Getting the most from your machines and foundations

Process plants around the world depend on millions of rotating machines: compressors, pumps, blowers, fans, presses, generators, mills, mixers, and so on through a long list. The maintenance department is generally pretty busy keeping these machines together, repairing them, and making sure they are available for production.

The diagnostics of machine problems have been steadily improving since the electronics revolution, and catastrophic failures are getting fewer every year. Yet there is still a gap between the sophisticated diagnosis of vibration and alignment issues, and the understanding of how best to solve intractable and recurrent problems.

It has been stated frequently that a large percentage of the installed base of rotating machinery is operating in a less-than-optimal alignment condition. This percentage could be as high as 70% of all operating machinery. Mis-alignment causes excessive vibration, increased power consumption, reduced output, and wear and tear on components. But the major cause of mis-alignment - *grout failure* - is very rarely diagnosed. During the last 35 years or so our group of companies has regrouted and repaired the foundations for thousands of rotating machines in all types of industrial plant. Invariably, alignment is a found to be miles out, and the grout severely degraded. Using the techniques developed and refined in various Alphatec operations around the world, we are able to restore a machine to a condition which is close to original, or even better in cases where "original" was actually sub-standard.

Our work is based on a series of premises:

- The concrete foundation is the main vibration absorbing element of the installation, provided that it is of sufficient mass; that it is one integral whole; and that it is properly connected to the machine.
- Sufficient mass can be calculated from the traditional rule-of-thumb (6 times the weight of the machinery in the case of reciprocating equipment, or 3 times for general rotating machinery), or using a power based criterion. Our records suggest that 100 kg of concrete per kW of power input (in the case of a driver) or output is normally adequate to damp the vibrations of a reciprocating machine, and that 30 kg/kW will do the job for most other machines.
- The primary cause of a foundation's inability to attenuate vibrations is the cold joint. These occur when the concrete is poured in several lifts, and cannot be avoided by chipping the surface, water-blasting, or any of the usually mandated construction techniques. Use of an epoxy bonding agent is the only way to obtain full adhesion between pours, and its use is rare. Most foundations therefore have this inherent problem.
- The best way to ensure that the foundation is correctly connected to the machine is to use epoxy grout, and good anchoring techniques.
- The anchor bolts are designed to hold the machine down, and the grout is designed to hold it up. The grout must therefore have sufficient resistance to the anchor bolt's fastening force, which is inevitably much greater than the deadweight load of the machine itself.
- The shaft alignment must be as close to "zero-zero" as possible when the machine is operating in its normal condition, not when it is stopped for repairs, adjustment, etc. The question of offsets, both thermal and mechanical, must therefore be addressed before pouring the grout.
- In order to ensure the best possible connection between machine and foundation, full-contact grouting is always advised. The base of the machine should be encapsulated in the grout, to ensure good contact on the underside, as well as a measure of lateral and longitudinal restraint.

Many clients prefer soleplate grouting, which is a second-best approach, and stems mainly from the many small failures which are built into a majority of installations, and the necessity to make subsequent modifications and adjustments. If the job is professionally done, these adjustments become unnecessary.

Some specific case histories may help to illustrate the above points.

This compressor in a German refinery was suffering severe vibrations, not only in the main machine train, but also in the piping, and the surrounding structure. Alphatec Engineering was asked to look at the problem, in parallel with a specialist engineering firm who were monitoring and analyzing the vibrations. Alphatec engineers rapidly concluded that the problems stemmed almost entirely from the compressor grout, which was badly oil-soaked, and had essentially no resistance left to the anchor bolt forces.

Grout supporting the motor baseplates was also suspect, with surface cracking visible, and the possibility of corrosion underneath the baseplates. The complex shape of the foundation suggested that several cold joints might exist, and the mass of the underground portion of the foundation could not be determined due to missing civil engineering drawings. All the plinths supporting the high-pressure piping were in bad shape, with some showing complete separation from the lower mat, and anchor bolts no longer in contact with the concrete. A rapid proposal and cost estimate was drawn up, and a contract awarded the day after the inspection - rather faster than expected.

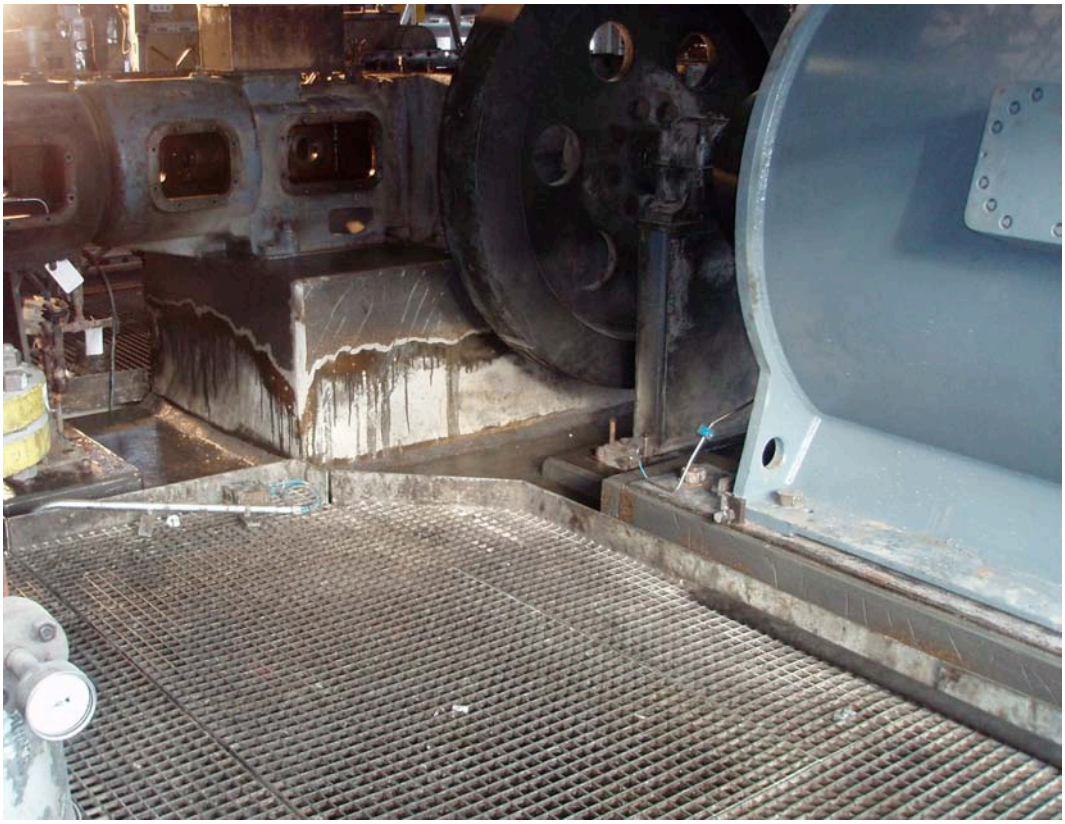
The team mobilized in 3 days, and the grout removal around the motor baseplates started immediately, together with a trial core drilled through the underground mat to determine the depth of concrete, which turned out to be 900mm. Due to the extent of the compressor house mat, this meant that some 45 m^3, or 100 tonnes of concrete, were available for vibration damping, once the connection between mat and plinths could be re-established.

The foundation repair was done in parallel with the grout removal. Injection holes were drilled into the foundation at strategic spots, high-strength reinforcing bar inserted, and the holes sealed with epoxy grout. ALPHATEC injection resins were pumped into the holes (through pre-placed tubing) to fill all cold joints, cracks and fissures.

Meanwhile, the existing grout and underlying damaged concrete was removed.

Shims, packers and miscellaneous hardware were also removed, and our proprietary ALPHAPADs used to support the machine.

Finally the compressor was free of the foundation, and could be properly aligned. the crankcase was set up first, then the motor aligned to it. The crosshead and cylinder-head supports were then aligned, and the whole thing grouted in place.



Since the grout under the pipe supports in the immediate vicinity was so bad, they were also chipped out, and regrouted.

Anchor bolts were tightened to the proper torque after the grout had cured for 24 hours, and the piping and wiring re-connected. The compressor was returned to service 15 days after we started work, and was soon found to be essentially vibration-free.

The downtime costs for this machine (and the associated unit) was more than €20,000 per day, while the direct costs of the repair were less than €100,000, so the return on investment was rather rapid, and the benefits continue to accrue every day that the compressor keeps running sweetly.

The story is basically the same regardless of the machine in question; in the last few years we have regrouted diesel engine generating sets, compressors, pumps, blowers, steam turbine generating sets, steel mill machinery, extruders, coal mills, cement mills, ID fans, and many others, with great success, measured mainly by the huge reductions in vibration levels, and the rapid return to service offered by our system.

ALPHATEC® 800, our general purpose epoxy grout, is the star of the show, being the most visible component of the repair procedure, but it is complemented by 35 years of know-how behind our installation work, and great attention to detail.