KÖTTER CONSULTING ENGINEERS

MACHINE DYNAMICS

5 MW natural gas turbo compressor calmed down

RWE Dea has planned and built a compressor station with connection to two separate natural gas pipelines (fig. 1). The three planned pipeline compressors are multi-stage centrifugal compressors with a variable speed engine. The turbo compressor can be operated 1-stage and 2-stage with a variable suction pressure between 17 and 54 bar (max. 13,000 1/min, P = 5,000 kW). After commissioning when checking various characteristics for the operating conditions, shut downs of the machine occurred due to suddenly increased compressor vibrations. As all three compressors showed an equal uncontrolled soar and increased shaft vibrations (> 50 mm ptp) which led to a machine switch-off, firstly the rotor dynamic calculations of the manufacturer were checked. Since no miscalculation was found, KÖTTER Consulting Engineers was charged with a metrological investigation. The aim was to check if the vibration excitation resulted from the pipeline system. Pressure pulsations and vibrations were measured in the pipeline system as well as directly at the compressor. In addition, the existing shaft vibrations of the entire compressor unit were recorded at the same time with different operating conditions. The results of the measurement can be summarised as follows:

1. No flow or vibration excitation of the compressor originating from the pipeline system could be found.
2. Independent of the volume flow abruptly increased vibrations occurred after exceeding of a certain compression ratio or compressor rotation speed.
3. The vibrations were sinusoidal with a frequency below half of the rotation speed. These vibrations occurred in the first natural bend frequency of the rotor.
4. The observed vibration phenomenon indicated a self-excitation mechanism (vibration instability) which can result out of different causes.

Because of the detected vibration characteristic (subsynchronous vibrations in shaft rotation, frequency ratio: 0.46 – 0.49) and the compressor construction with outer multi-surface plain bearings, a self-excitation effect out of a sealing gap was suspected as possible excitation mechanism. The pressure pulsations directly determined at the compressor showed in the area of the suction side of the second stage group an increased amplitude in the subsynchronous vibration frequency. Furthermore, it became clear that the instability criterion Δp detected during the measurement over the middle labyrinth sealing, portends to the sealing gap of the middle labyrinth.

To review the situation, rotor dynamic calculations were carried out by KÖTTER Consulting Engineers. As a reduction measure, the installation of twist crushers in the middle labyrinth sealing was proposed. The modification was done by a conversion of the middle sealing system on the compressor in the plant. The restart was carried out successfully with the installed twist crushers. Thereby, no vibration instability was detected. The maximum vibration shaft occurred with 13 mm ptp only as "good vibration" so that the work at the plant could be continued without any restriction.

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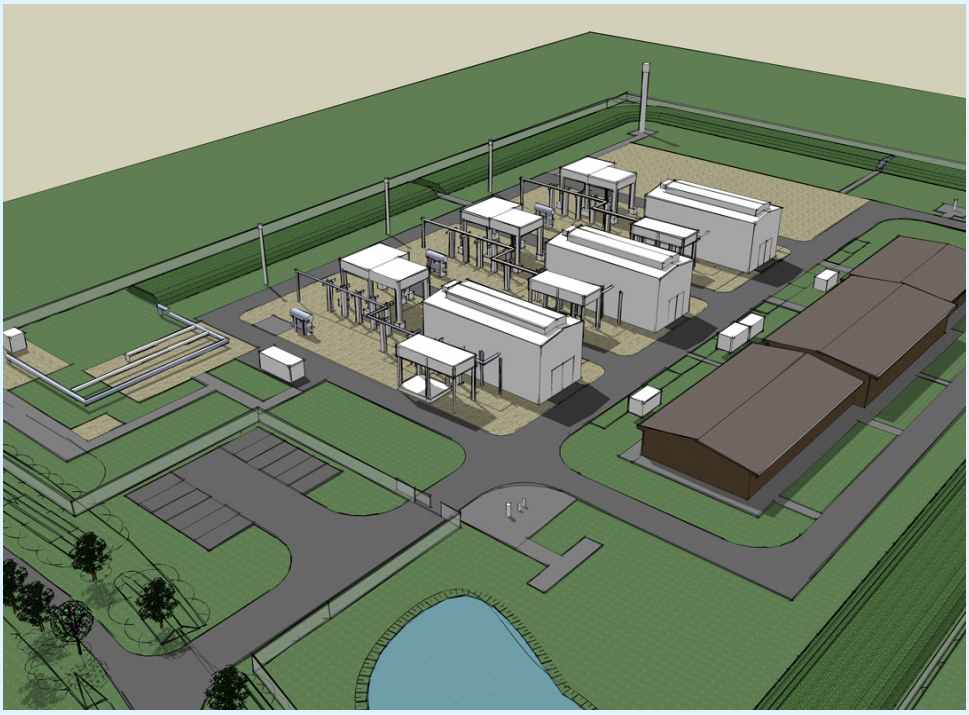

Overview of the new RWE compressor unit.

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