Machine Train Shaft Alignment

Client:

The client is an electrical submersible pump (ESP) manufacturer for oil wells located in Dammam, Eastern Province, Saudi Arabia.

Equipment (s) measured:

The whole machine train is comprised of electric motor connected to one end of torque cell. The other end of torque cell was connected to the thrust chamber. Refer to Figure 1. The electric motor was made by Marathon Electric with a rating of 260 kW and RPM of 3570. The torque cell was made by Honeywell with a rating of 5000 in-lbs.' and RPM of 22000. The thrust chamber was an in-house design.

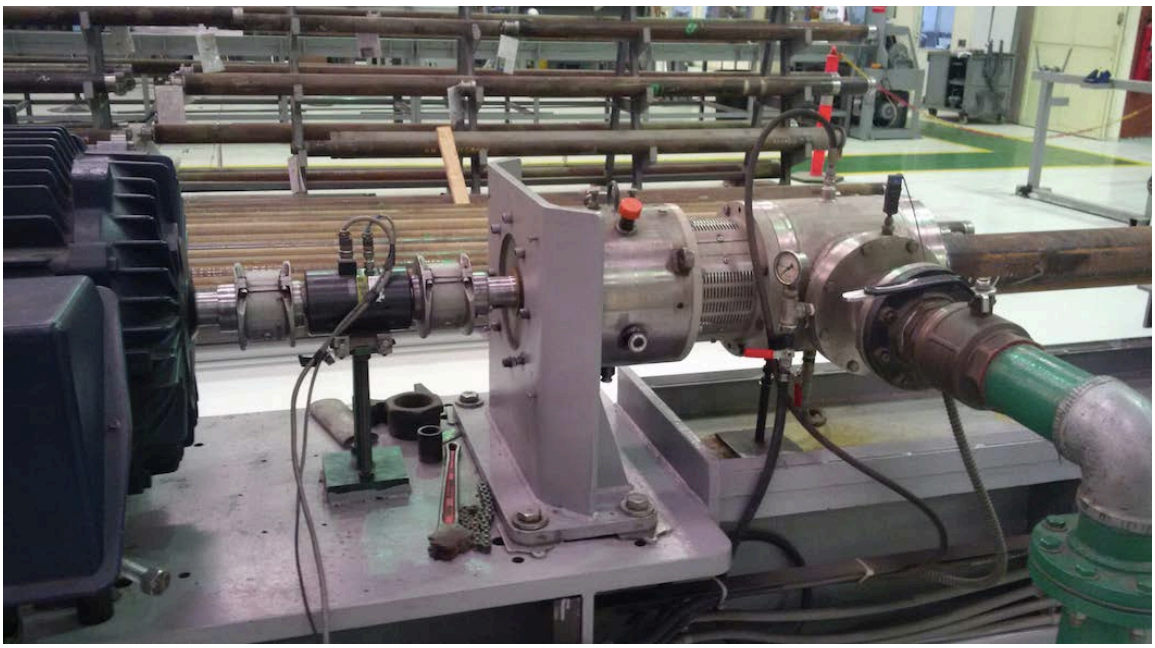

Figure 1. Machine train setup.

Problem:

The old torque cell was damaged due to vibration and was replaced by a new torque cell. The whole machine train was experiencing severe vibration issue and has been the number one cause of downtime and parts replacement. With the new torque cell installed, the clients' alignment team performed alignment but the vibration was not solved, and there were unacceptable alignment results. This machine train is used to test electrical submersible pumps (ESP) for oil wells. The pumps need to pass the quality check using the machine train as a test bed before shipment to the end users. The client wanted to get the machine train up and running as soon as possible as there are several pumps waiting for testing. Further delay should be avoided at all cost since there is no backup equipment. Due to a backlog of pumps awaiting testing, and with the shipment deadline looming, ACQUIP was contacted to do the laser alignment.

Job site/equipment review:

When ACQUIP team arrived on site, it was observed that the machine train had several weak structures/supports. The base of the torque cell is not sufficient in mass, not stable and rigid to fully support the torque cell during operation and is suspected to be one of the sources of vibration. Also, the thrust chamber was supported rigidly on one side only. The client representative insisted to proceed with the alignment and get the equipment running on the soonest possible time.

Solution:

As found readings were recorded on the thrust chamber and torque cell. The alignment setup is shown in Figure 2.

Figure 2. Setup for taking readings between thrust chamber and torque cell.

After these readings were recorded, as found readings between torque cell and motor were taken and recorded. The result was the torque cell was misaligned to the thrust chamber. The motor was also misaligned to the torque cell. Alignment corrections were then carried out on the torque cell and it was observed that the torque cell base was flimsy/weak. Due to unstable torque cell base, it greatly affected the alignment corrections and readings. Also, there is a greater tendency for alignment to change in a short time due to instability issue of the base.

Recommendations were given to the client to modify the base since it is one of the suspected sources of vibration and misalignment. ACQUIP team managed to align the torque cell to the thrust chamber.

Alignment then continued between torque cell and electric motor. Refer to Figure 3.

Figure 3. Setup for taking readings between torque cell and electric motor.

It was discovered that all feet of the motor had a bent foot. Corrections were made and ensured that soft foot was eliminated. After aligning the motor to the torque cell, final alignment check was performed on the whole machine train. The team found out that the torque cell was misaligned to the thrust chamber again. The first observation was then confirmed that the flimsy support/base of the torque cell influenced the alignment readings and correction. Worked stopped and the problem was discussed to the responsible personnel. The top management got involved and

the situation was assessed. It was then decided that a new base should be made. ACQUIP was then instructed to be back on site once the new base is ready.

ACQUIP team went back to site when the new base was installed. The new base was more rigid and stable than the old one. Refer to Figure 4.

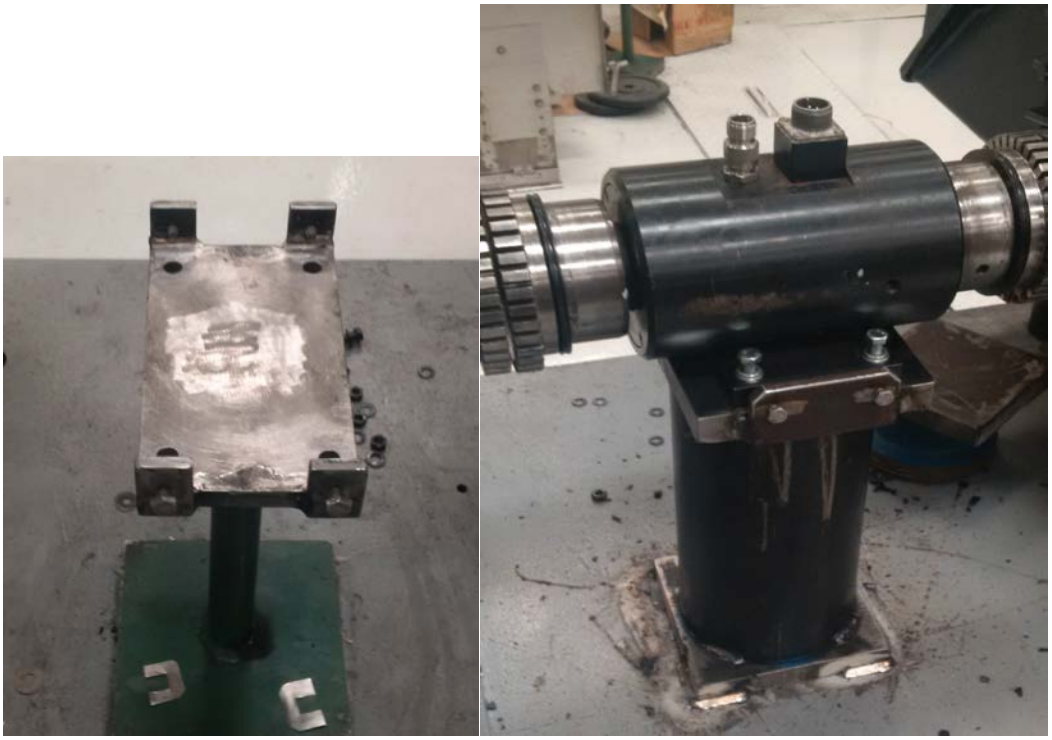

Figure 4. (Left) Old torque cell base. (Right) New torque cell base.

With a stable torque cell base, as found readings were acquired again between the thrust chamber and torque cell. Custom shims were made to accommodate the small footprint of the base that comes with the torque cell. Once satisfied with the corrections made and repeatable readings were obtained, the torque cell was then locked and torque down to its final position.

The motor was then aligned to the torque cell. Various rough alignment check was performed like runout check, shaft lift check, shims and soft foot check. Step shims were employed on some foot of the motor due to bent/angled foot issue. Another set of readings was taken after the mandatory rough alignment checks. After analyzing the data, prescribed moves were calculated and executed. All moves were performed on the electric motor. After getting excellent alignment results on the electric motor, the motor was locked and torque down to its final position. As left readings were then recorded on the whole machine train.

Conclusion:

The old torque cell base was flimsy/weak resulting to instability during operation thereby experiencing vibration and misalignment. Due to the long-term effect of the unstable base to the machine train, it affected the couplings and bearings as evident during alignment check. The coupling had a +/- 2 mils runout and the bearings had clearance/play that contributed the vibration. All motor feet were bent due to improper alignment procedures that try to compensate for the instability of the torque cell base. Some malpractice on shims like using washer and stacking more than necessary to attain the required height was observed. The thrust chamber was observed to be improperly supported despite the pressure, weight, high RPM and all forces acting on it during operation. All of these factors summed up the severe vibration issue experienced by the client and constant replacement of parts and downtime.

Thanks to ACQUIPs' extensive experience with rotating equipment. All the issues regarding the machine train were raised up to the management to make them aware of the impact of improper shaft alignment procedure and practice. Recommendations were given regarding sound engineering practice on dealing with rotating equipment.

ACQUIP was able to perform correction resulting in excellent alignment results, lower the vibration issue to acceptable level, corrected wrong practice on shaft alignment and most of all giving the client recommendations and advices on dealing with rotating equipment and machinery as a whole.