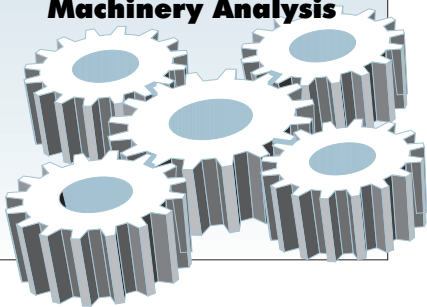


THE BETA BULLETIN



Machinery Analysis



INSIDE VOLUME 7 #2

Cost Effective Modifications Reduce Excessive Skid Vibration

2

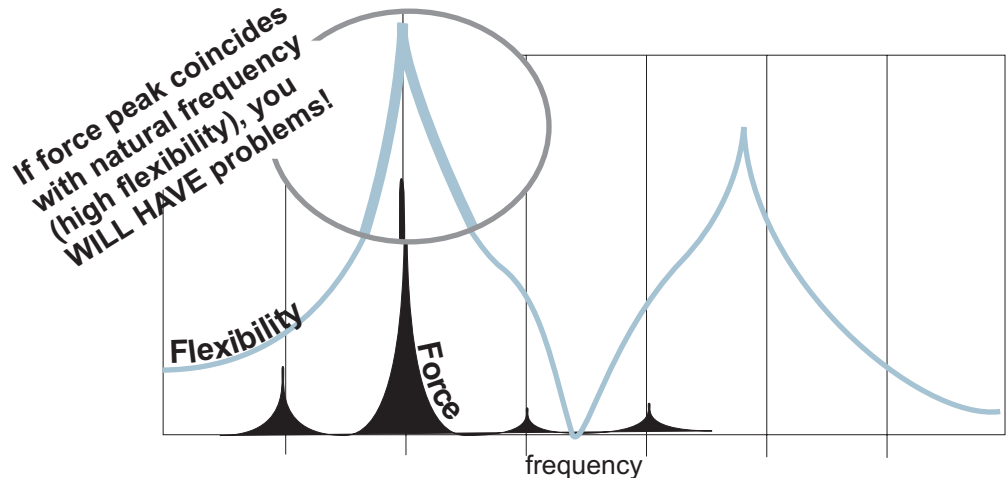
Free Seminar Program

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Beta Machinery Analysis Ltd. is registered to the ISO 9001 Standard

Skid Design



Dynamic Analysis is Critical

Reciprocating compressor skid design should be based on *dynamic* analysis. Using past practice or static analysis is too risky, especially with today's higher compressor speeds.

Inevitably, many forces act on the skid of a reciprocating compressor. Some of these forces can be minimized through suitable analysis and design, but they cannot be eliminated. As shown in the figure, high vibrations result when the frequency of some forcing function of significant amplitude is near a skid mechanical natural frequency. Without the application of advanced dynamic models, there is really no way of predicting these occurrences. Simply making the skid stronger and heavier might well have the effect of *matching* a natural frequency to an exciting force.

Potential Costs

At the design stage the incremental cost of a proper design based on dynamic analysis is very small. The total skid cost might even be less expensive than otherwise. Moreover, field fixes (which usually involve major compromises to operations and maintenance) are avoided.

At Beta Machinery Analysis over the years, we have executed numerous skid models and designs. Many of these projects have involved the correction of problems arising for the reasons described above (see one

example inside). In these cases the incremental costs for modifying the structure and for lost production are much larger than any incremental cost for a good dynamic analysis based design.

Skid Service Package

To respond to this need, we have compiled several techniques into a comprehensive package. Our package offers:

- evaluation of stress levels against AISC codes
- analysis of transportation and lifting loads
- models of skid and foundation system to determine mechanical natural frequencies
- recommendations for modifications to ensure adequate separation of forcing frequencies and mechanical natural frequencies
- evaluation of foundation, including suitability for the skid, pile locations, etc.
- optional comparison to acoustical/mechanical results, to determine most *cost effective set* of modifications
- forced response analysis to predict vibration and stress levels
- analysis of thermal stresses.

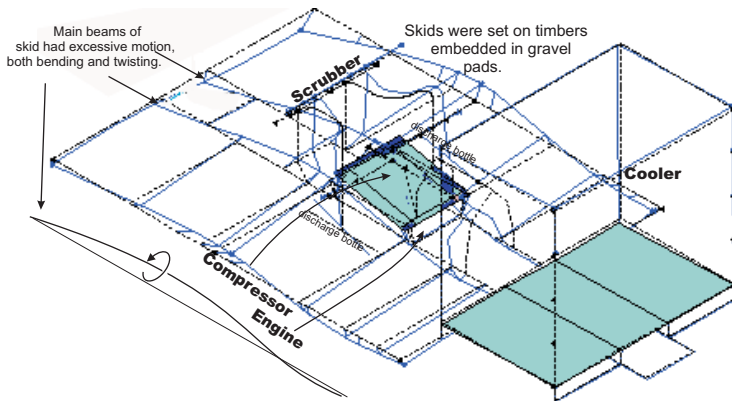
Appropriately applied, using *dynamic* models to optimize design is money in the bank. The cost of the analysis is more than offset by the reduction in risk cost*.

*Risk Cost = Probability of Failure times Cost of Failure

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Try it out.

Cost Effective Modification Reduces Excessive Skid Vibration

As-Found System Vibrated at Close to 2.0 IN/S



Excessive Vibration on Two Skids

The compressors were engine driven two throws, and had the largest cylinders available. The foundations were somewhat unusual; the skids had been placed on timbers embedded in gravel pads. The packager had measured the vibrations at levels approaching 2 in/s pk at the front of the engines at crankshaft height.

Several Failures

Due to the vibration levels there had been several failures of throttle linkages as well as other auxiliary equipment.

Attempted Modifications

Over a number of months, several modifications were attempted. The front engine supports were stiffened considerably, but with little effect. Then one of the skids was shimmed to ensure contact between the timbers and the skid beams, while the other skid was removed and then placed onto a recompacted gravel pad without timbers. The vibrations were reduced on both skids, but not enough to comfort either the owner or the packager. The packager then requested that Beta visit the skids and recommend solutions.

Field Visit by Beta

The field visit revealed that the main beams of the skid had excessive motion. The operating deflection shape showed

bending in the horizontal plane plus twisting of the beams along their longitudinal axis with the largest deflections occurring under the centre and front of the engine. The skid on the timbers was also bending in the vertical plane at the back end of the compressor due to poor contact between the skid and timbers. A bump test confirmed that the skids had mechanical natural frequencies just above the top of the run speed range.

Several possible field modifications were identified including:

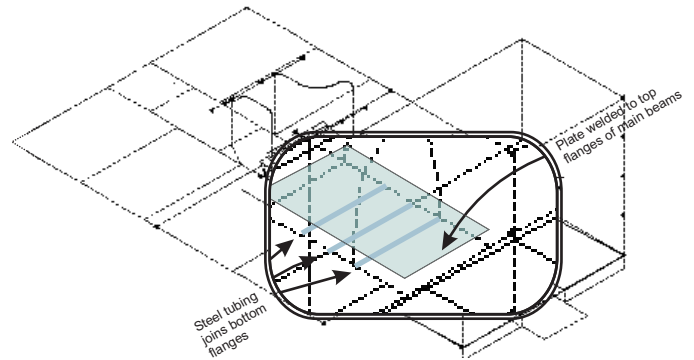
- stiffening the main beams under the engine by adding considerable steel
- pouring the skid full of concrete, and
- placing the skids on pile foundations.

All of these involved significant downtime, which was unacceptable to the owner of the units.

Finite Element Model

Beta used a finite element model to evaluate the possible field modifications. We found that the skid could be stiffened with far less effort than had been anticipated during the field visits.

Modified Skid Vibrates Less Than 0.5 IN/S



Modifications (without removal of the engines)

The skids were modified by welding 1/2" plate across the top flanges of the main beams under and in front of the engine. As well, three pieces of structural steel tubing were used to tie the bottom flanges together under the engine. These modifications reduced the vibrations on the engines to less than 0.5 in/s pk, with the levels on the skids in general **less than half** of their previous readings.

Application to New Skid Designs

After successful modification of the skids, the finite element model was used to evaluate changes to the packager's skid design. Several factors were considered:

- cost of production changes
- effectiveness in stiffening, and
- maintenance accessibility to the engine oil pan.

The proposed solution was acceptable on all counts.

Modelling skids in the design stage is the cost effective approach.

The model takes into account construction, installation and maintenance considerations, giving you a design that is neater, simpler and less costly. You avoid the risk of costly field fixes and get maximum availability right from the start.

There is an additional benefit to skid models and design done in conjunction with MAPAK service. There is then an opportunity to balance the gas forces (via acoustical design including bottle sizes, pressure drops) against the structural design. The result can be reduced construction and/or operational costs.

Free Seminar Program

	Recip Pulsation and Vibration	Beyond Predictive Maintenance	Torsional Analysis
General List of Contents	Vibration Basics Forcing Functions Resonance Pressure Pulsation --Frequency Content --Extent and Effects Unbalanced Forces Pressure Drop Guidelines -Mechanical -Acoustical	PdM Methods Performance Analysis Shutdown Inspections Economic Analysis Risk Management Case Studies	To Do or Not To Do ... Design vs Field Study Guidelines Design Optimization Torsional Analysis Process Torque Effort Curves Torsional Natural Freq. Mode Shape Resonance Shaft Stress
Benefits	Understand how acoustical & mechanical analysis gives you smooth startups and trouble-free operation. Learn to specify compressor studies.	Learn how to use new machinery analysis techniques to improve the bottom line.	Be able to determine the need for a study. Understand the wide scope of cost effective solutions. "A flywheel is not the only answer".
Who Will Benefit	Engineers and technicians who build or operate recip compressor packages. Owners of problem compressors.	Personnel responsible for planning and implementing cost effective operations. Operations and maintenance personnel.	Field engineers and project supervisors who design and operate recip compressors.

Please see calendar (included with this issue), or call for dates and locations.

Beta Machinery Analysis

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