

# Vacuum heater installation

**One refinery has proved it is possible to revamp any process unit by modification and/or replacement of key process equipment in situ. The project was completed in less than 12 months and included a 350-ton fired heater module**

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The JSC Mozyr oil refinery in the Republic of Belarus recently completed the installation of a new vacuum distillation heater, which had been assembled directly within the 1800 000 tpy vacuum distillation (UVDM) unit.

With a challenging schedule of 12 months from contact signature to start-up, the 350-ton fired heater fabricated module was moved onto existing foundations. Careful project planning meant it was possible to achieve the installation in less than 30 days, well within the scheduled vacuum unit turnaround. The newly installed fired heaters dramatically improved the process unit performance.

On 3 November 2005, the UVDM unit was started up after a scheduled unit turnaround lasting less than 30 days. During this turnaround, the existing fired heater was replaced with the custom-designed Foster Wheeler furnace in order to optimise process operations and ensure that all process requirements, and environmental and refinery demands were met. A detailed analysis was carried out with refinery management, process unit operators and mechanical specialists.

Foster Wheeler had previously supplied the refinery with a new visbreaker heater. The JSC Mozyr oil refinery took this into account during the evaluations and analysis for a new heater supplier, together with the fact that Foster Wheeler had the capability to carry out this type of refurbishment. Detailed knowledge of all aspects of heater design was an extremely important issue. Factors to be taken into consideration included:

- Plot space for lifting
- Logistics for modules access and egress for plant and heavy equipment
- Lay-down and working areas.

These factors had to be considered during the initial planning and evaluation phase of the project due to their potential impact on cost and schedule. Prime challenges for the project team were:

- **Project timing** This was critical, as

Vacuum heater item P-101M — review of key milestones	
Bid tender declaration & RFQ	14 August 2004
Contract signature	14 October 2004
Material delivery	June–September 2005
New heater erection	August–October 2005
Old heater dismantling	5–12 October 2005
New heater module moving	16–18 October 2005
New heater piping tie-ins	20–30 October 2005
New heater start-up	3 November 2005

**Table 1**

the turnaround had already been defined as October/November 2005, less than two years after the commencement of feasibility studies

— **Feasibility of the project** Since the vacuum unit shutdown period was short, the construction work had to be completed in the shortest possible time, thereby minimising production losses.

In the preliminary analysis, cost-effective and innovative solutions were identified to safely undertake the replacement of the fired heater in the shortest time. These solutions ranged from in situ modifications to full unit replacement. The ideal solution was to effect a full fired heater unit replacement, but with the following restrictions:

- Modifications of process and utilities piping had to be reduced to a minimum, with no changes to existing foundation piers
- A new vacuum heater needed to be designed to maintain the new foundation loads within the allowable values
- The existing steam recovery system through which the flue gases left the convection section had to be modified, and the new heater convection section had to take this factor into account.

A proper tie-in on flue ducts was required, since the flue gases were to be sent to the existing concrete stack through the flue gas ducting system already in place.

After careful analysis of the various options, JSC Mozyr oil refinery personnel were confident that the proposed total revamp was possible and work commenced (Table 1). The new furnace

was to be erected in the area next to the existing fired heater, which needed to be kept in production and operation until the last day before turnaround.

## Main process parameters

Among the various factors driving the revamp and replacement of the vacuum heater, there were several process considerations and problems relating to the operation and efficiency of the existing furnace. The radiant surface of the original heater was insufficient. Therefore, the heat flux was too high when compared with the heat flux value of 25 500 W/m<sup>2</sup>, which is generally utilised for current vacuum heater installations.

The vertical disposition of the radiant tubes of the original heater was a critical configuration for the flow pattern inside the process coil, with local overheating and high coke build-up in the zone where vapourisation occurred. The tube size and the process fluid velocity were inadequate and the heat-transfer efficiency was very low, with a high fluid film temperature and coke build-up as a consequence.

The new design was developed on the basis of the available existing plot area, and took into consideration the installation of a mixed configuration of vertically and horizontally disposed coils. The new heater was designed to present standard and codes, and offered the following advantages:

- Longer operating periods without decoking
- Tube size properly selected, taking



Figures 1 to 3 On-site heater assembly

into account the process fluid velocity

- Radiant surface designed according to 25 500 W/m<sup>2</sup> heat flux max
- Reduction of maintenance activities for long periods
- High efficiency. Table 2 highlights the estimated fuel saving based on 8000 hours/year

- Very short payout period due to both the fuel saving and refurbishment costs of the existing heater
- Reduction of NO<sub>x</sub> emission into the atmosphere.

Table 2 highlights the following process factors and parameters pertaining to the vacuum heater:

- Same absorbed process duty
- Lower heat fired and consequently lower fuel consumption
- Lower radiant heat flux and consequent milder furnace operation
- Lower excess air
- Lower flue gas emissions.

### Project initiation

The JSC Mozyr oil refinery awarded Foster Wheeler Italiana SpA a fixed-price lump sum contract for engineering services and the supply of critical equipment for the refinery on 14 October 2004, following a bid declared in compliance with Belarussian law. There were two immediate major challenges, which related to project timing and project feasibility:

- Strong demand for the steel materials and metals to be used for the heater pressure parts meant delivery times were under pressure during Q404
- The original 350-ton furnace had to be rapidly dismantled to allow sufficient time to install the new unit on the existing foundations. Also, the new heater had to be pre-assembled to minimise the erection time, and this had to be done within close proximity to the existing plant. This would allow easier transfer of the new equipment onto the existing foundations. The system (new heater materials as well as the method of moving the new heater) was designed and all materials purchased and fabricated well before the scheduled turnaround. Careful planning of material delivery was carried out in order to optimise construction activities. Actual delivery of materials started according to the original contract schedule, thereby assuring the site that assembly could be completed in a timely manner.

### Job site activities

As soon as the materials arrived on site, pre-assembly commenced next to the existing furnace. The heater was built and completely prefabricated with piping, ladders, stairs, platforms, instrument, electrics and lighting off-plot on an area immediately adjacent to the existing heater. It was then moved onto the existing foundations during the shutdown phase using a skate-type arrangement on steel rails, as shown in Figures 1 to 3.

The positioning of the existing piers and the narrow space around the heater meant a hydraulic-type trailer, commonly used to move such large structures, was unsuitable for the purpose (Figure 4). The temporary support base for the erection of the new heater was made by designing a steel frame that laid directly on the existing paving without any additional foundation works (except for a 50mm thickness grouting for levelling). This area was previously monitored and tested to gain the average soil bearing load

capacity, as well as all the data required for the proper sizing of the temporary support frame and rails.

Both the temporary support frame and the rail systems were designed to maximise all field connections by a bolting joint option to save time during assembly and disassembly.

While the construction of the new heater was under way and the existing furnace was still operating, the construction of the rail system (to connect the temporary support frame to the existing heater foundations) was carried out using materials available on the local market.

Final tie-ins and detailed finalisation of the rail system were completed after the dismantling of the existing heater. The special equipment arrived at site and comprised:

- Eight heavy-duty rolling skates
- Eight hydraulic jacks for vertical lifting (150mm stroke)
- Four hydraulic jacks for horizontal translation (150mm stroke)
- One hydraulic switchboard.

The new furnace was built in the dedicated area inside the process unit (Figure 5). The JSC Mozyr refinery and their subcontractors rapidly assembled the unit. The construction included:

- Radiant steelwork and pressure parts
- Tube supports
- Refractory and burners, ready to be connected to the fuel systems
- Convection section (inclusive of soot blowers)
- Part of flue gas duct, which connected into the existing flue gas ducting system.

At the end of September 2005, the refinery and Foster Wheeler completed the new furnace construction adjacent to the previous unit. At the same time, the main equipment and details relevant to the movement of the heater were finalised, ready for the process unit shutdown.

### Time constraints

The critical dismantling activities of the existing vacuum heater had to be accomplished in a very short time frame because of the unit turnaround. The preparatory works required the transportation of the new furnace and disposal of old equipment and materials to exacting safety standards.

After the existing heater was completely demolished and removed, the existing piers were checked and arranged to receive the new heater by installing a special new counter baseplate in order to avoid the possible mismatch of bolts. The new heater was then moved from the pre-erection area to its final position.

On 10 October 2005, after the original heater had been dismantled, it was necessary to install skidding beams

Process factors and parameters pertaining to the vacuum heater

Vacuum heater item P -101M	Old heater	New heater
Absorbed duty, MW	28.624	28.624
Heat fired, MW	42.094	34.907
Net efficiency, %	68.0	83.5
Heat losses, %	2.0	1.5
Radiant heat flux, W/m <sup>2</sup>	28.250	24.900
Excess air, %	40	25
Fuel oil consumption, ton/y	30.480	25.280
Fuel oil saving, ton/y	5200	
NO <sub>x</sub> emission, ton/y	145	82
NO <sub>x</sub> reduction, ton/y		63 (-43.4%)

Table 2



Figure 4 On-site heater assembly

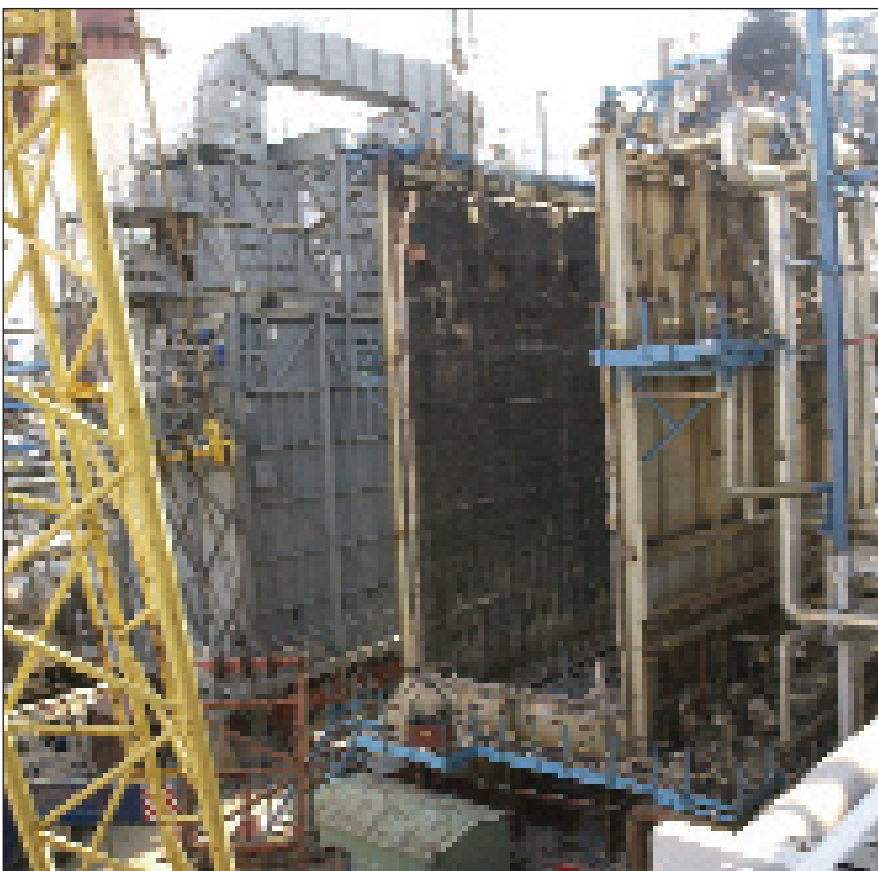


Figure 5 New furnace construction



Figure 6 Final preparations to new furnace



Figure 7 Furnace installation prior to startup

between the foundation piling and the design plate to avoid any foundation bolt mismatch. Work continued to finish the preparatory works to enable smooth transportation of the furnace.

On 15 October 2005, the heater was

trial-lifted by hydraulic jacks to briefly check the system without moving it horizontally. The following day, the module was moved horizontally by pulling at a velocity of about 5m per day and was finally pushed due to limited

space within the unit. The detailed sequence of the transportation of the module can be summarised as follows:

1. Insertion of No. 8 off-vertical hydraulic jacks under the proper lifting point on the furnace main beam
2. Furnace lifting for approximately 100mm and placing No. 8 heavy-duty rolling skates between the furnace main beam and rails
3. Furnace lowering on the No. 8 heavy-duty rolling skates
4. Placement of No. 4 off-horizontal hydraulic jack, ready to pull
5. Furnace transportation in successive pulling steps along the track, 0.5m at time, until reaching the existing foundation plinths
6. Furnace lifting and removal of the No. 8 heavy-duty rolling skates
7. Furnace lowering on the existing foundation plinths and fixed by welding to the new counter baseplate
8. Furnace completion and tie-ins connection (piping, flue gas duct).

Bad weather conditions slowed down work considerably during the critical days of moving the heater, but the refinery specialists, their sub-contractors and Foster Wheeler allowed the new vacuum heater to be successfully moved to its final place on 18 October 2005, exactly one year after contract signature.

Startup was successfully achieved without any significant problems and the furnace reached 100% capacity immediately after completion of the dry-out cycle.

Process operations at the refinery started with fuel gas operation, as time was limited to finalise the fuel oil and steam system. However, recommendations were given to allow such a change into fuel oil operation to go smoothly and in full accordance with process parameters and specifications.

With activities planned in advance and the goal to remain within the 30 days of scheduled vacuum unit shutdown, there has been a substantial improvement in operating conditions as well as in the operating efficiency of the new furnace of the vacuum unit. The fired heater design capacity was not increased for specific process considerations and requirements.

The project clearly proved it is possible to revamp any process unit by modification and/or replacement of key process equipment such as a fired heater in situ.

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