

Exercise #11: Moto-Compressor Foundation Basic Design

1. Introduction

1.1. Basic Design

A motor-compressor foundation must be pre-dimensioned / key parameters must be studied, determined and proved. The aim of the exercise (as part of the lecture “Machine-Induced Vibrations”) is to deal with essential dynamic aspects of a machine foundation. Not all aspects of a basic design are covered within this exercise; focus is laid on Serviceability Limit States (SLS).

The purpose of a basic design is to finalise overall main dimensions of the foundation and – in this case - the spring layout (position, stiffness, etc.), excluding substructure. Such a design step consists „simplified“ design calculation, i.e. not as detailed as the final design and neither reinforcing drawings nor detailed formwork drawings will be issued during this phase, only overall layout drawings.

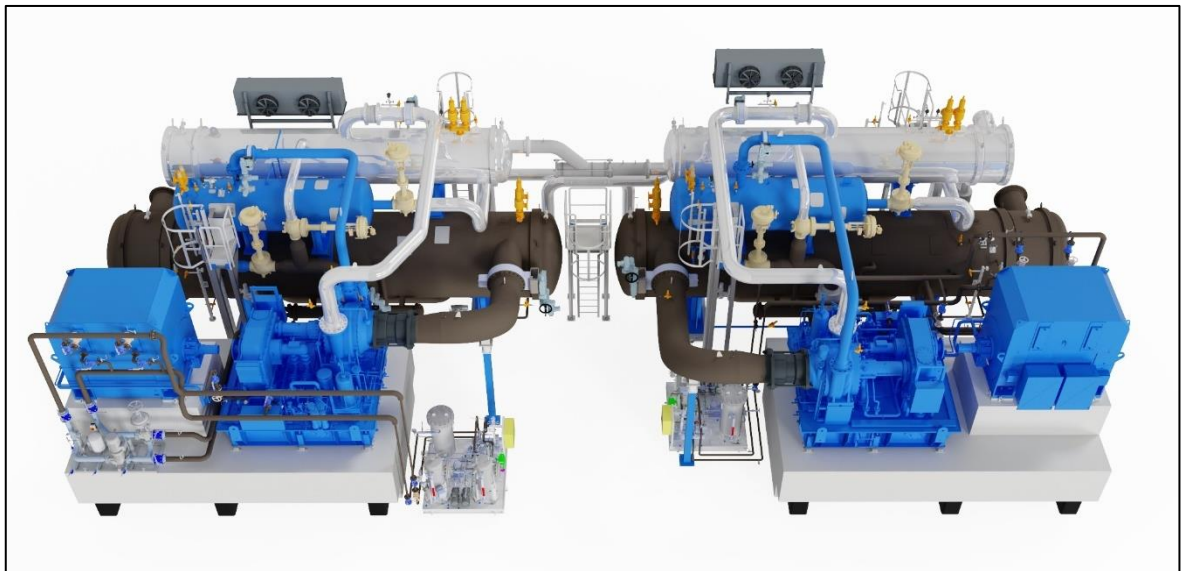


Figure 1.1: Visualisation of 2 Units

1.2. Structure-Borne Noise Protection

The moto-compressor is installed in an urban environment and the decoupled foundation is intended to counteract the radiated structure-borne noise.

➔ **Concept: Spring Mounted Machine Foundation**

1.3. Machine Data

	Total Mass [kg]	Rotating Mass [kg]	Operational Speed [rpm]	Balancing Quality [mm/s]
Drive engine	15'500	3'775	1'489	G 1.00
Low-speed Clutch	20'100	352.5	1'489	G 0.66
Gearbox: Gearwheel		1'956	1'489	G 0.67
Gearbox: Pinion		101.5	9'238	G 0.67
High-speed Clutch		35	9'238	G 0.67
Compressor		177	9'238	G 6.3
Steel Frame	400	-	-	-
Cooling Unit		-	-	-

Figure 1.2: Machine Data

1.4. Construction Materials

Concrete: Grade C 25 / 30

Reinforcement: Grade BSt 500 SB

1.5. Acknowledgements

Many thanks to Friothers AG, Switzerland and Trombik Ingenieure AG, Switzerland for providing the case study (e.g. machine data, visualisations, pictures).



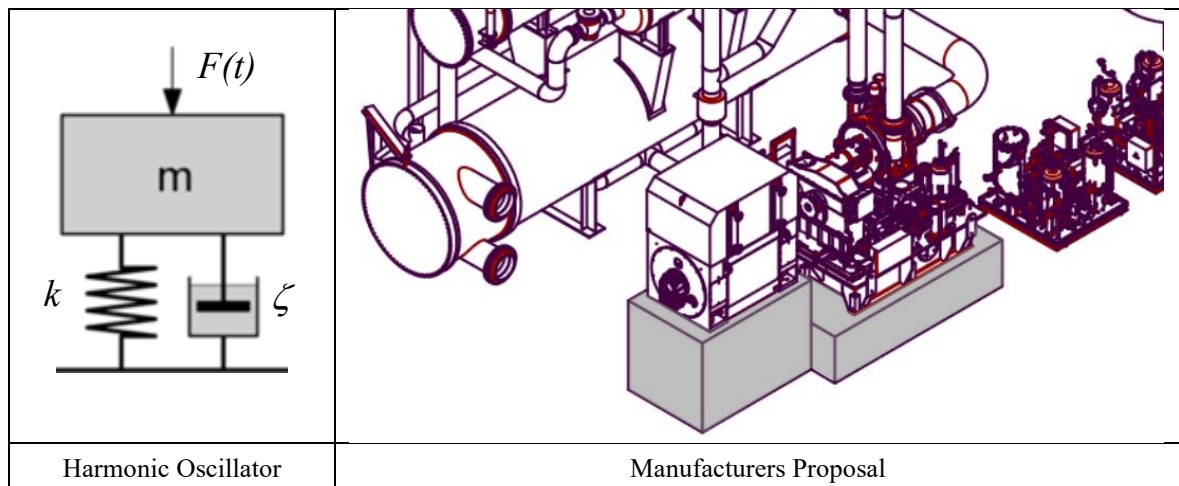
Figure 1.3: Installation of the Spring Elements / Lifting of the Foundation

2. Exercise

2.1. Harmonic Oscillator

Simplifications

For this exercise the spring mounted foundation (elastic decoupling: low-pass filter) can be considered as a harmonic oscillator (harmonic excitation by the machine) and only the vertical direction must be examined. As a maximum isolation is aimed for, damping can be set to zero.



Figures 2.1 Simplifications / Initial Situation

Compressor and Motor must be installed on one continuous foundation ('no' relative deflections between the components are allowed).

Tuning Frequency / Spring Stiffness

First draft of the foundation in relation to the machine manufacturers proposal (width x length x height):

- Compressor Plinth: 3.20 x 7.08 x 0.88 m
- Motor Plinth: 1.95 x 2.87 x 1.86 m

The spring mounted foundation should be designed for an **isolation ratio 0.05** (maximum force transmission of 5%), meaning $(F_d + F_k) / F_0 < 0.05$.

- Define the tuning frequency and
- the (overall vertical) spring stiffness.

Vibration Velocities

C) Calculate the operational vibration amplitudes (velocities and deflections) due to the motor unbalance and – separately – due to the compressor unbalance.

The unbalance forces have to be calculated based on the balancing quality: $F = m * e * \Omega^2$; whereas the balancing quality is equal to $G = e * \Omega$.

The allowable vibration velocities must be compared with values specified as per ISO 10816-3 for Zone A, Group 2 and Soft Support: The value $v_{\text{eff}} = 2.3 \text{ mm/s}$ should not be exceeded.

2.2. Structural Eigenmode(s)

D) Calculate / estimated the first flexural mode of the foundation by simplifying the foundation to a representative cuboid.

2.3. Discussions

E) Discuss the following topics

- **Modelling:** What do you think of the simplifications? Are the calculations still realistic? Which model parameters do you consider to be particularly important?
- **Calculation Results:** Do you consider the structural eigenmodes to be critical for the present situation? Evaluate the deflections (e.g. regarding the connecting pipes)
- **Next steps:** Which optimisations do you suggest? Which further checks should be carried out (as part of the basic design)?