to be 12-16% of the cost of a compressor. We are using 15% as a higher approximation for our calculations. The estimated cost of the new variable drive for the

compressor (30 hp) is $7,546; the estimated costs to update recirculation pumps are $6,237 and $14,402 for 15 hp and 60 hp, respectively.

Implementation cost of the compressor (IC 1) = ($7546) + (15% × $7546) = $8677.9

Implementation cost of the 15 hp recirculating pump (IC 1) = ($6237) + (15% × $6237) = $7172.55

Implementation cost of the 60 hp recirculating pump (IC 2) = ($14402) + (15% × $14402) = $16562.3

The total implementation cost for installing the VFD's (*IC) = IC 1 + IC 2 + IC 3*

= 8677.9+7172.55+16562.3

= $32,413

<u>Simple Payback Period</u>:

The *simple payback period, SPP*, is the time required to pass before the estimated total cost savings equal the estimated implementation cost, and is calculated by:

$$SPP = \frac{IC}{TCS} \times 12\ months/year$$

$$SPP = \frac{\$32{,}413}{\$22{,}987/yr} \times 12\ months/year$$

= 16.9 months