RIGHT FIRST TIME STEAM VALVE COMMISSIONING

Luder Zegarra, AST Turbo, Switzerland, outlines lean practices when commissioning steam turbine valves.

Mechanical-drive steam turbines, built to the API 612 standard, are typically the driver of choice for most compressor trains in the petrochemical industry. The quality and amount of steam flowing through the steam turbine will directly influence the speed and power of the compressor train. Furthermore, any controlled and/or uncontrolled variation of steam flow will affect the turbine operation and potentially represent a risk to the safe operation thereof. Therefore, the reliable and accurate control of steam flow through the turbine is critical for the reliable and efficient operation of the entire compressor train. Both valve arrangements should be thoroughly inspected at every major turnaround in line with the manufacturer's instructions. The proper commissioning of the steam valves often falls short due to time constraints imposed by production requirements. This article discusses how the testing activity can be taken off the critical path and the steam valves commissioned right first time.

Overview

The steam flow through the turbine is controlled by a set of valves located upstream of the turbine inlet nozzle. These valves also play the key role in protecting the turbine against overspeed events and other operating abnormalities that require an emergency shutdown. The process variables of the turbine operating parameters are read by the turbine control system. The output signals from this system are converted, via the hydraulic system, into controlled movement of the steam valves which modulates the steam flow.

A steam turbine is typically equipped with two types of valves to control the steam flow: the trip and throttle valve (TTV) and the governor valves. In turbines with controlled extraction steam, an additional set of extraction valves are found. The aforementioned valve types are within the scope of supply of the turbine manufacturer.

The TTV is located downstream of the turbine isolation valve and upstream of the governor valves. Its two main purposes are to control the ramp up of turbine speed during the start-up process until reaching the minimum governor speed, and to isolate the steam supply in case of an emergency.

Some manufacturers only consider a shut-off valve, rather than a TTV upstream of the governor valves. On this type of arrangement, the governor valves control the speed during the turbine start-up at all times. The shut-off valve is in fully open position during operation, including start-up; it will fully close in case of a trip event.

The governor valves on steam turbines are commonly shell-mounted valves. They are designed as a set of venturi-type valves, typically four to six, that control the steam flow to individual segments of the inlet nozzle ring. The purpose of the governor valve is to control the turbine speed and power, and to be the first line of defence to stop the turbine.

Figure 1. An AST Service Engineer operating a trip and throttle valve during a solo run.

The extraction valves are either shell-mounted or diaphragm-mounted. The extraction valves are normally of the bar-lift, spool-type or grid-type design. The purpose of these valves is to control the extraction line steam flow or pressure. The extraction valves are controlled by extraction steam flow (or pressure), turbine speed and power demand.

During a planned turbine overhaul event, inspection of the steam valves is typically included within the scope of work. The steam side of the valves is inspected to ensure the tight contact of the sealing surfaces, as well as the proper clearance between sliding surfaces such as valve stems and bushings to mitigate the risk of steam leaks and seized valves.

Once mechanical completion is achieved, the pre-commissioning and commissioning activities take place. The proper and documented set-up of the steam valves is a critical task within the commissioning work. However, in many cases a lack of know-how and experience in valve set-up procedures, amplified by a lack of suitable documentation for older devices, leads to the omission of these activities before proceeding directly with the turbine start-up process. In other cases, partial stroke checks are performed. However, deviations are simply noted and not corrected, mainly due to a lack of understanding of the valve operation and the adjusting steps.

A widely-applied practice is the recording of 'as found' dimensions on valve linkage, and the adjustment of features during the disassembly works to duplicate them during reassembly works. However, this cannot justify the omission of the valve set-up procedure as part of the commissioning activities.

TTV commissioning

Pre-commissioning and commissioning on steam valves should include activities such as TTV stroking and exercising, governor system set-up, and governor valves cracking point set-up.

During the commissioning of a TTV, the full stroking of the valve should be carried out. The valve stroking will provide information on the stroke length and valve closing time which, in addition to confirming the proper assembly of the valve and the correct installation of orifice plates, will also be used as reference values for periodical operational checks.

The TTV is equipped with features to periodically (typically weekly) exercise the valve while the turbine is in operation. TTV exercising entails the partial stroking of the valve to verify that the valve movement is free of restrictions, and to minimise the build-up of deposits between the valve stem and bushings. This process is usually a manually-executed task, however it may be automated on more modern plants. Exercising of the TTV is performed as part of the commissioning activities.

The aforementioned TTV commissioning tests are normally carried out with the TTV mounted to the inlet pipe and the oil system commissioned and running. A good practice, which is gaining acceptance nowadays, is to pre-emptively perform the above TTV commissioning tests

at the facility where the TTV was overhauled by connecting the TTV to an independent hydraulic oil skid. This set-up takes the pre-commissioning of the TTV off the critical path. It will also provide the opportunity to train the operators on activities such as TTV throttling, exercising, and understanding of the TTV operating mechanism in general. This task usually does not fit in the restart schedule but should not be underestimated.

Governor valves commissioning

The pre-commissioning of the governor valves and the extraction valves when applicable should start with setting up the valve cracking points. In many cases, this activity is included as part of the mechanical reassembly of the turbine.

The cracking point is defined as the sequencing of a set of governor valves where the opening of a valve cracks (i.e. lifts off the seat) as the previous valve reaches its governing point lift and the preceding valves continue to open to the fully open position. The governing point of a governor valve is the valve opening position where approximately 98% of the possible steam flow is reached. The governing point of a valve is reached at approximately 43% of its total stroke. During the remaining 57% of the valve stroke, the steam pressure drop through the valve is considerably reduced, while only a minimum additional amount of steam flow is admitted.

The governor valves are equipped with different features for the set-up of the cracking points. During the set-up of the valve cracking points these features (adjusting screws, adjusting nuts, threaded pins, etc) are adjusted to set the proper timing for transferring the movement from the governing lever or camshaft to the valve stem assembly. The cracking point set-up procedure, including the implicated tools, varies between the different manufacturers. The commissioning specialist should be familiar with the governor valve arrangement, understand the valve operating mechanism, understand the manufacturer's technical documentation, and prepare the activity in advance. It should be noted that in many cases, depending on the turbine arrangement and thermal expansion calculations, the cracking point setting, as achieved in turbine cold condition, should be fine-tuned with the machine in hot condition.

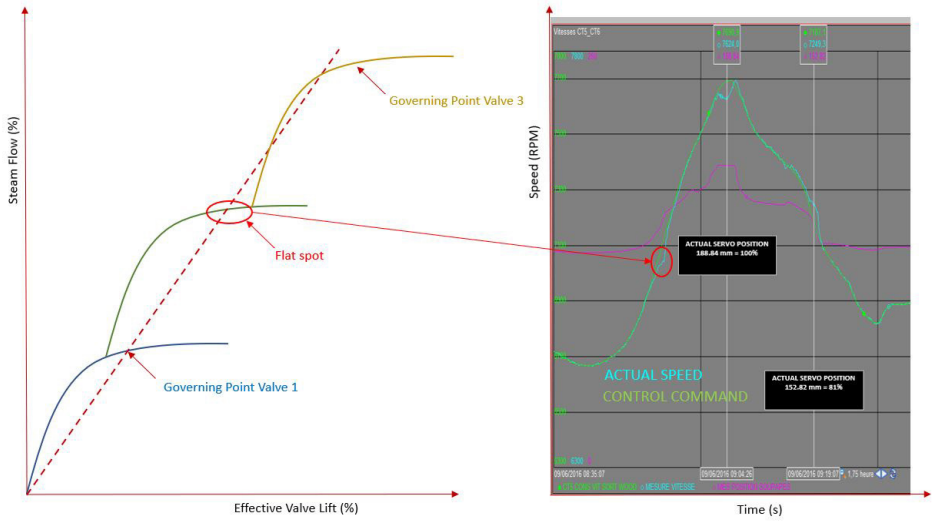

Figure 2. Indications of an improper set-up of valves' cracking points on the steam turbine speed control.

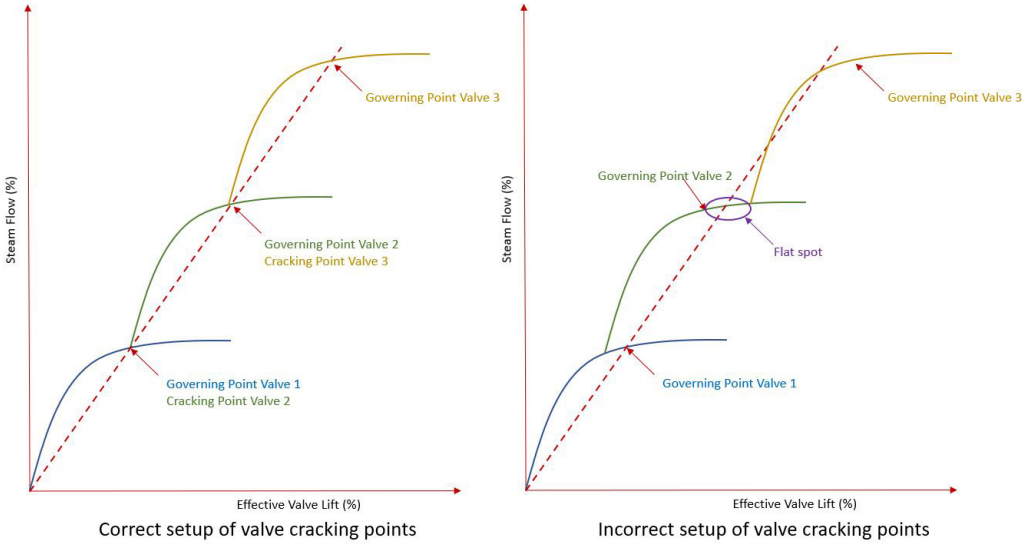

Figure 3. Set-up of governor valves' cracking points.

Theoretically, the turbine speed control is based on a linear relationship between the command to the governor valve power piston, the power piston travel, the governor valves opening, and the steam flow through the governor valves. The governor valves' cracking point setting influences the linear relationship between the steam flow and the valves opening. The set-up of the governor linkage will influence the linear relationship between the command to the power piston and the valve opening.

On an electro-hydraulic governing system, the output from the control system, in milliamps, should be linear to the travel of the electro-hydraulic actuator, the electro-hydraulic actuator travel should be linear to the power piston travel, and the power piston travel should be linear to the valve opening.

The governor linkage is equipped with adjustable-length features to achieve the desired linear relationship between the governor components. During the commissioning process, the governor system components should be stroked, both fully and partially. The current signal, actuator travel and valve opening at different operating points should be recorded and plotted on charts, preferably Excel-based, to evaluate the linearity between the components. The adjustment requirements should be implemented by adjusting linkage lengths. A thorough understanding of the governor mechanism, as well as the technical documentation by the commissioning specialist, plays a key role in lean work set-up. A proper understanding of the governor system will lead to sharp and effective corrective actions, while a poor grasp of the system could result in delays, inadequate governor function, or the system might simply be left improperly calibrated.

Summary

The success of the commissioning efforts on the steam valves, as described above, will directly influence the turbine performance and safe operation. A deficit in the TTV commissioning activities could result in a turbine being insufficiently protected against trip events. A poor commissioning effort on the governor system will impact the precision of turbine speed control, resulting in valve actuator hunting issues. The poor set-up of cracking points will affect the linearity between steam flow and valve opening: early cracking causes excessive throttling of the steam with lower thermodynamic efficiency, and late cracking causes flat spots between the commanded position and the valve opening. Ultimately, a flat spot could cause speed variations on an extraction turbine. The turbine speed governor or the pressure governor will try to correct the lack of steam flow caused by the late valve cracking. The governor and pressure control could override each other, which could lead to speed oscillations.

The precision of turbine speed control and operating performance are relevant factors measured by the petrochemical site operators to evaluate their contribution to minimising CO_2 emissions, especially when operating at partial compressor load is required on several sites.

The commissioning efforts on the steam valves should not be underestimated or even omitted at the back end of an overhauling event. An efficient and transparent commissioning programme on the steam valves demands thorough understanding of the operating mechanism of both the valves themselves and the operating system. The results of the mechanical overhauling works should be complemented with well-structured commissioning activities to achieve a reliable machine that performs well.