6.1 Introduction

In this chapter economical outcome of application of VSD in Motor Driven Pumping System is worked out. The economic justification of using VSD for pumping system for test set-up as well as RO Plant in Dairy industry is carried out briefly compared to DCM.

Energy projects are important to the economy as well as environment. For any energy conservation projects to justify the capital investment, it is important by carrying out the financial analysis. The simple pay-back analysis is the most popular method but energy conservation projects should be analyze in more detailed methods like Net present value and Return on investment.

The simple payback period is the time required to recover the capital investment. After the completion of payback period capital investment is recovered and any additional cost saving are considered as profit.

\[
\text{Payback period} = \frac{\text{Capital Cost}}{\text{Net annual savings}} \quad (6.1)
\]

Return on Investment is the annual return as a percentage of Capital investment. Return on investment is the reverse is the inverse of payback period.

\[
\text{Return on investment} = \frac{\text{Annual net savings}}{\text{Capital cost}} \times 100 \% \quad (6.2)
\]

Return on investment should be higher than the interest rate at which money is borrowed. The higher return on investment shows better investment opportunities.
The net present value (NPV) method gives the present value of annual net savings and capital investment of all the years of service life of the energy saving project. Investment costs are shown as negative values while saving are shown as positive values. The NPV is the sum of present values of all the years of service life. Higher value of NPV shows that the project is more attractive.

\[
NPV = \frac{NAS_0}{(1+i)^0} + \frac{NAS_1}{(1+i)^1} + \ldots + \frac{NAS_n}{(1+i)^n} = \sum_{t=0}^{n} \frac{NAS_t}{(1+i)^t}
\]  

Where,

NPV = Net Present Value

NAS = Net Annual Savings at the end of year \( t \)

\( n \) = Life span of the project in years

\( i \) = Interest rate

The project is better if the NPV is positive. Negative value of NPV means project will cause the economic loss.

\subsection*{6.2 Financial analysis of application of VSD with experimental set-up}

The economic analysis of DCM v/s VSD application for test set-up is worked out. For this economic analysis certain operating assumptions are made. Since such motor-pump sets are used in process industries, it is assumed that the set is used for 24 hours a day for 300 days in a year. The typical variation in flow rates in a day is given in Fig. 6.1.

![Fig. 6.1 Flow rate variation for Test set-up](image-url)
Electricity cost is taken as Rs.4.25 per unit. Maximum Demand charges are not considered for this application. The capital cost including VFD, wiring, spare parts and installation costs are taken as Rs. 22000. The service life of set-up is considered as 10 years and annual interest rate is considered as 9%. Fig. 6.2 shows the comparison of power consumption for VSD and DCM at different flow rates. Annual cost saving is worked our as Rs. 17000 per annum. (Table 6.1)

![Graph showing power consumption comparison for DCM and VSD](image_url)

**Fig. 6.2 Comparison of power for DCM and VSD for Test Set-up**

<table>
<thead>
<tr>
<th>Flow m³/hr</th>
<th>DCM KW</th>
<th>VSD KW</th>
<th>Saving KW</th>
<th>Hours/day</th>
<th>Saving KWh/day</th>
<th>Annual working hours</th>
<th>Annual Saving KWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5</td>
<td>0.544</td>
<td>0.361</td>
<td>0.183</td>
<td>3</td>
<td>0.549</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.634</td>
<td>0.262</td>
<td>0.372</td>
<td>8</td>
<td>2.976</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td>0.744</td>
<td>0.191</td>
<td>0.553</td>
<td>6</td>
<td>3.318</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.844</td>
<td>0.147</td>
<td>0.697</td>
<td>3</td>
<td>2.091</td>
<td>7200</td>
<td>17000</td>
</tr>
<tr>
<td>1</td>
<td>1.2</td>
<td>0.101</td>
<td>1.099</td>
<td>4</td>
<td>4.396</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>1.33</strong></td>
<td><strong>24</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Payback period \( = \frac{22000}{17000} \) \( = 1.3 \) years

Return on investment \( = \frac{17000}{22000} \times 100 = 77.2 \% \)
\[
NPV = \frac{-22000}{(1 + 0.09)^0} + \frac{17000}{(1 + 0.09)^1} + \frac{17000}{(1 + 0.09)^2} + \frac{17000}{(1 + 0.09)^3} + \frac{17000}{(1 + 0.09)^4} + \frac{17000}{(1 + 0.09)^5} \\
+ \frac{17000}{(1 + 0.09)^6} + \frac{17000}{(1 + 0.09)^7} + \frac{17000}{(1 + 0.09)^8} + \frac{17000}{(1 + 0.09)^9} + \frac{17000}{(1 + 0.09)^10}
\]

\[= -22000 + 15596 + 14308 + 13127 + 11048 + 10136 + 9299 + 8531 + 7827 + 7180\]

\[= 87095\]

The NPV of 87095 indicates that the project will generate all the savings of Rs. 87095 in terms of present value.

### 6.3 Financial analysis of application of VSD in RO Plant in Dairy Industry

A large Dairy Industry located in Gujarat is having a RO water treatment plant with a pump capacity of 64 M\(^3\)/hr and maximum head of 196.9 meter coupled with an Induction motor of 37 KW/2950 rpm/50 Hz with full load current of 69amps. The average working of pump is 16 hours a day at a flow rate of 39 m\(^3\)/hr. As the pump is not operating at full load, it is a good example of application of VSD.

Looking at the loading pattern of the RO plant pumping system, annual energy consumption is worked out and comparison of power and energy consumption with DCM and VSD in given in Fig.6.3 and Table 6.2.
6.3.1 Saving in Energy cost and demand charges calculation

Annual energy consumption with DCM = 143 MWh
Annual working hours = 16 hours/day * 365 days = 5840 hours

As per affinity laws,
Pump flow rate is proportional to speed.

\[ Q \alpha N \]

\[ \frac{Q_1}{Q_2} = \frac{N_1}{N_2} \]

Speed with VSD = 2950 * 39/64 rpm
= 1798 rpm

Also, \( P_1/P_2 = (N_1/N_3)^3 \)
Power with VSD = 37 KW * (1798/2950)^3 = 8 KW

Annual energy consumption with VSD = 47 MWh
Annual energy saving = 96 MWh (Fig.6.4)

As per Gujarat Electricity Regulatory Authority schedule of charges for HT consumers,
MD Charges per month = Rs. 120 per KVA
Current energy price = Rs. 4.25 per KWh
Table 6.2 Comparison of parameters of DCM v/s VSD for RO Plant

<table>
<thead>
<tr>
<th></th>
<th>DCM</th>
<th>VSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Operating Hours</td>
<td>5840</td>
<td>5840</td>
</tr>
<tr>
<td>Speed of Motor (rpm)</td>
<td>2950</td>
<td>1798</td>
</tr>
<tr>
<td>Power (KW)</td>
<td>37</td>
<td>8</td>
</tr>
<tr>
<td>Annual Energy Consumption (MWh)</td>
<td>143</td>
<td>47</td>
</tr>
</tbody>
</table>

Annual Savings:

1. MD charges \( = (37 - 8) \times 120 \times 12 = 41760 \)
2. Energy charges \( = (143 - 47) \times 10^3 \times 4.25 = 408000 \)

Total Annual Savings = Rs. 449760

Total cost of VFD, installation charges and spare parts is worked out as Rs. 600000.

a) Payback period \( = (600000/449760) = 1.33 \) years
b) Return on investment \( = (449760/600000) \times 100 = 75 \% \)
c) Net present value (NPV) : The service life span of equipment is considered as 10 years and rate of interest is taken as 9 %.

\[
NPV = \sum_{t=0}^{10} \frac{NAS_t}{(1+9)^t}
\]

\[
= -600000 + 412624 + 378554 + 347297 + 318621 + 292313 + 268177 + 246034 + 225719 + 207082 + 189983
\]

\[
= 2286401
\]

The NPV of 2286401 indicates that the project will generate all the savings of Rs. 2286401 in terms of present value.

6.4 Conclusion

In this chapter economical outcome of application of VSD in Motor Driven Pumping System is worked out. The economic justification of using VSD for pumping system for test set-up as well as RO Plant in Dairy industry is carried out briefly compared to DCM.