ABSTRACT

The McKay Bay Refuse-to-Energy Facility underwent a three-year retrofit program completed in 2001. The major portion of this work involved the replacement of all four combustion trains. The existing turbine generator set, rated at 22.5 MW, was retained. Each of the four boilers had a maximum continuous rating (MCR) of 62,186 lb/hr of steam; i.e., 248,744 lb/hr with all boilers in operation. The turbine generator operated at about 220,000 lb/hr (about 93% capacity), thus allowing for load swings due to fuel inconsistencies. As a result of the difference between the boiler MCR and the rate into the turbine, excess steam (over 26,000 lb/hr) was sent to an existing bypass (dump) condenser.

Upon installing a new automatic governor control system for the turbine during the retrofit, the potential for providing additional control capabilities was realized. Utilizing an available second control feature on the governor control system, a major portion of the bypassed steam could be sent to the turbine via an innovative split-range control system configuration. The formerly bypassed steam was now added to the energy recovered, and had a positive effect on the net kwh/ton of waste.

This paper discusses the research, design and installation of the split-range control system, as well as the economics of the project. The capital cost of this system enhancement was recovered in the first three months of operation, and the process continues to operate successfully.

BACKGROUND

The McKay Bay Refuse-to-Energy Facility, located in Tampa, Florida, is owned by the City of Tampa and operated by Wheelabrator McKay Bay, Inc. (WMBI). WMBI also served as the developer for the three-year retrofit project, completed in 2001, of this 1000-TPD facility. Facility operations were ongoing over the duration of the retrofit project, the major portion of which involved the replacement of all four combustion trains. [1,2] The existing turbine generator, a 22.5 MW General Electric unit, was kept in place.

Contract specifications required that each boiler have a minimum continuous rating (MCR) of 62,186 lb/hr. With all four boilers in operation, the total steam flow would be 248,744 lb/hr. The turbine, at maximum output, would operate at about 93% capacity, 220,000 lb/hr average, with all four boilers on line. Running the boilers below MCR allowed for load swings without affecting steam header pressure to the turbine. Excess steam, over 26,000 lb/hr, was sent to an existing bypass (dump) condenser. This bypassed steam represented energy not being realized, as well as affecting the net kwh/ton of processed MSW. We decided to investigate the possibility of enhancing the operation of the facility, and the generation of energy and revenue, by minimizing and at times eliminating bypassed steam.

SYSTEM DEVELOPMENT

At the time of the facility retrofit, normal maintenance schedules were kept in place for the turbine generator. During an outage, we investigated an upgrade of the mechanical hydraulic control (MHC) governing system to an electro-hydraulic control (EHC) digital governor. A new Woodward 505 governor control (Fig. 1) was installed by the facility’s turbine contractor, Turbine Diagnostic Services, Inc. (TDS). When the turbine was brought back on line, it was immediately noted that the steam flow to the turbine was more stable with regard to the high and low points during a boiler load swing. However, steam still had to be bypassed to the dump condenser to maintain MCR set points when all four boilers were on line.

We then decided to investigate the capability of controlling a second valve from the Woodward 505 governor in a split-range configuration. The key question was whether the operation of a second valve, an automatic control valve working from the second digital controller on the 505, would
be able to send some of the bypassed steam back to the turbine during boiler load swings that sometimes dropped the steam header pressure.

In cooperation with TDS, WMBI developed a new control scheme to enhance the operation of the plant and improve electric revenues. The theory behind the control scheme enhancement was that if the plant could maintain 100% "valves wide open" (VWO) on the turbine and utilize the second control feature of the Woodward 505, steam would not be bypassed to the dump condenser.

Two disciplines were involved in the design of the project: Electronics and Instrumentation for the control aspects, and Mechanical Engineering for all changes that would have to be made to the existing piping layout.

A control valve (Fig. 2) was installed parallel to the main dump condenser valve already in place, to control steam from the main steam line to the dump condenser. This valve was sized to allow for an additional 10% of plant steam flow to the dump condenser beyond the maximum rated input flow to the turbine. The sizing was based on the fact that the bypassed steam, with four boilers on line and at MCR, was a little over 26,000 lb/hr. This equates to 10% over the amount of steam going to the turbine under these operating conditions (MCR). The control valve in place to the dump condenser was an eight-inch valve on an eight-inch line. For the kind of control needed with this volume of steam, a three-inch line and associated four-inch valve with transmitter would have to be fabricated for this control enhancement to work with the relative accuracy that would be required.

The Woodward 505 was configured with two output valve drivers set up as a split-range control function based on load control demand. The inlet control valve on the turbine (V1) was set up to drive from 0 to 100% based on the control system demand for 0 to 93% load (linearized to valve position). With some overlap in its operating range, the new three-inch bypass valve would stroke from 0 to 100% based on the system load demand for 91 to 100% (linearized valve position). Utilizing the linearization functions of the two output devices available in the Woodward 505 governor provided an operating range of steam flow control for the turbine governor up to 110% of turbine rating. This is allowable with this particular turbine.

The operators now fire the plant, with all units on line at MCR, to exceed the turbine output steam flow requirements. The turbine inlet control valves saturate wide open, and the excessive steam flow which had been bypassed to the dump condenser is now sent through the turbine while maintaining the desired inlet pressure control of the plant by the Woodward 505 control system.

Controls And Instrumentation

For control and instrumentation, the existing Rosemount 3050 pressure transmitter on the inlet to the turbine control valve is utilized to send its pressure signal to the electro-hydraulic governor. The Woodward 505 utilizes the pressure signal and the linearization function to set the VI position, as well as the position of the bypass control valve, which allows the machine to run in inlet pressure control with both valves open. This system also includes a Rosemount 1151 pressure transmitter for indication of pressure in the main steam line. This transmitter has a control function for the eight-inch control valve to the dump condenser. If the eight-inch valve was to be in automatic and steam header pressure went too high, the valve would open, lowering the pressure in the main steam header. This existing transmitter (1151) would be for indication only, and control of the existing eight-inch valve.

The Rosemount 3050 pressure transmitter located at the turbine takes its reading after the stop valve. There is a considerable pressure drop across the stop valve. With existing pressure transmitters able to take care of the pressure indications for the split-range project, all that was needed to complete the split-range control aspects was an in-line flow meter and a control valve. A decision was made to procure a Rosemount 8800A Smart Vortex Flowmeter (Fig. 3) and a Fisher Rosemount easy-e heavy duty, globe-style control valve (Fig. 4). Chosen package options for the control valve included: a Whisper Trim Cage for noise reduction, a Graphite High-Seal Packing System, and a Type 585C Actuator for the valve. These considerations were based on ease of maintenance and reliability in low-flow conditions. The same considerations hold true for the 8800A Vortex Flowmeter. The relative accuracy at low-flow conditions, microprocessor based electronics with wide rangeability, and simultaneous analog, digital, and pulse output signals provided the flexibility needed.
Piping

The installation of the three-inch pipeline required several piping stress analyses on the line intended to bypass steam from the main steam header at the facility. The main steam line experiences thermal movement of up to four inches north from the turbine steam chest. The analysis was to alleviate any concern regarding possible interference of the line with a structural column near the line, and any pipe stress effects on the line. AEP Pro Serv, Inc. was contracted to perform the analyses. Mr. Henry Simpson, the AEP engineer, utilized the stress analysis program CAEPIPE, applying the rules of ASME B31.1, the Power Piping Code.

Using a sketch of the proposed bypass run (Fig. 5) and a description of the purpose and history, a computer-generated drawing (Fig. 6) was composed. The initial analysis showed flange overload. A combination of actual design pressure in the line, with the equivalent line pressure calculated from the force and movements composed by the piping stresses, exceeded the rated pressure for the flanges. Another conclusion was that thermal expansion stress on the elbow nearest the main steam line was at 91% of the allowable stress range. While this is acceptable per ASME B31.1, Mr. Simpson noted that piping engineers prefer to hold the "as designed" stresses to under 75% of the allowable stresses. This provides a greater margin for variations in field installation and operation.

A second analysis was undertaken to devise modifications that would make the configurations meet all of the requirements. (See Fig. 7.) The changes proposed were not extensive:

1. The east-west piping run with the flow meter was moved 6 inches to the south (away from the column), to clear any potential interference.

2. An expansion loop configuration was put in, to swing the east-west run to the south. This provided flexibility in the line near the first upstream elbow.

3. The rigid NPS six-inch piping supports downstream of the final isolation valve were changed to a variable spring support on the NPS4 piping just upstream of the final valve. This, along with the expansion loop, eliminated flange overloading.

4. The run upstream of the control valve was changed, to shorten the north-south horizontal run by six inches to match the six-inch relocation of the line upstream. A drip leg and steam trap were provided upstream of the control valve, and a drip leg and steam trap were also provided on the downstream side of the expansion loop.

With these modifications made to the project design, the City's consultants gave their approval to move forward on the project.

**ECONOMICS**

With the Woodward 505 governor already in place (since the retrofit of 2001), there would be no cost associated with utilizing its second control function. The cost of the added instrumentation and installation was estimated at $48,000.

There was a facility shutdown in November of 2003. The connection was then made to the main steam line, and the upstream block valves were welded in place. The same was true with the downstream connection at the dump condenser. The line and block valves were welded in. After the plant was started back up, the rest of the line, the flow meter and the control valve were fitted, and all electronics were connected to the TG governor control, as well as indication instrumentation being hooked up to the plant Distributed Control System.
When the installation was complete and the final costs were tallied, the project came in under budget. The total capital asset value of the project came in at $39,242.80 — more than $8,700 under budget.

Wheelabrator McKay Bay, Inc., as the operator of the facility for the City of Tampa, must meet a contract obligation of 370 net kw/ton of refuse received at the facility. After meeting our requirement, the company receives 75% of the revenue above 370 net kwh/ton. The owner of the facility would get 25% of the revenue after the 370 kwh/ton, and all electrical revenues before the guarantees are met. Based on the City of Tampa's fiscal year, which runs from October of each year through September 30th of the following year, the increases in MWH and revenues were:

<table>
<thead>
<tr>
<th>Year</th>
<th>Increase in MWH</th>
<th>Increase in Revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct '02 - Sep '03</td>
<td>151,810</td>
<td>$3,436,644.19</td>
</tr>
<tr>
<td>Oct '03 - Sep '04</td>
<td>155,768</td>
<td>$3,839,940.92</td>
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</tbody>
</table>

**Tampa Electric Company Payment Less Capacity**

<table>
<thead>
<tr>
<th>Year</th>
<th>Increase in Revenue</th>
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</thead>
<tbody>
<tr>
<td>Oct '02 - Sep '03</td>
<td>$461,751.90</td>
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<tr>
<td>Oct '03 - Sep '04</td>
<td>$614,960.44</td>
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</table>

**WMBI Share of Electrical Revenue**

<table>
<thead>
<tr>
<th>Year</th>
<th>Increase in Revenue</th>
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</thead>
<tbody>
<tr>
<td>Oct '02 - Sep '03</td>
<td>$153,208.54</td>
</tr>
<tr>
<td>Oct '03 - Sep '04</td>
<td>$134,208.54</td>
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</table>

Accounting for turbine downtime in 2003 and 2004, the facility realized an 85% reduction in steam bypassed to the dump condenser. TG capacity increased by over 6.5%, and electrical production increased by over 50 kwh/ton, as shown below:

<table>
<thead>
<tr>
<th>Year</th>
<th>Steam Dumped Yr K lb/hr</th>
<th>TG Capacity %</th>
<th>TG Steam Rate kwh/ ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>'02</td>
<td>92.45</td>
<td>10.80</td>
<td>454.8</td>
</tr>
<tr>
<td>'03</td>
<td>93.01</td>
<td>10.83</td>
<td>450.3</td>
</tr>
<tr>
<td>'04</td>
<td>99.75</td>
<td>10.83</td>
<td>501.9</td>
</tr>
</tbody>
</table>

**SUMMARY**

In summary, a less than $50,000 capital project to improve electrical production by lowering the amount of steam bypassed to a dump condenser has seen the capital outlay returned in revenue in the first three months of operation. Over the life of the existing Operations and Maintenance Agreement between the City of Tampa and Wheelabrator McKay Bay, Inc., over $4 million of additional revenue will be realized by both the owner and the operator.

**ACKNOWLEDGEMENTS**

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**REFERENCES**
