Vibration monitoring in a pump-pipeline system

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1. Introduction of the problem

- Developments of a vibration monitoring technique based on measurement of pressure signals
- Testing in real environment

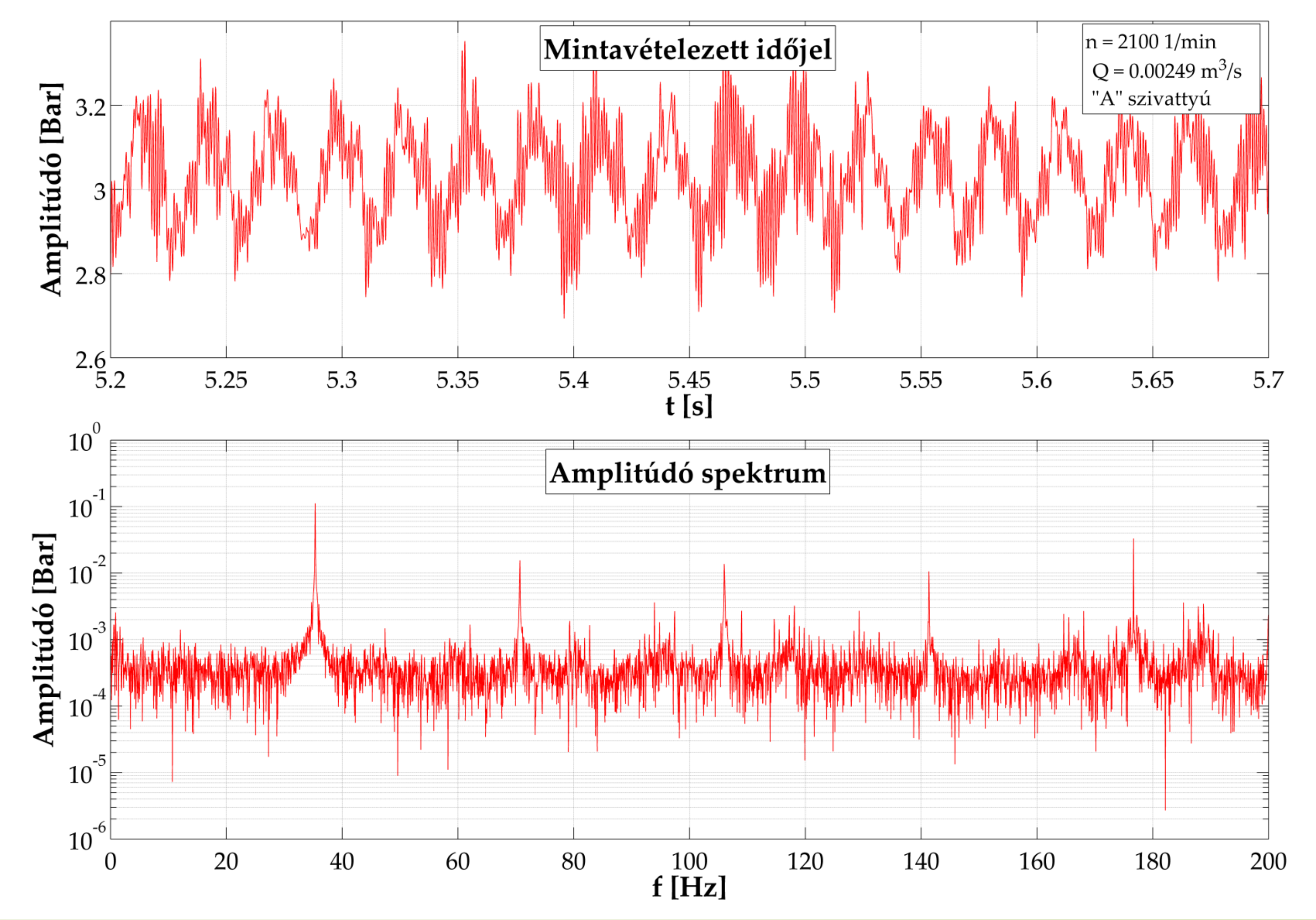
„A"

„B"

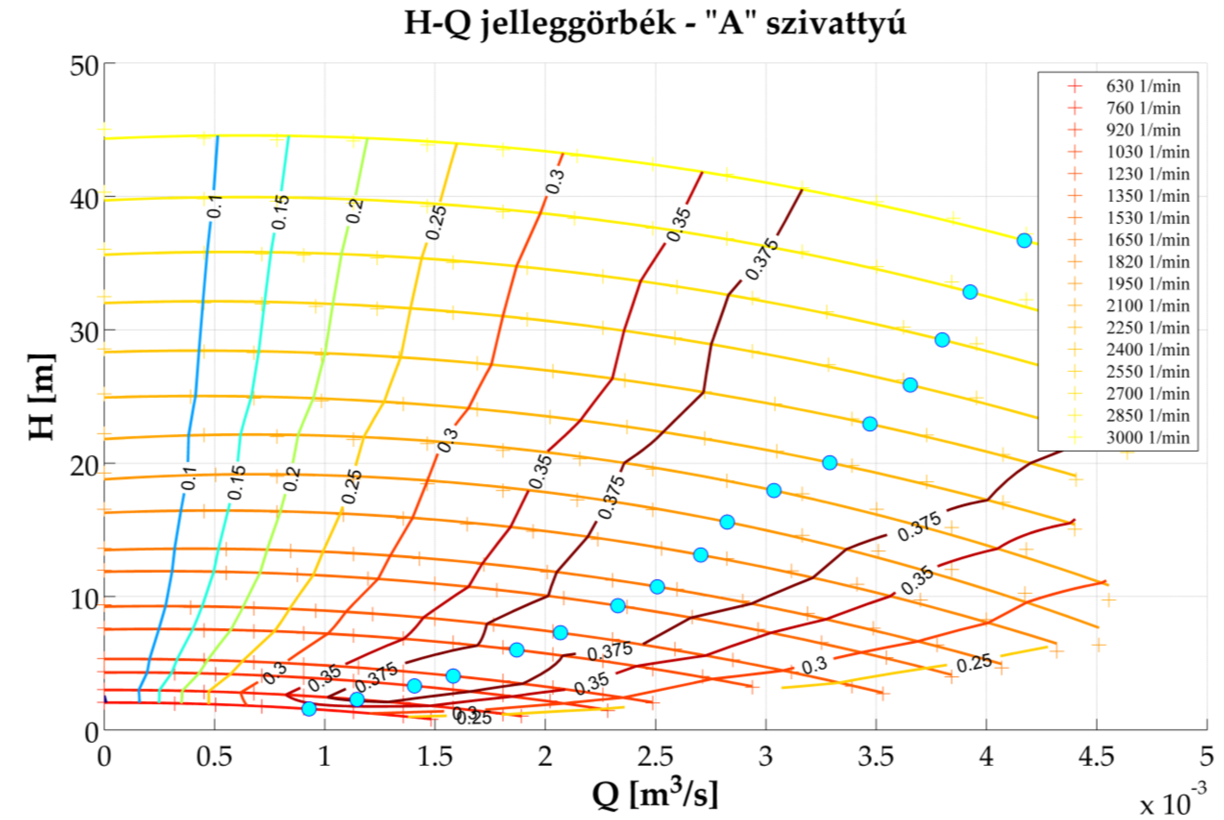
- Comparison, conclusions

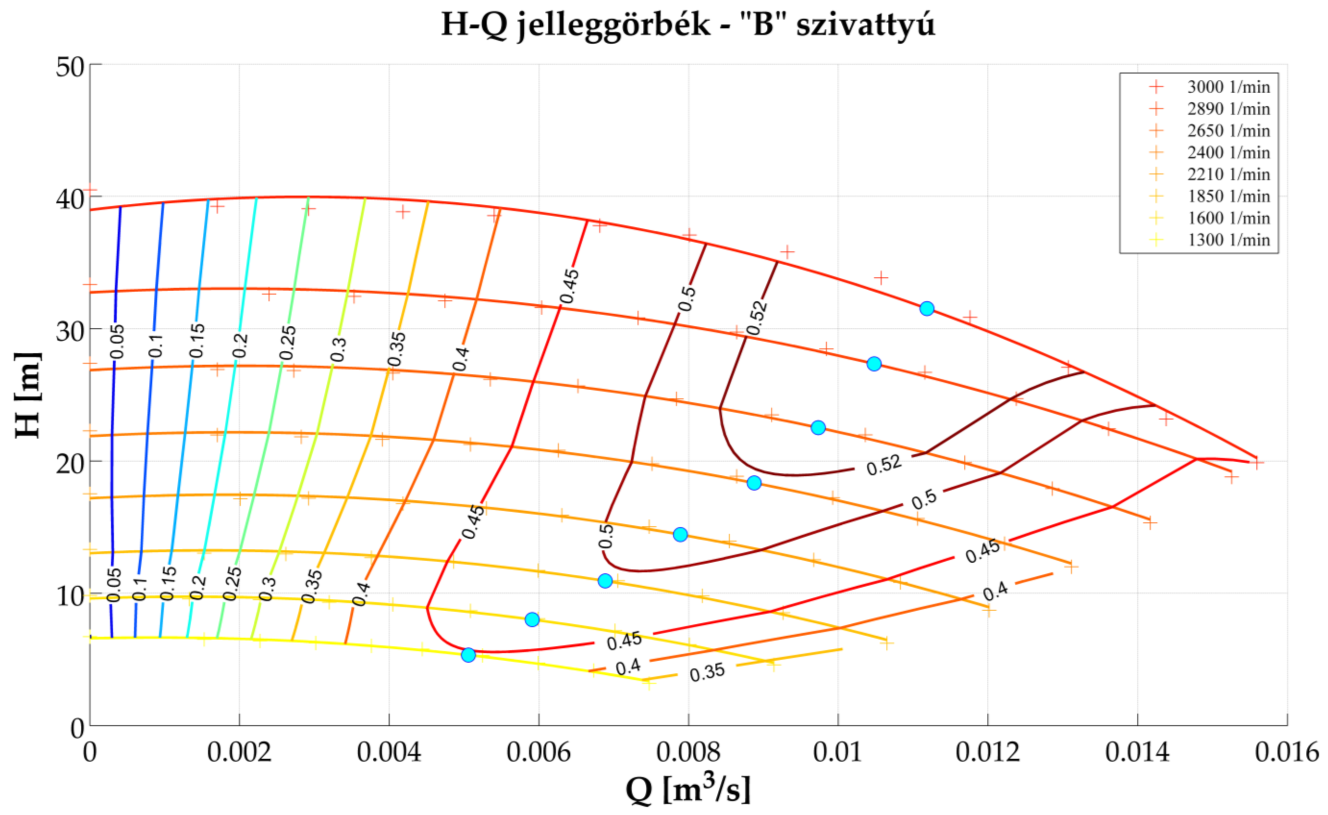
2. Vibration monitoring

- Summary of the method:
  1. Pressure signal
  2. Sampling
  3. FFT
  4. Spectra

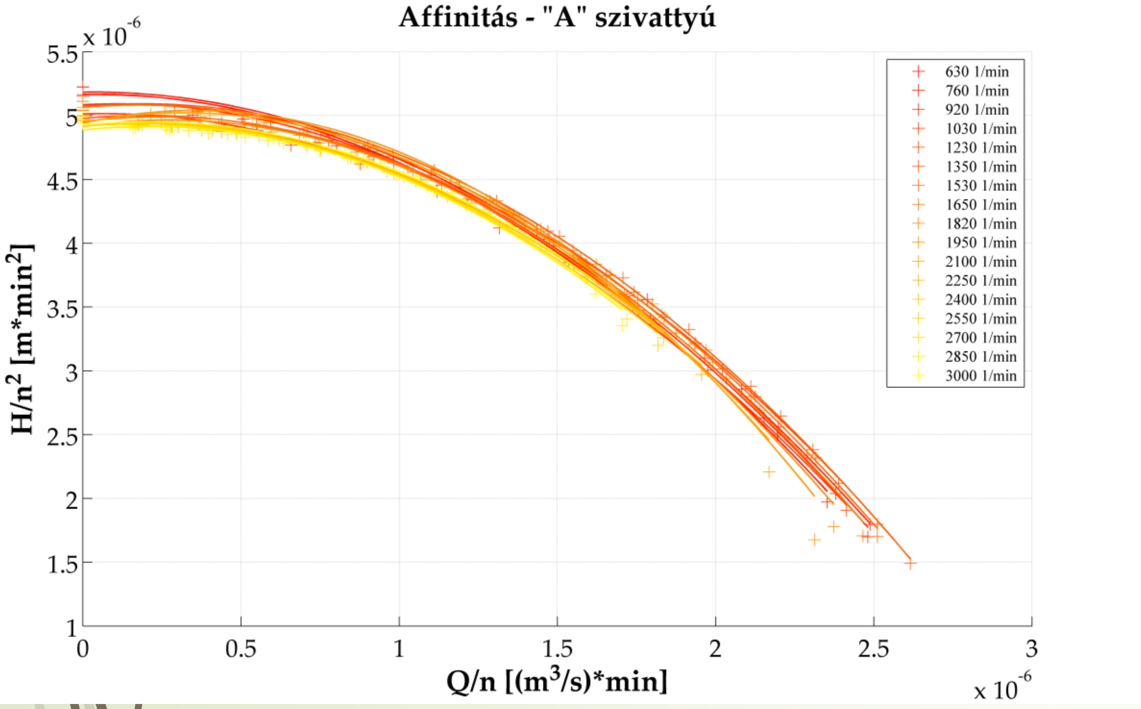


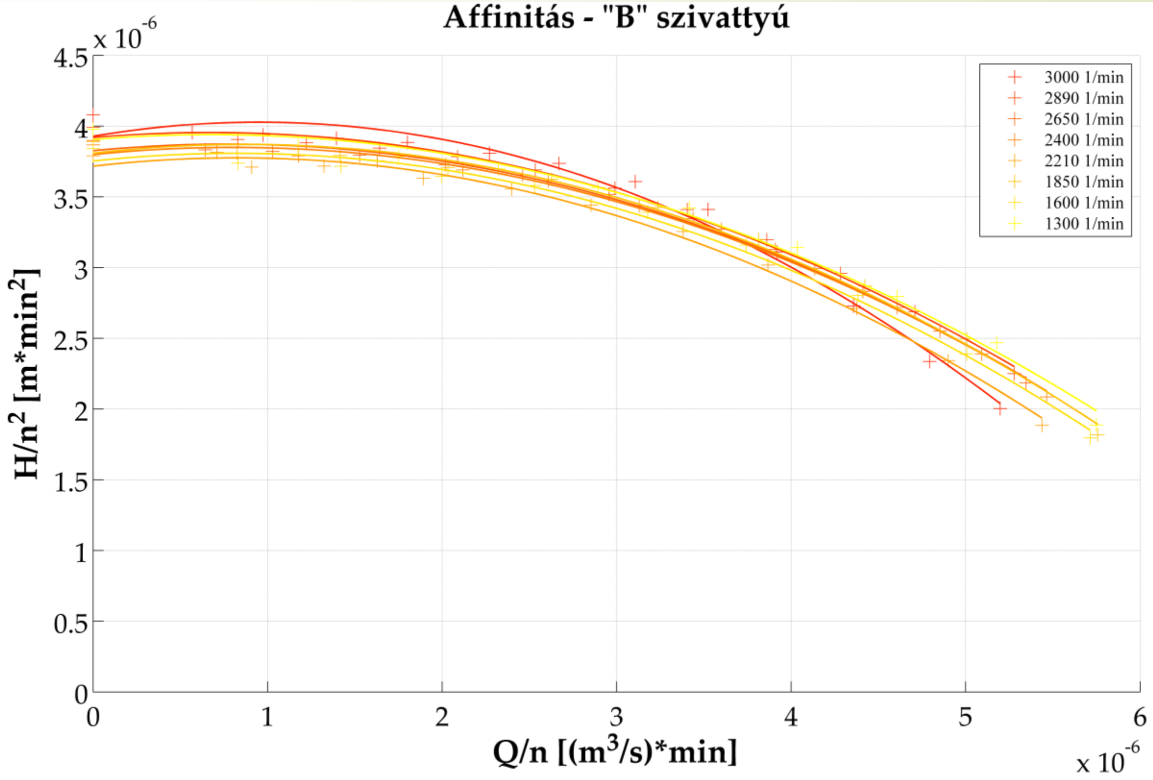
3. Characteristic curves





3. Affinity (only check)



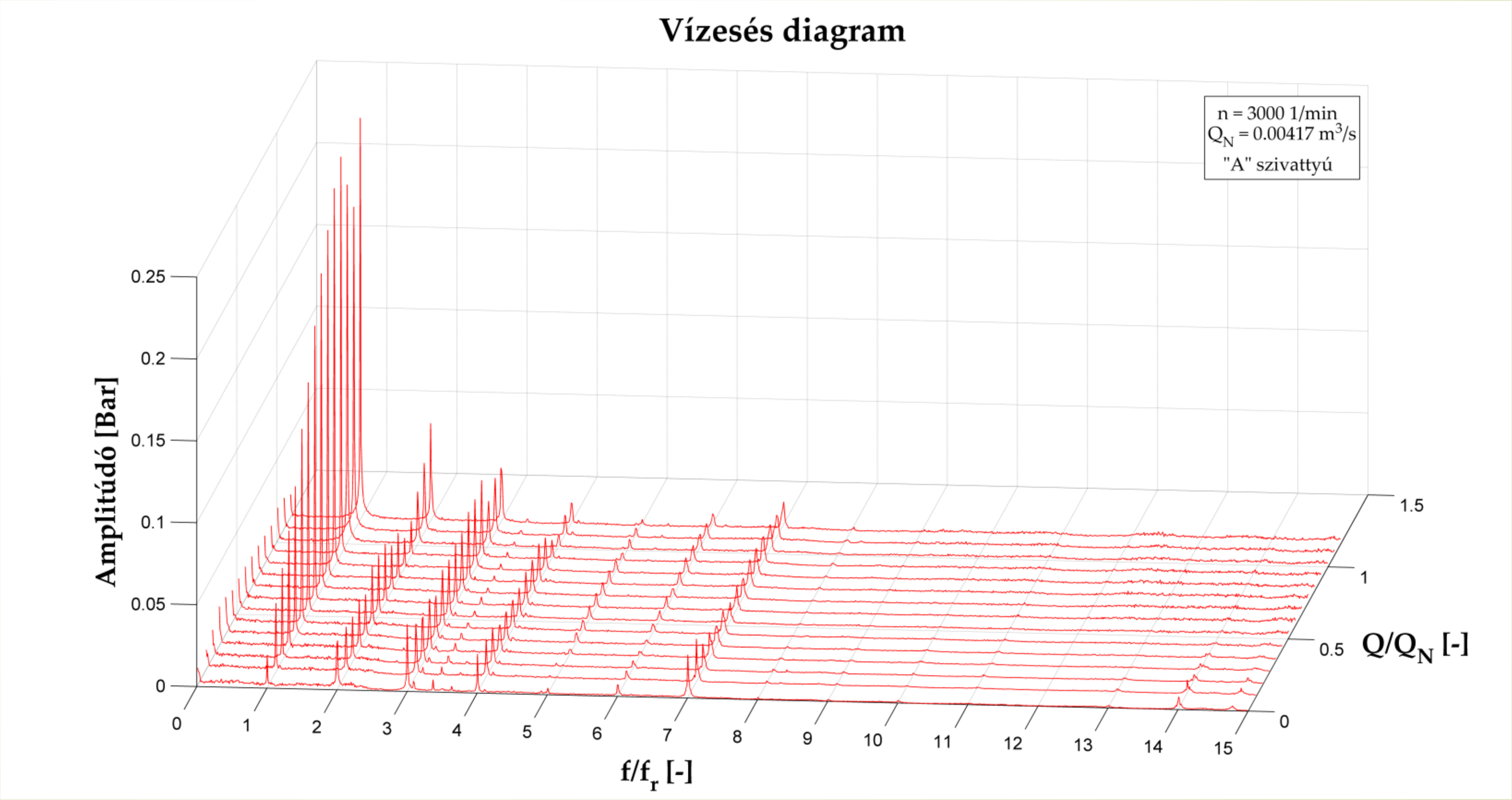


4. Origin of the peaks in the spectra

	Fizikai hatás	Hol növeli az amplitúdót?
Mechanical	Imbalance	f_r (= n/60)
	Eccentricity	f_r
	Deflection of pivot	$1 \cdot f_r - 2 \cdot f_r$
	Fitting errors	$1 \cdot f_r - 3 \cdot f_r$ (even $3\text{-}8 \cdot f_r$)
	Wear of bearings	$1 \cdot f_r - 3 \cdot f_r$
	Alignment of parts	$1 \cdot f_r - 6 \cdot f_r$ (maybe $0{,}5 \cdot f_r$, $1{,}5 \cdot f_r$, $2{,}5 \cdot f_r$ is)
Hydrodynamic	Number of blades	f_{BPF} (= $f_r \cdot z$)
	Flow separation	Small frequency broadband noise
	Cavitation	Broadband noise at high frequency
Motor	Motor instability	Frequency modulation
	Nonlinearity	Harmonic components

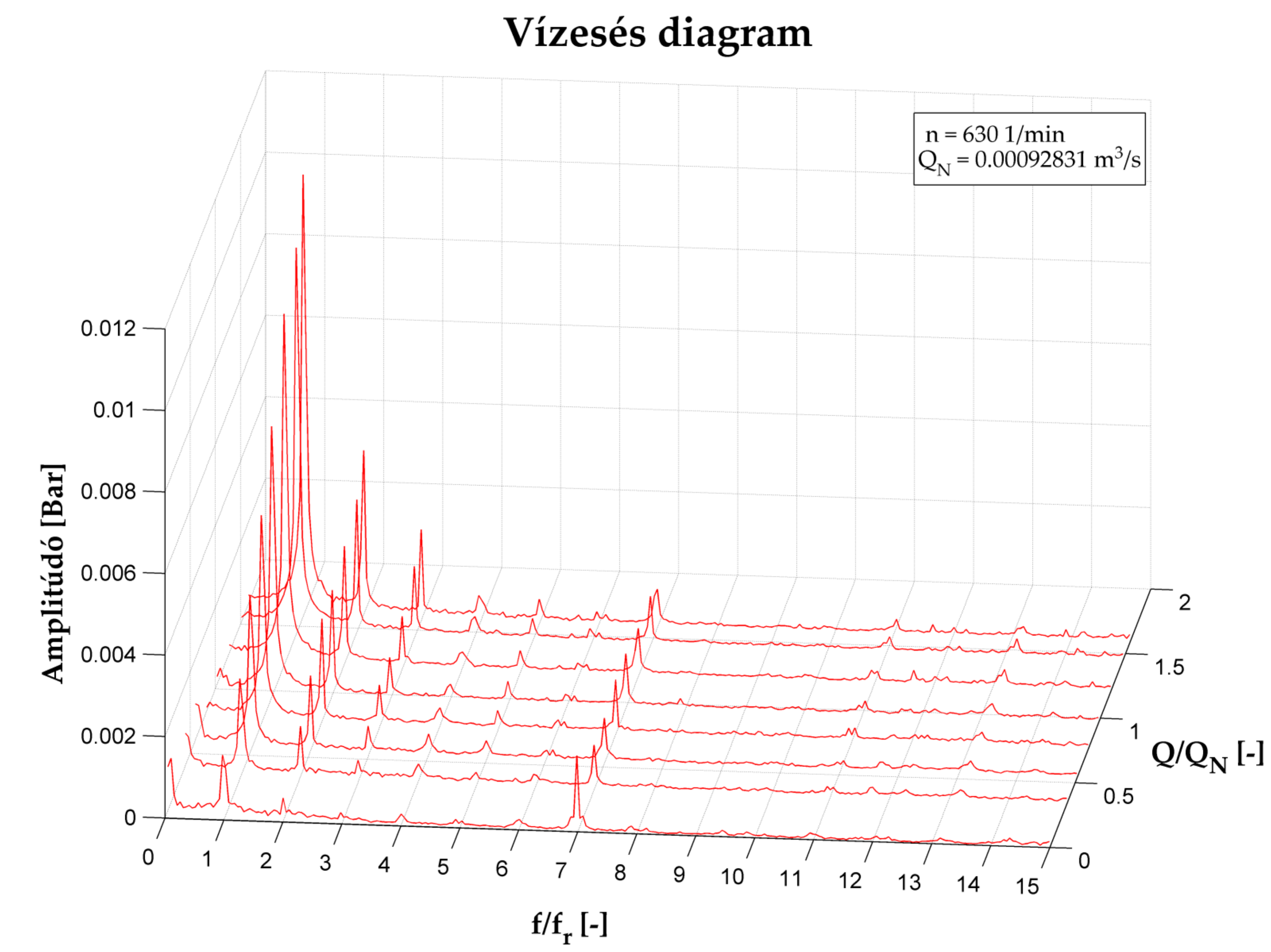
5. Waterfall diagram along a characteristic curve

- Spectra as a function of the volume flow rate at constant revolution number
- Dimensionless quantities:
  - f/f_r
  - Q/Q_N



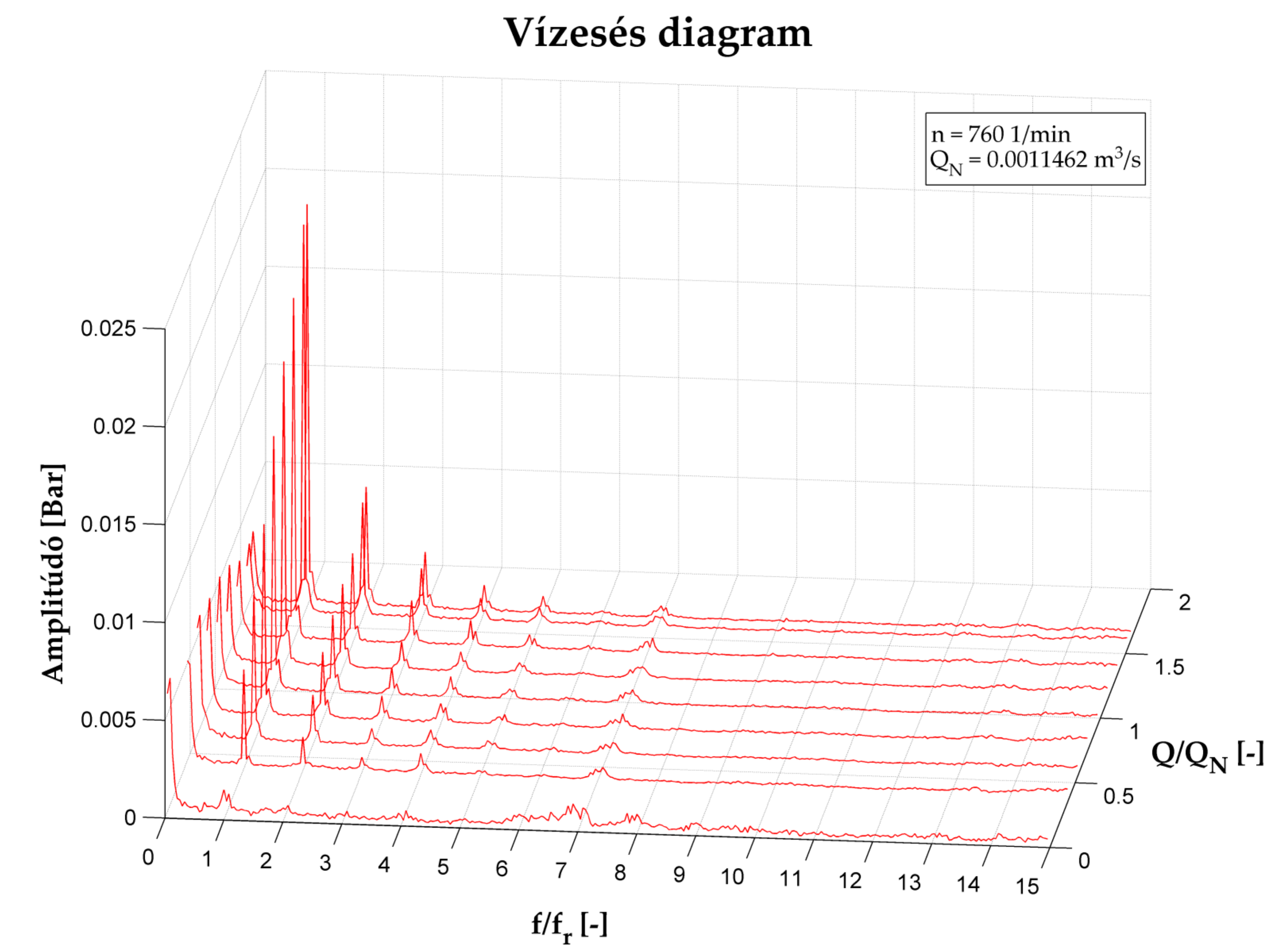
6. Pump (A), n=630 1/min

- Mainly mechanical forces: eccentricity and imbalance. The frequency f/fr=1 has been strongly excited.
- Effect of nonlinearity is clear. (Exponential decay of the harmonics)
- The number of the blades are 7! The frequency component f/fr=7 has been excited by the blades of the impeller. This peak has a physical origin, not only a harmonic component.



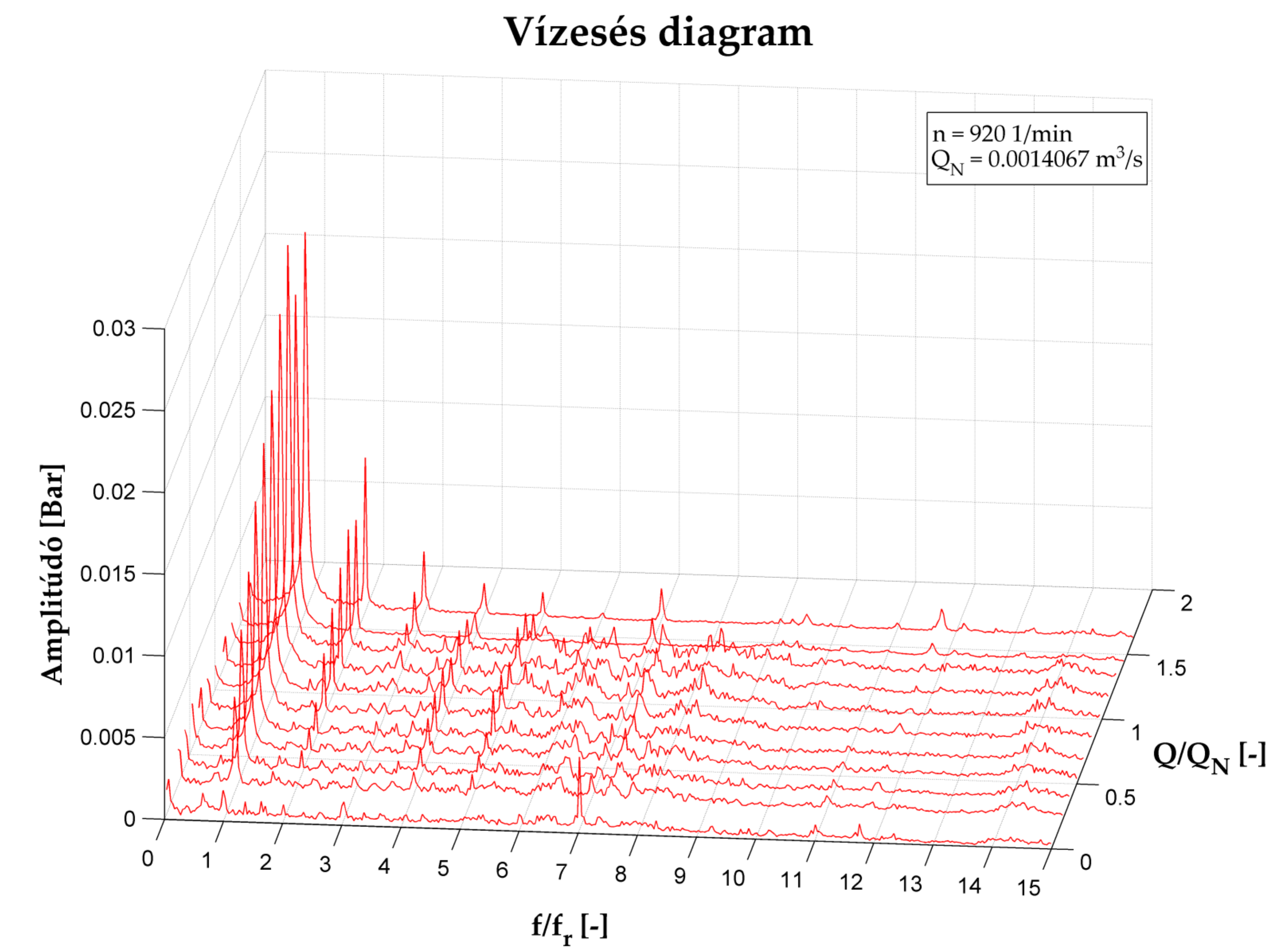
6. Pump (A), n=760 1/min

- Similar conclusion as before!
- The frequency component f/fr=1suppress the frequency component corresponding to the blade passage frequency.



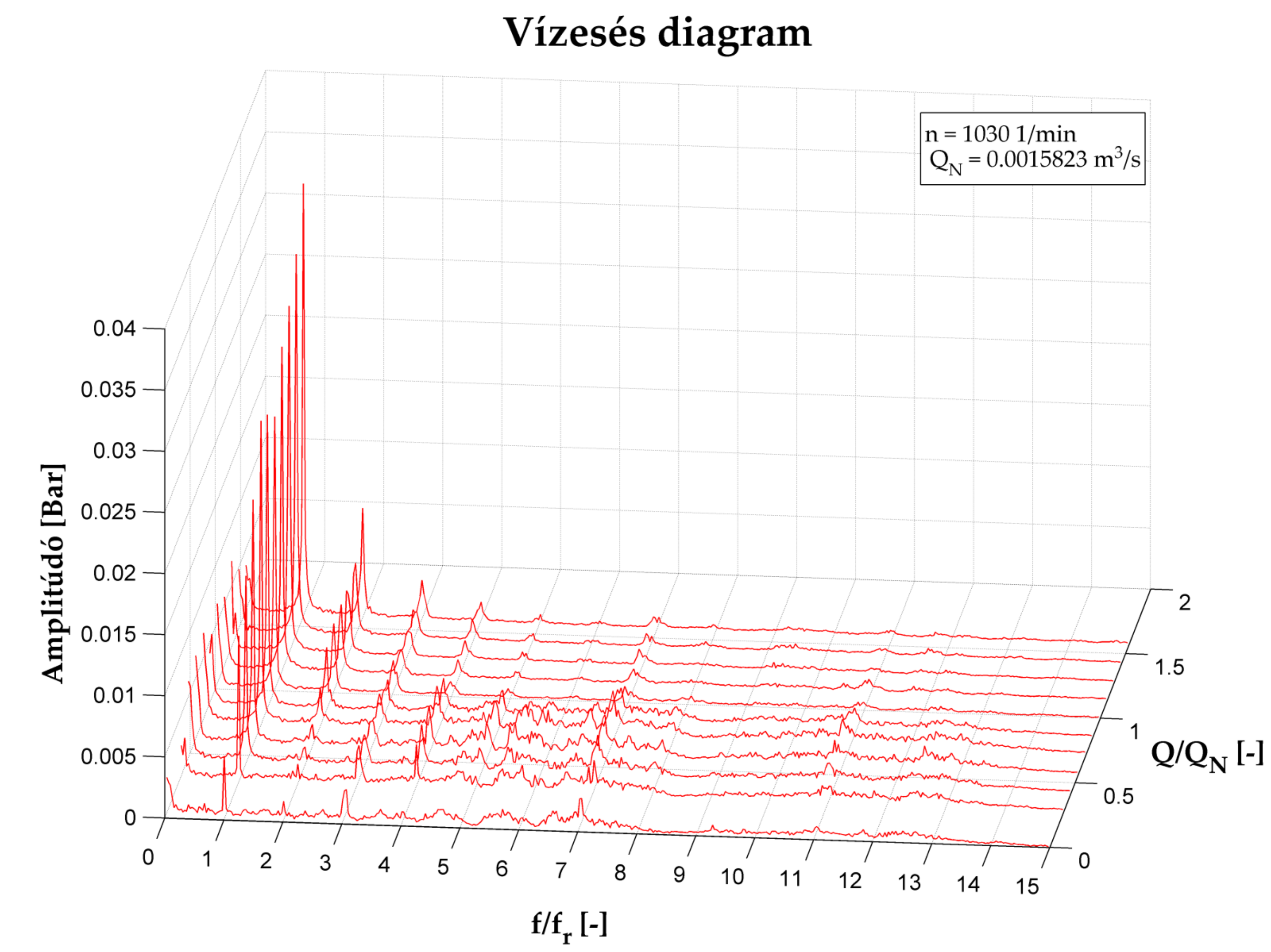
6. Pump (A), n=920 1/min

- A broadband noise appear approximately at relative flow rate lower than Q/QN = 1.4. Here the vibration and the resonance of the whole test rig could be heard.
- This strong vibration smoothen the blade passage frequency.
- The appearance of the frequency components f/fr=4-5 suggests the strengthen of mechanical forces: fitting and alignment inaccuracy etc…



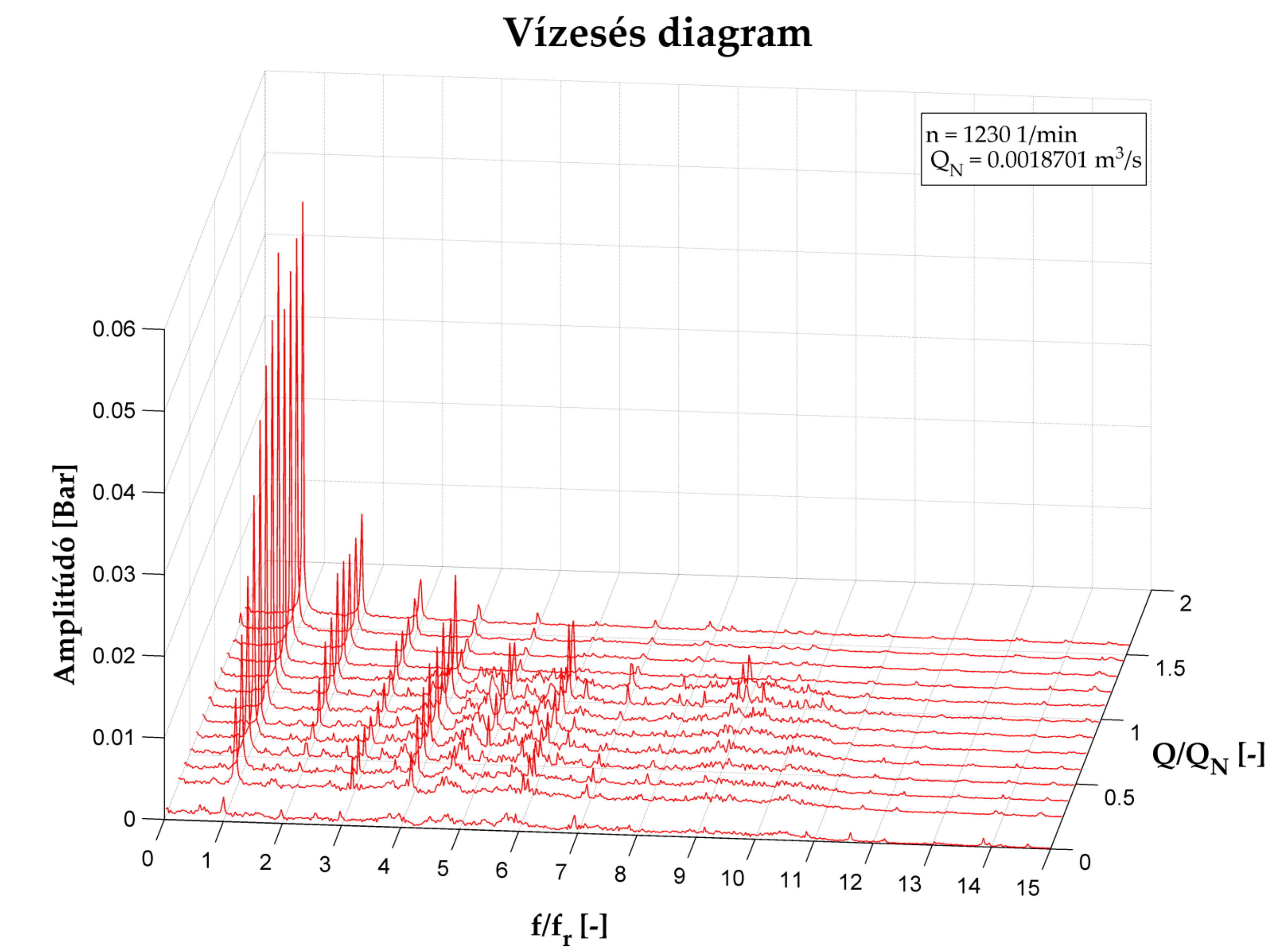
6. Pump (A), n=1030 1/min

- Similar conclusion as before!



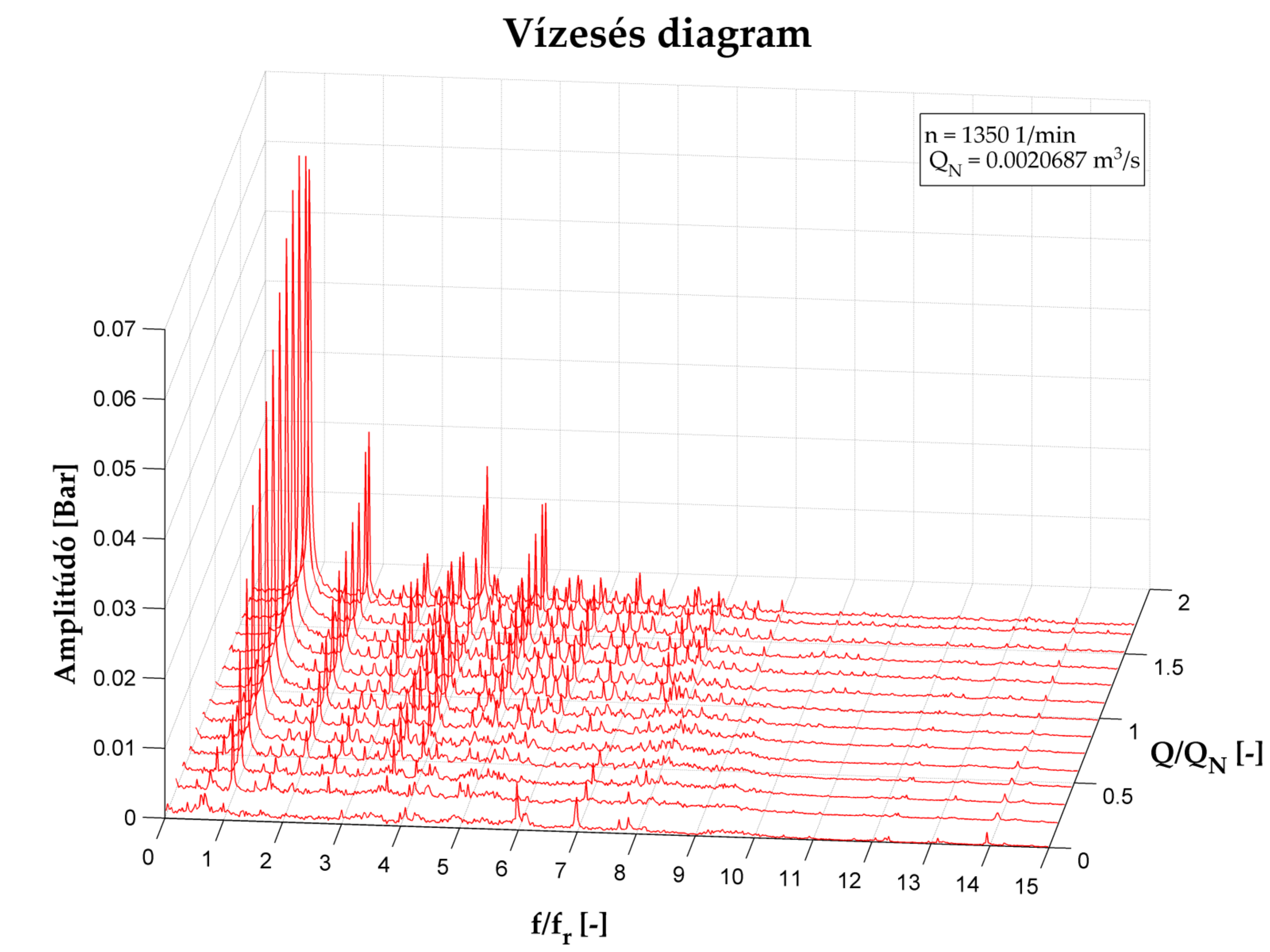
6. Pump (A), n=1230 1/min

- Similar conclusion as before!
- It can be clearly seen that above Q/Qn=1.2 the mechanical noise disappears and the main frequency component comes from the eccentricity and imbalance. The rest of the peaks are the effect of nonlinearity.



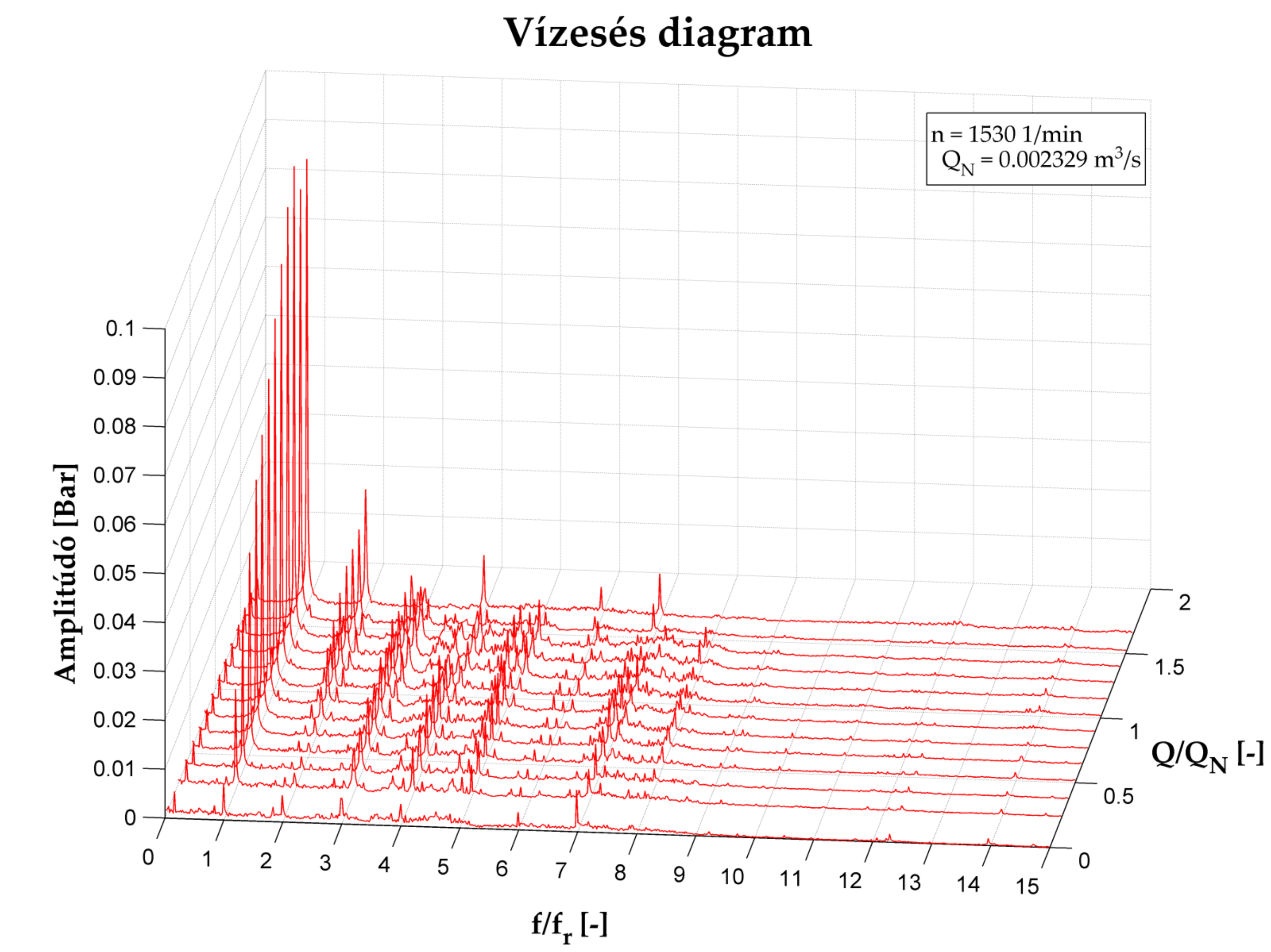
6. Pump (A), n=1350 1/min

- Strong motor instability as a form of frequency modulation.



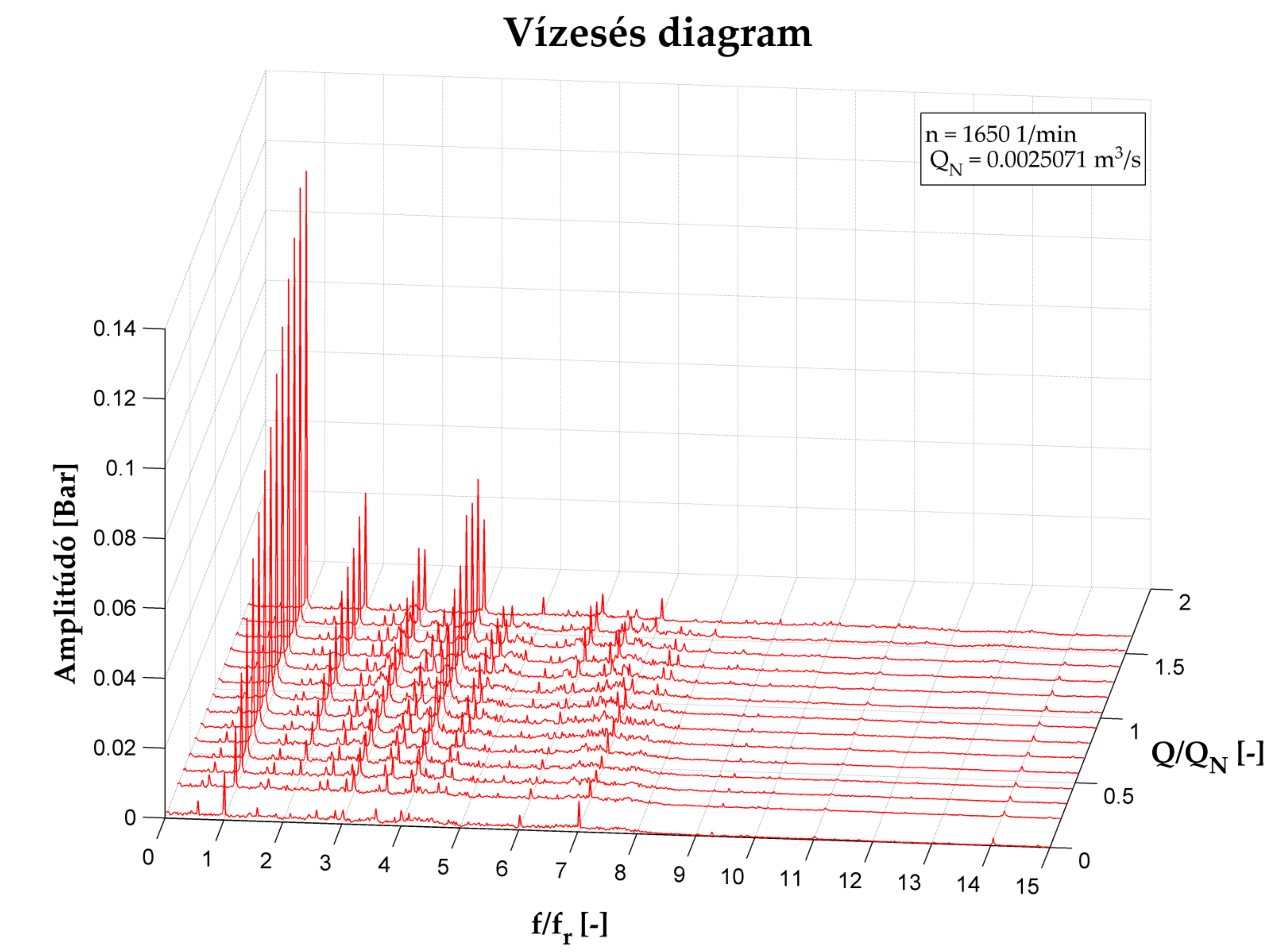
6. Pump (A), n=1530 1/min

- The motor instability weakens, the frequency modulation is weak.
- Approximately above Q/QN=1.5 the motor instability disappears.



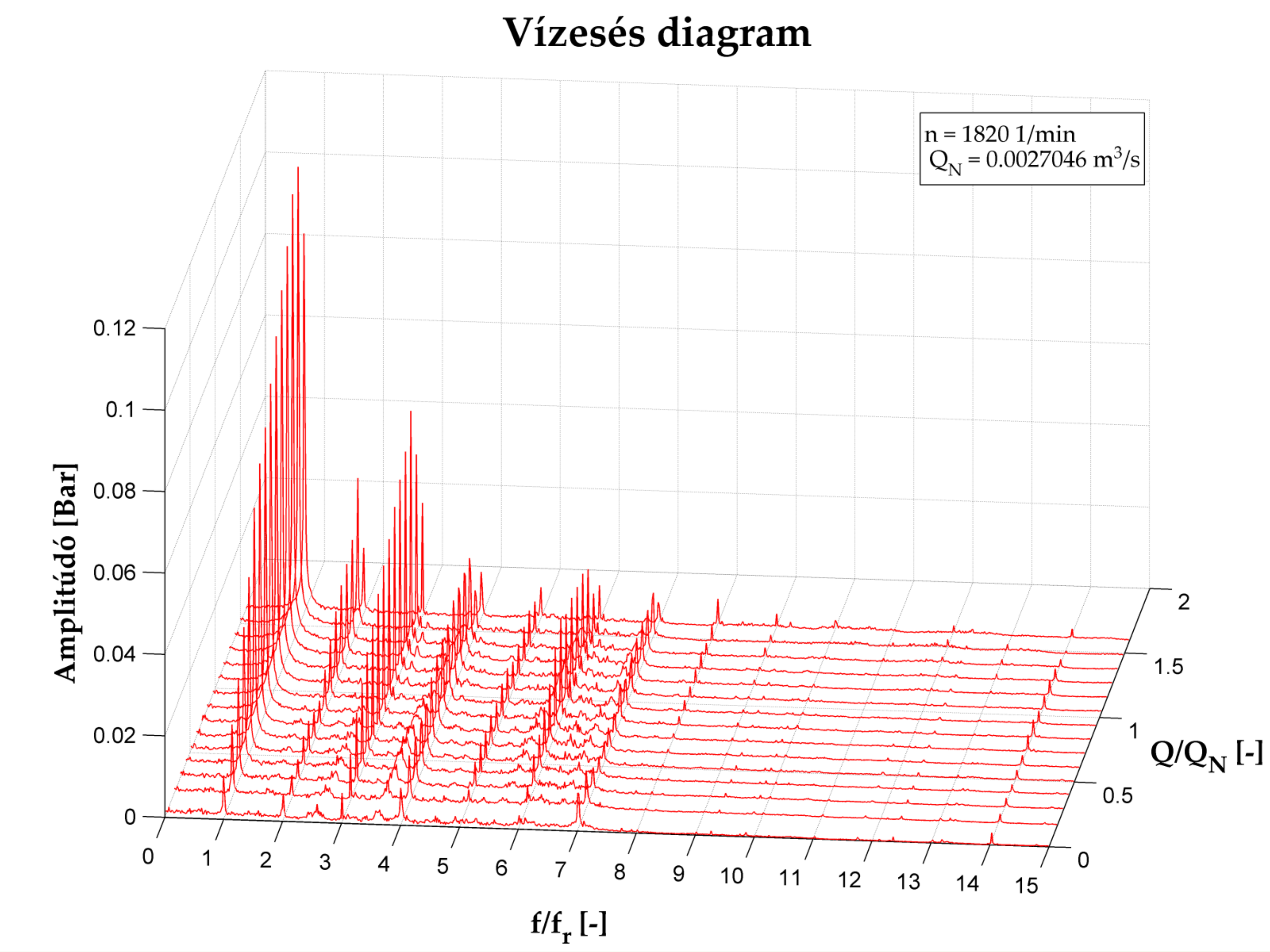
6. Pump (A), n=1650 1/min

- Strengthen the mechanical noise. (Strongly excited harmonics)



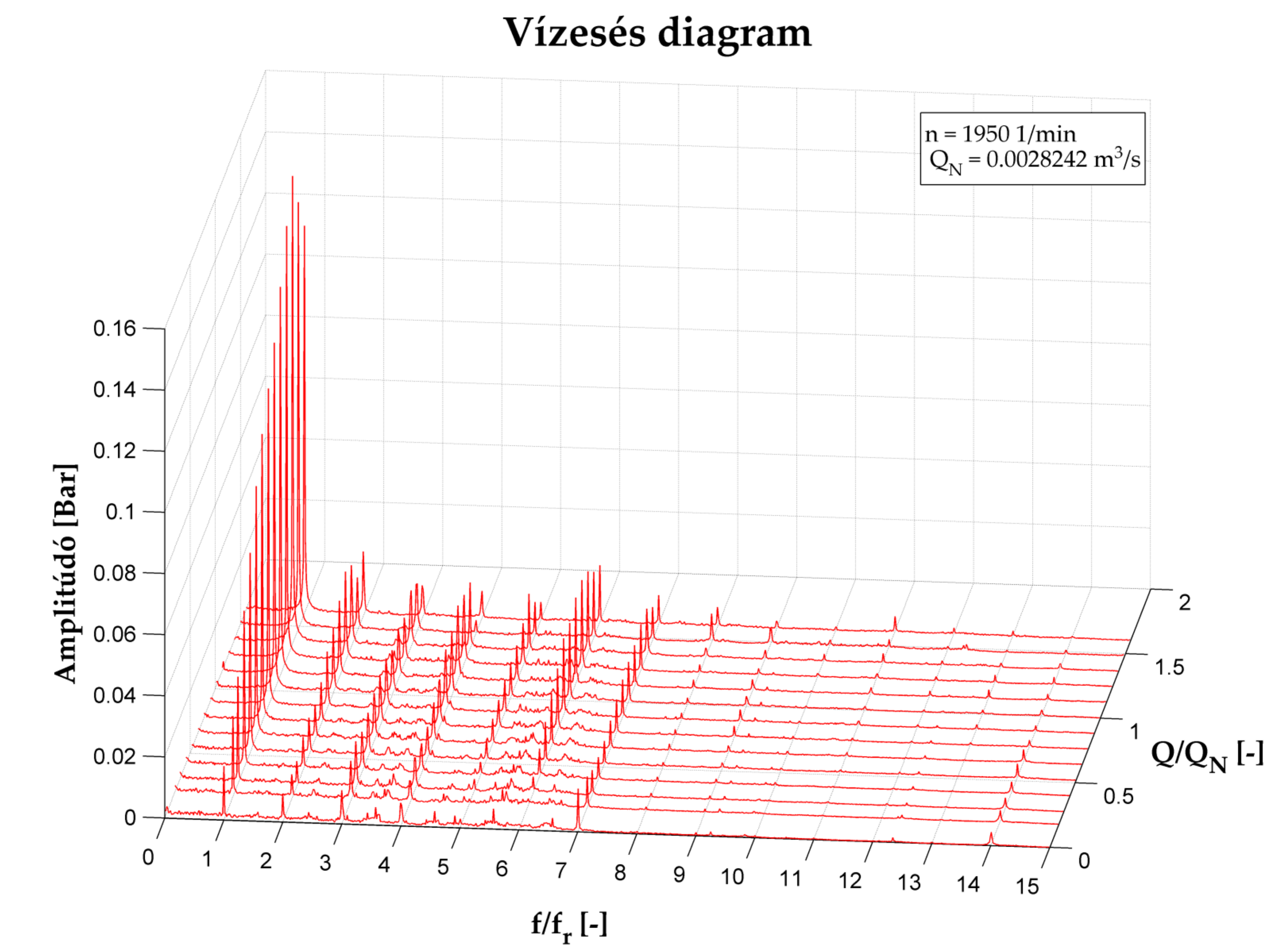
6. Pump (A), n=1820 1/min

- The mechanical noise strengthen further. It is not surprising since the forces in such cases are proportional to the second power of the revolution number.



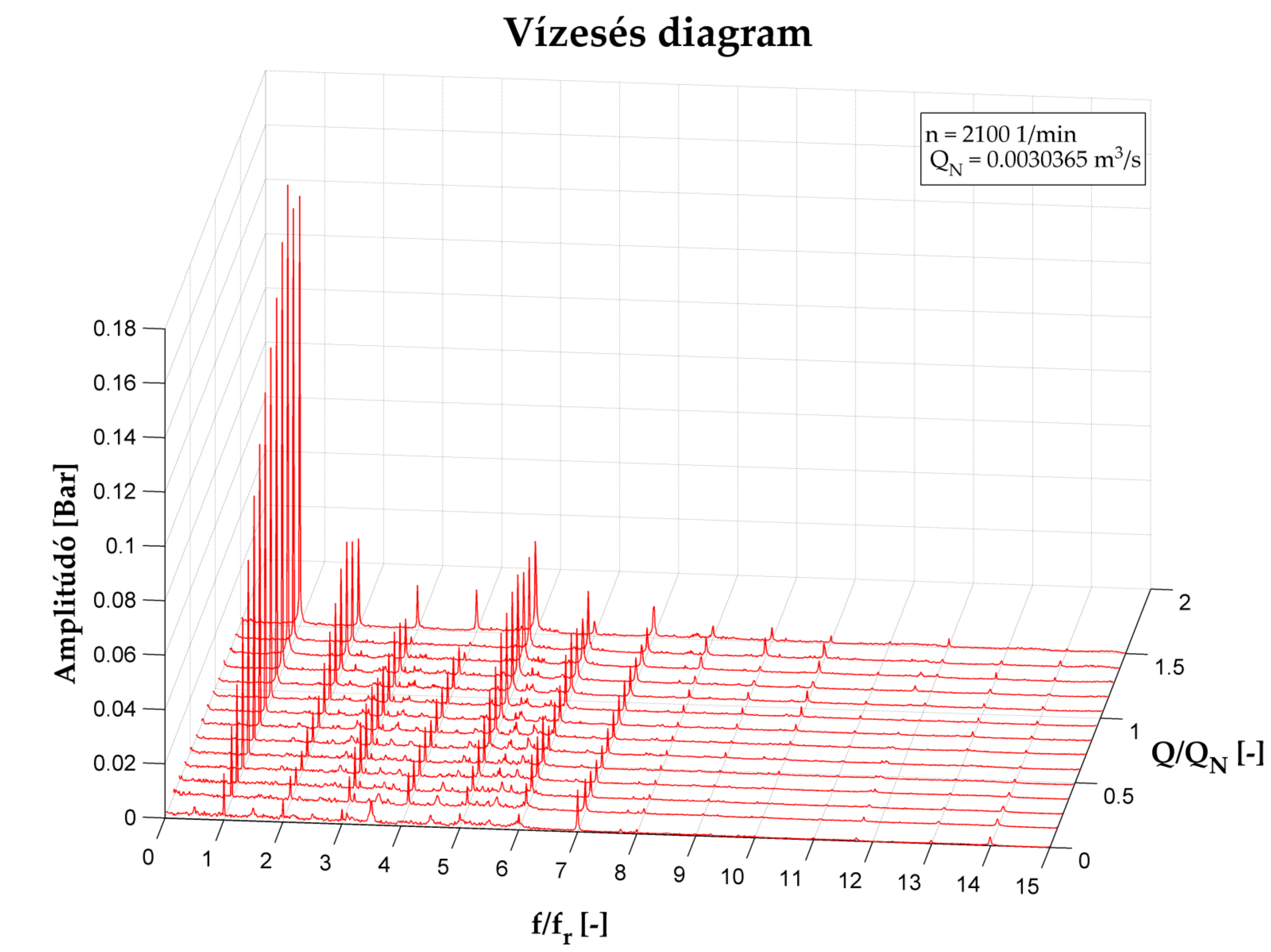
6. Pump (A), n=1950 1/min

- Similar conclusion as before!



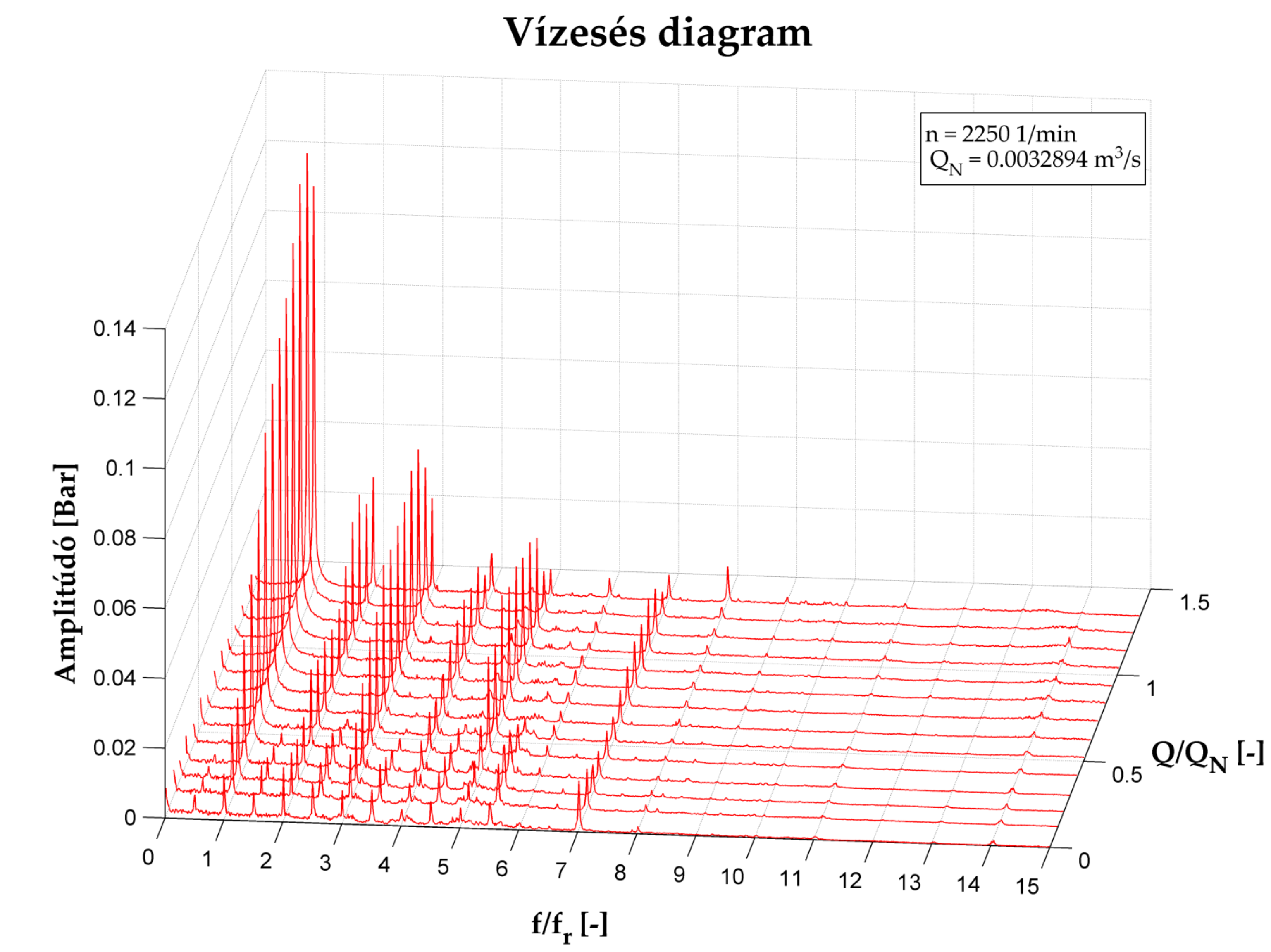
6. Pump (A), n=2100 1/min

- Similar conclusion as before!



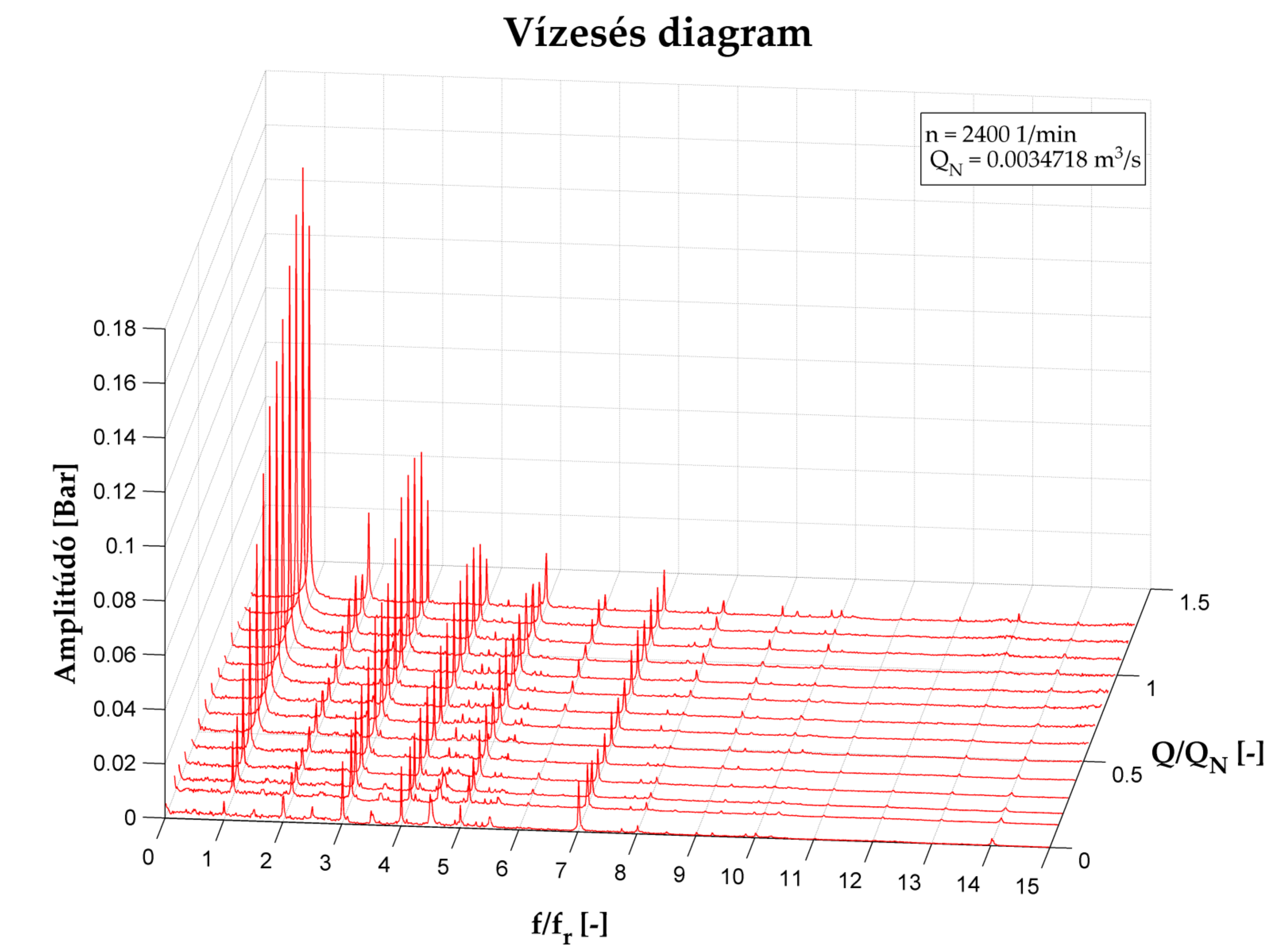
6. Pump (A), n=2250 1/min

- Similar conclusion as before!
- At small flow rates, the appearance of "half" frequencies suggest the influence of the improper alignment of mechanical parts(according to the literature).



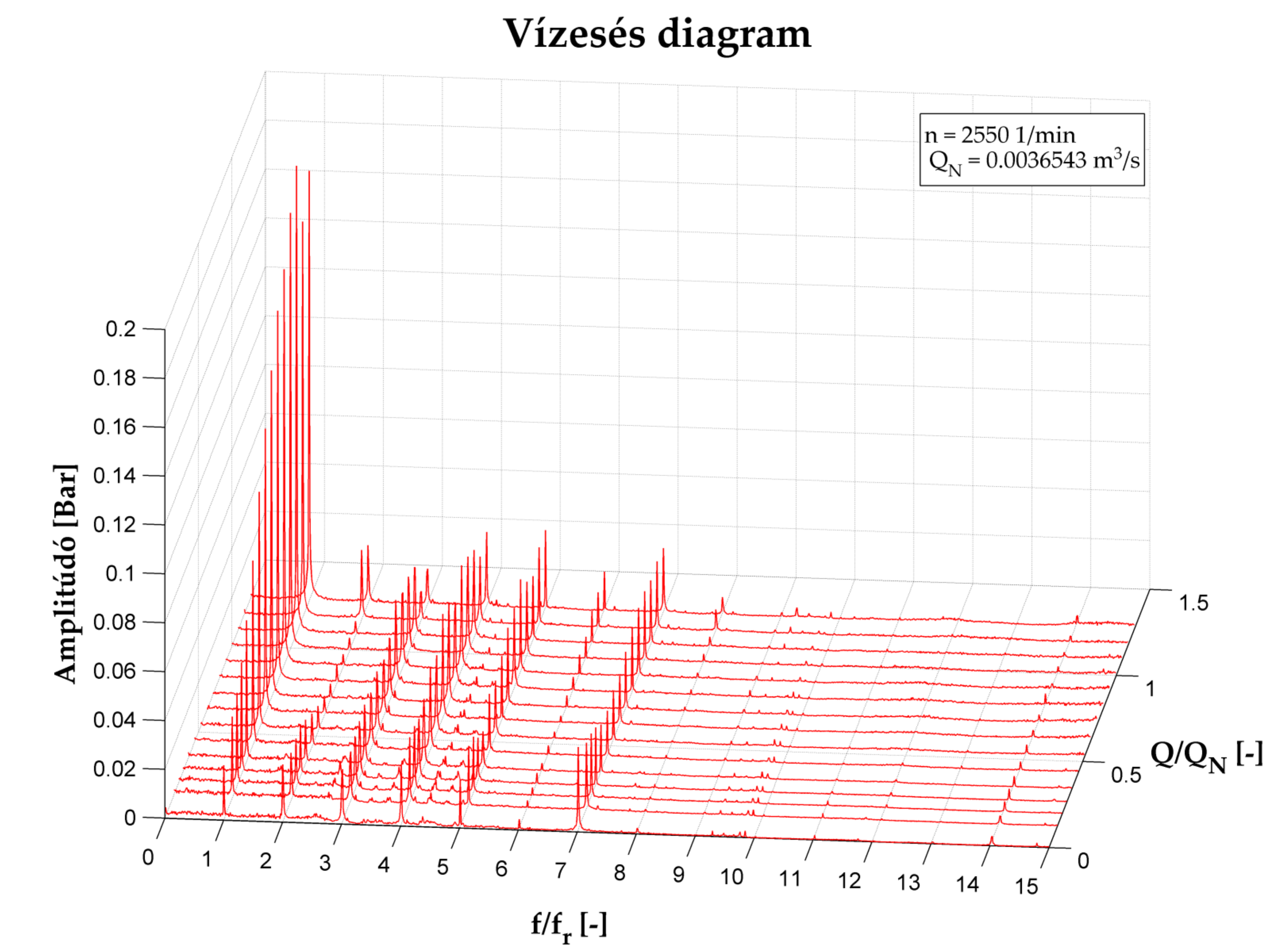
6. Pump (A), n=2250 1/min

- Similar conclusion as before!



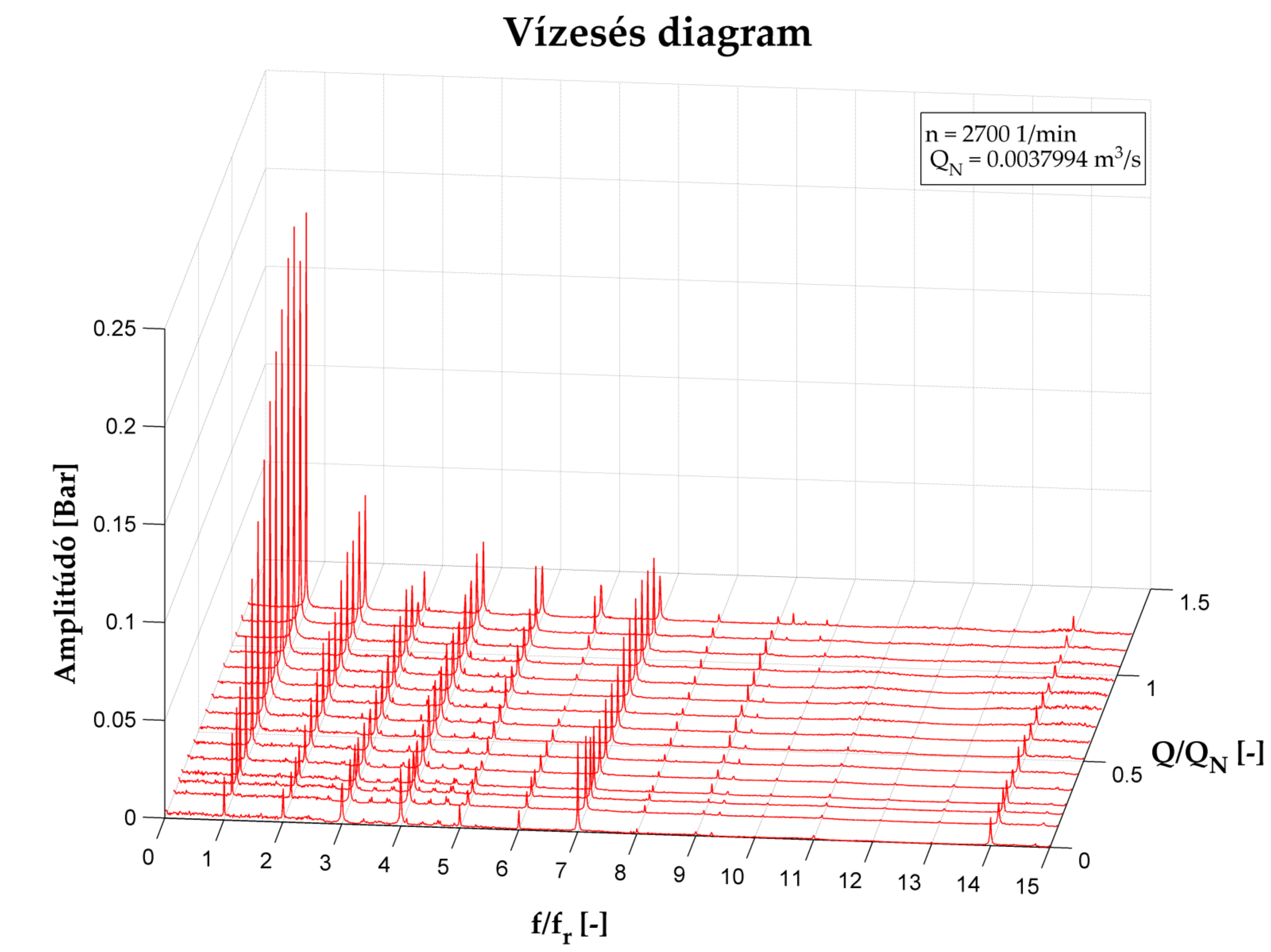
6. Pump (A), n=2550 1/min

- Similar conclusion as before!



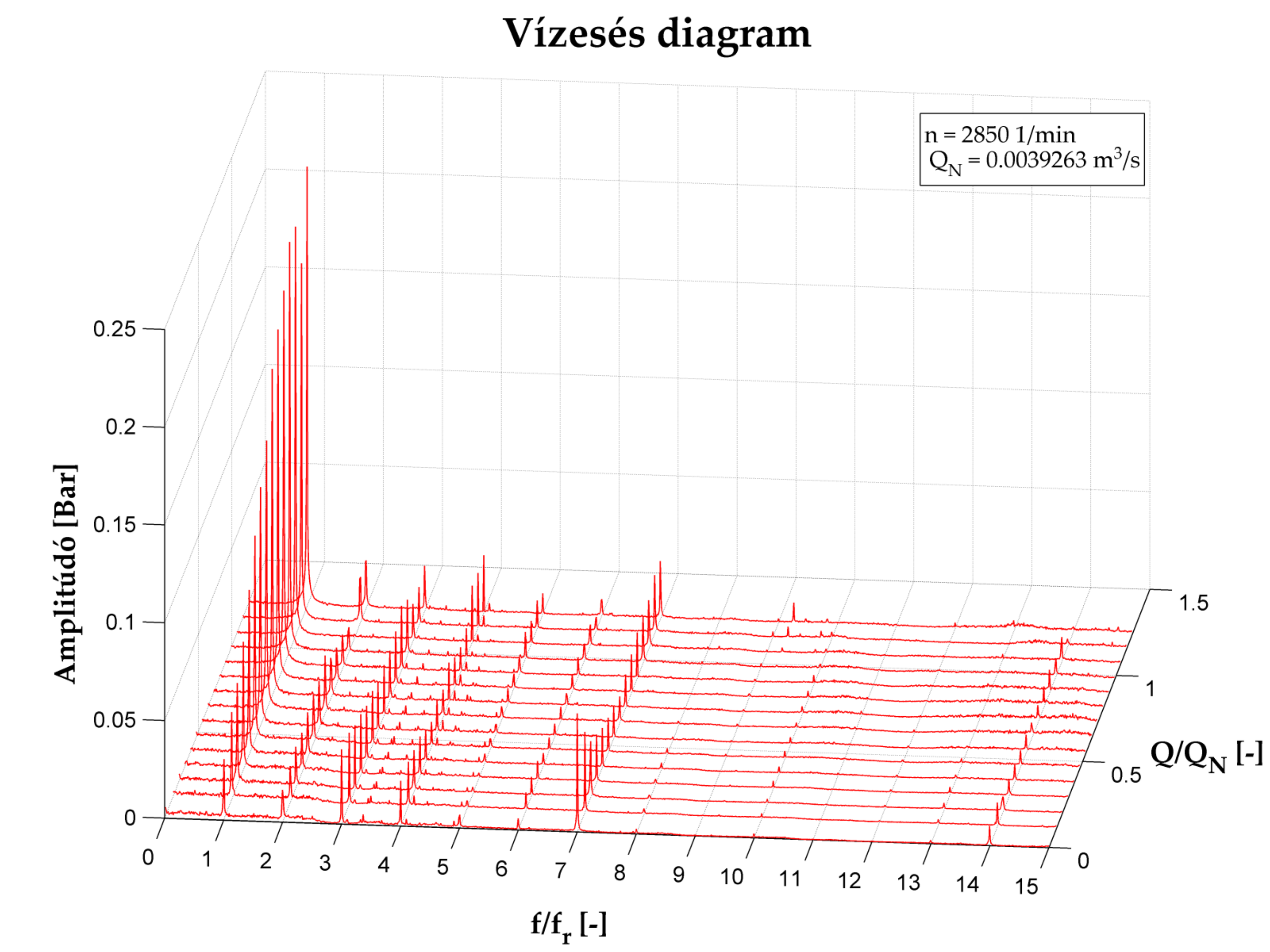
6. Pump (A), n=2700 1/min

- Similar conclusion as before!



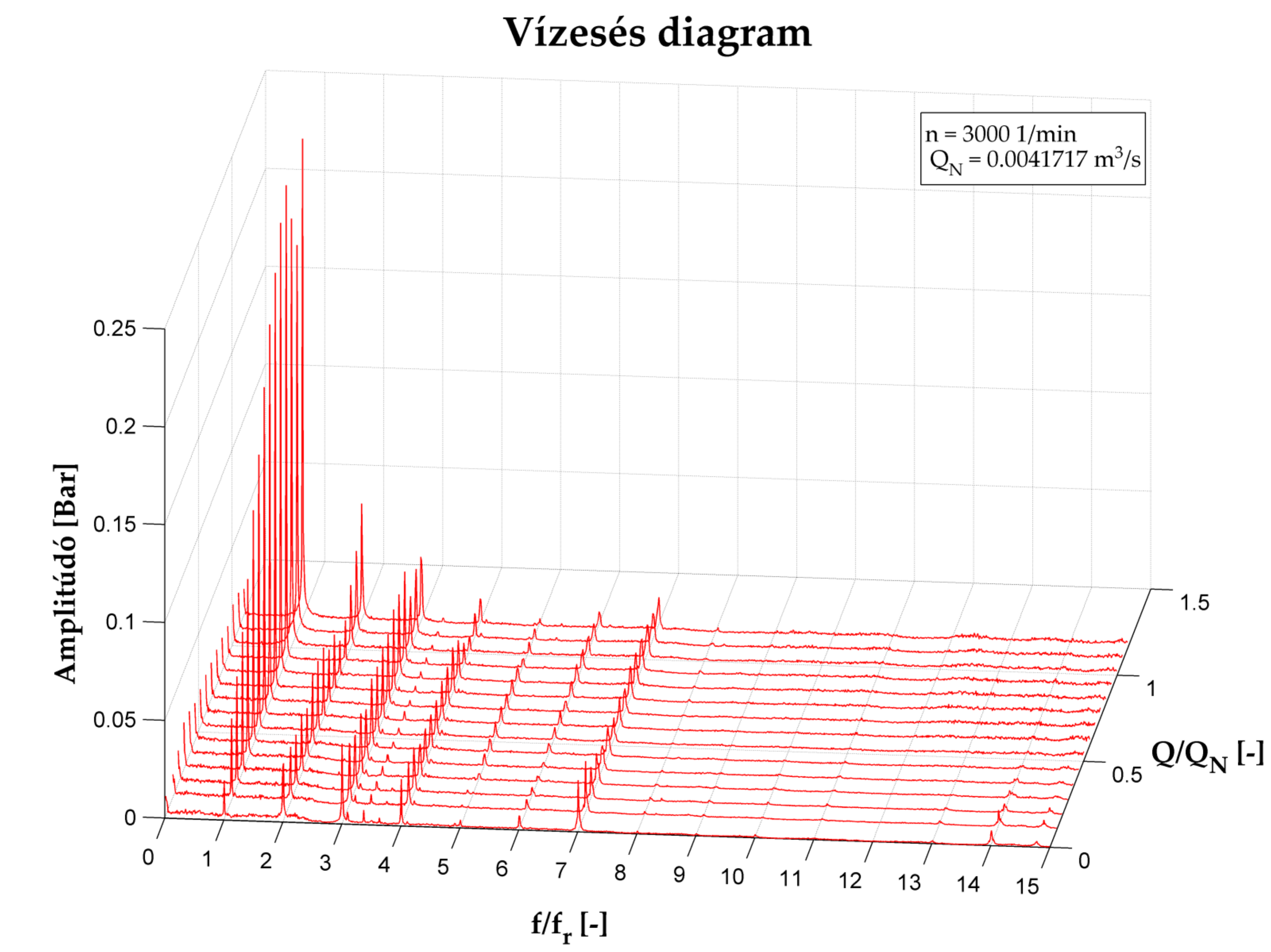
6. Pump (A), n=2850 1/min

- Similar conclusion as before!



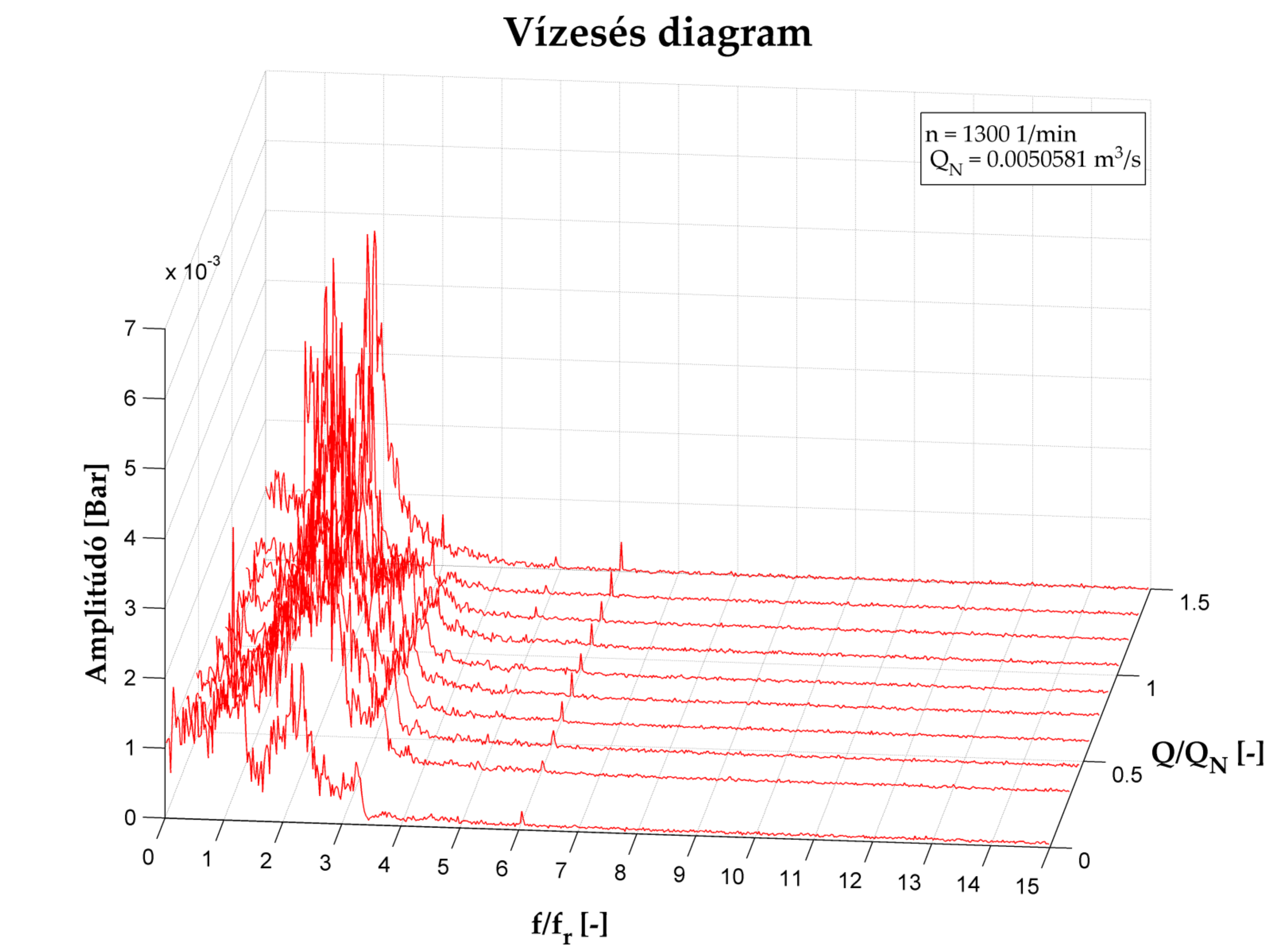
6. Pump (A), n=3000 1/min

- Similar conclusion as before!



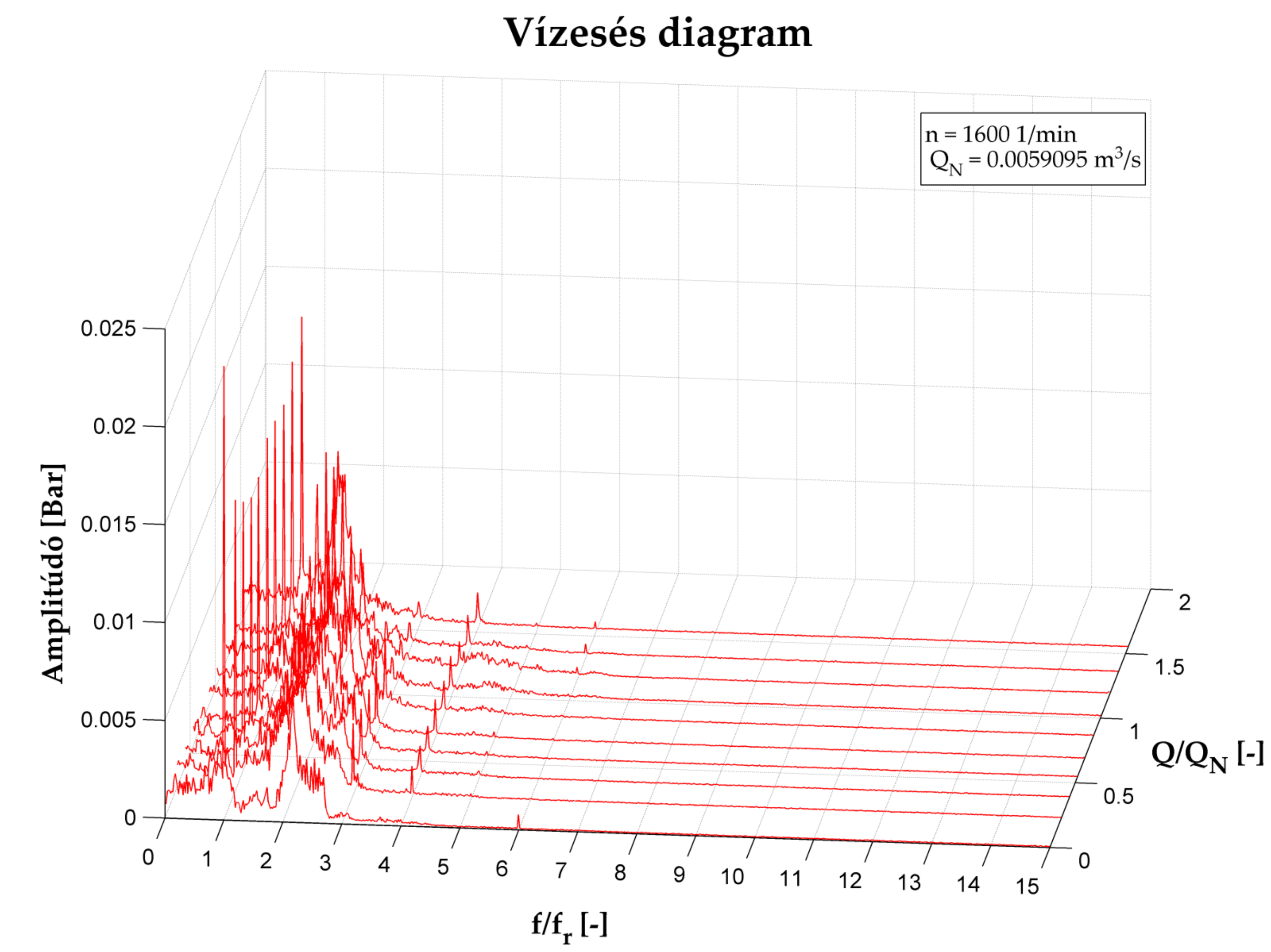
7. Pump (B), n=1300 1/min

- Mainly hydrodynamic noise.
- The number of the blades is 6!
- There is no peak from eccentricity and imbalance.
- The noise level is orders of magnitudes smaller compared to pump (A)!



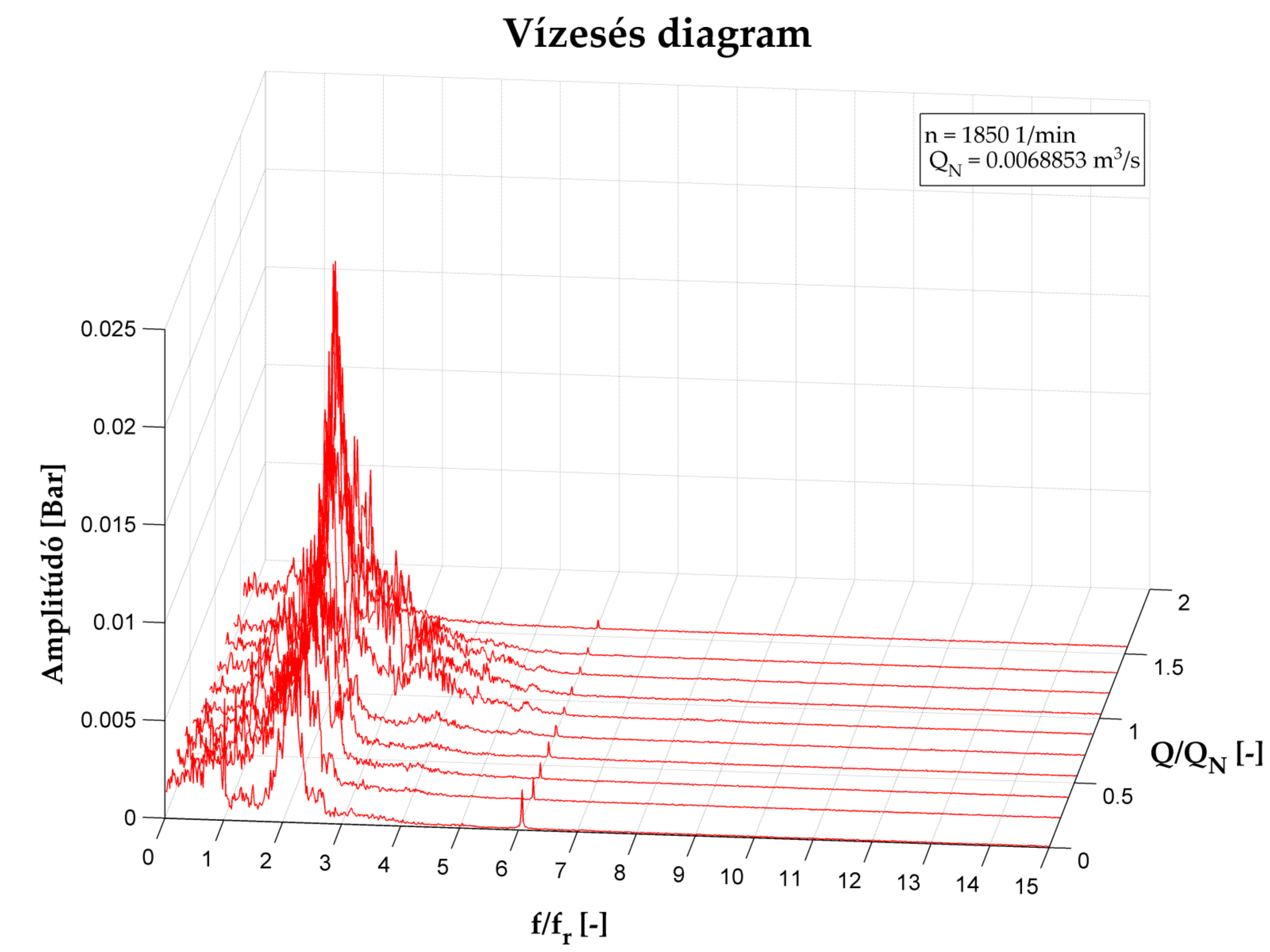
7. Pump (B), n=1600 1/min

- The peak due to eccentricity and imbalance appears only at this revolution number, which has exponentially decaying harmonics.



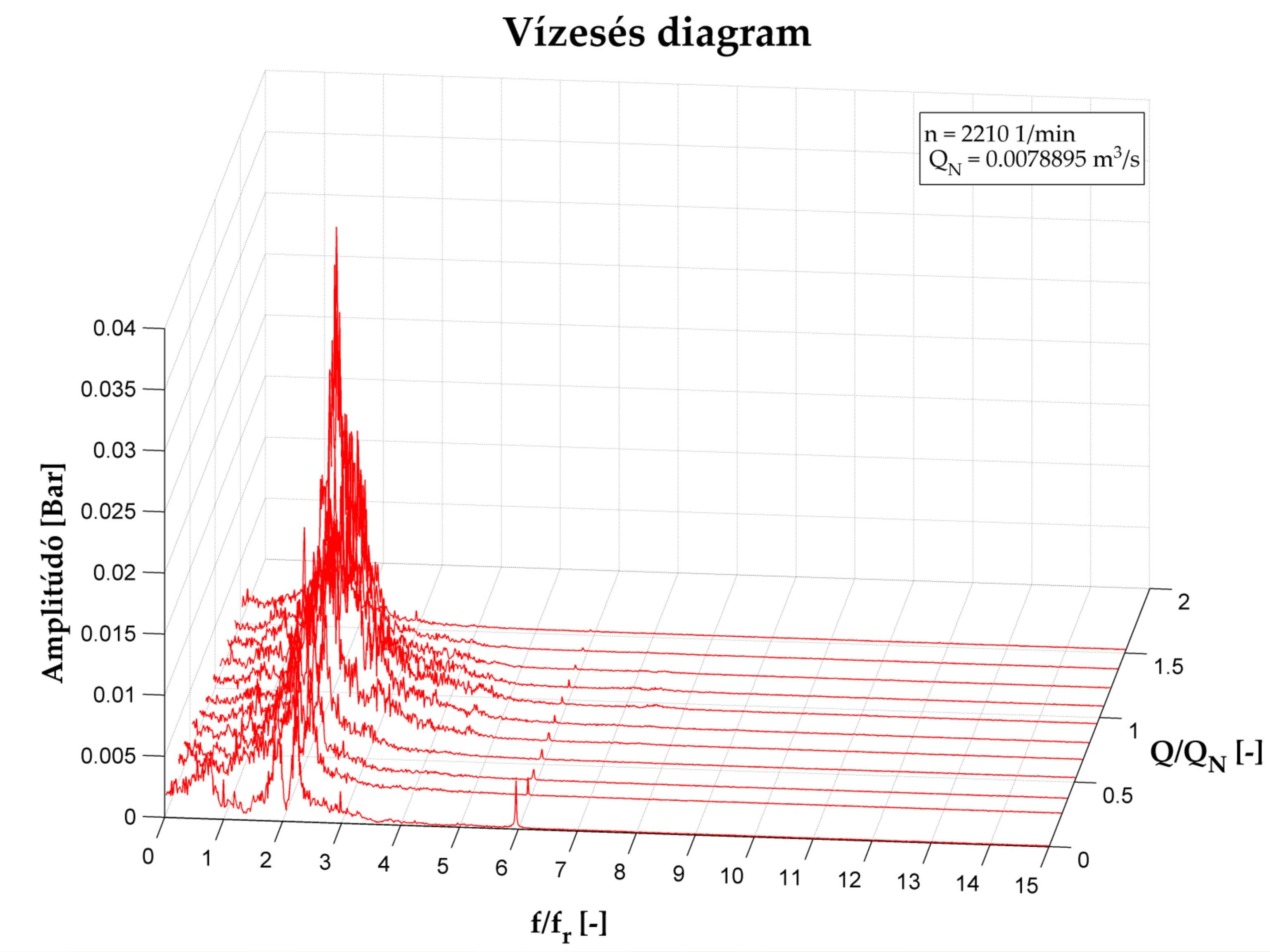
7. Pump (B), n=1850 1/min

- Only hydrodynamic noise again.



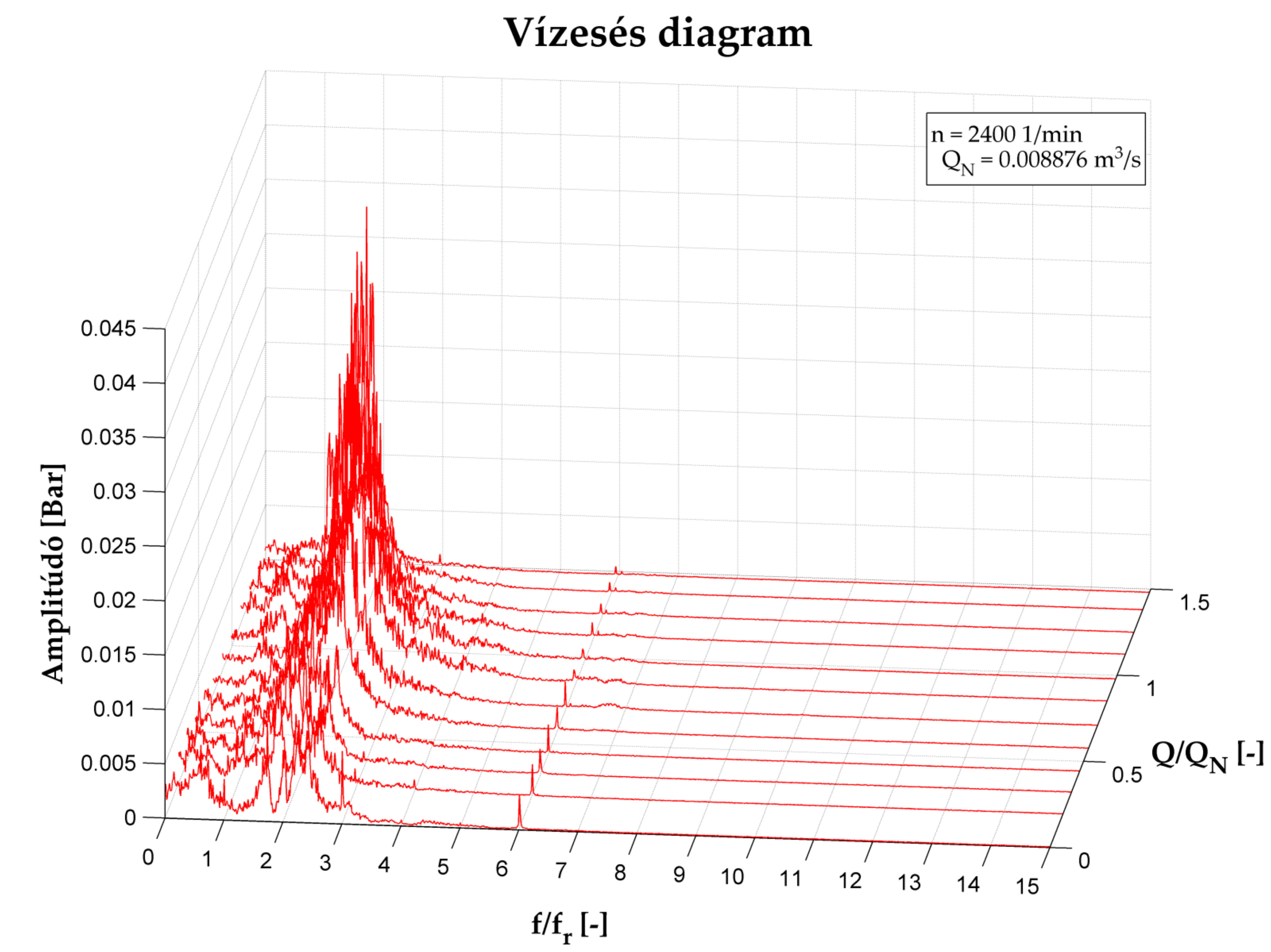
7. Pump (B), n=2210 1/min

- Similar conclusion as before!



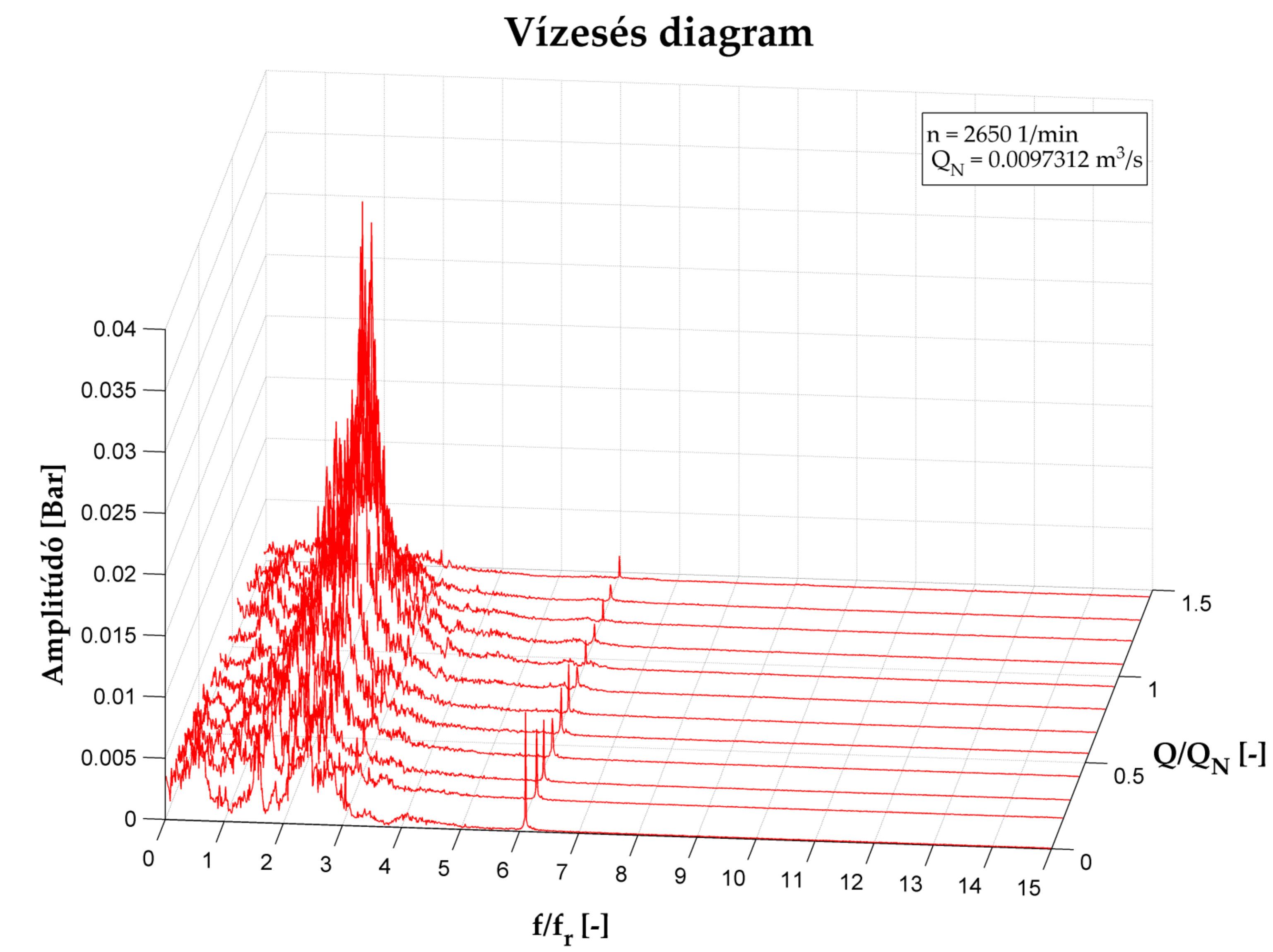
7. Pump (B), n=2400 1/min

- Similar conclusion as before!



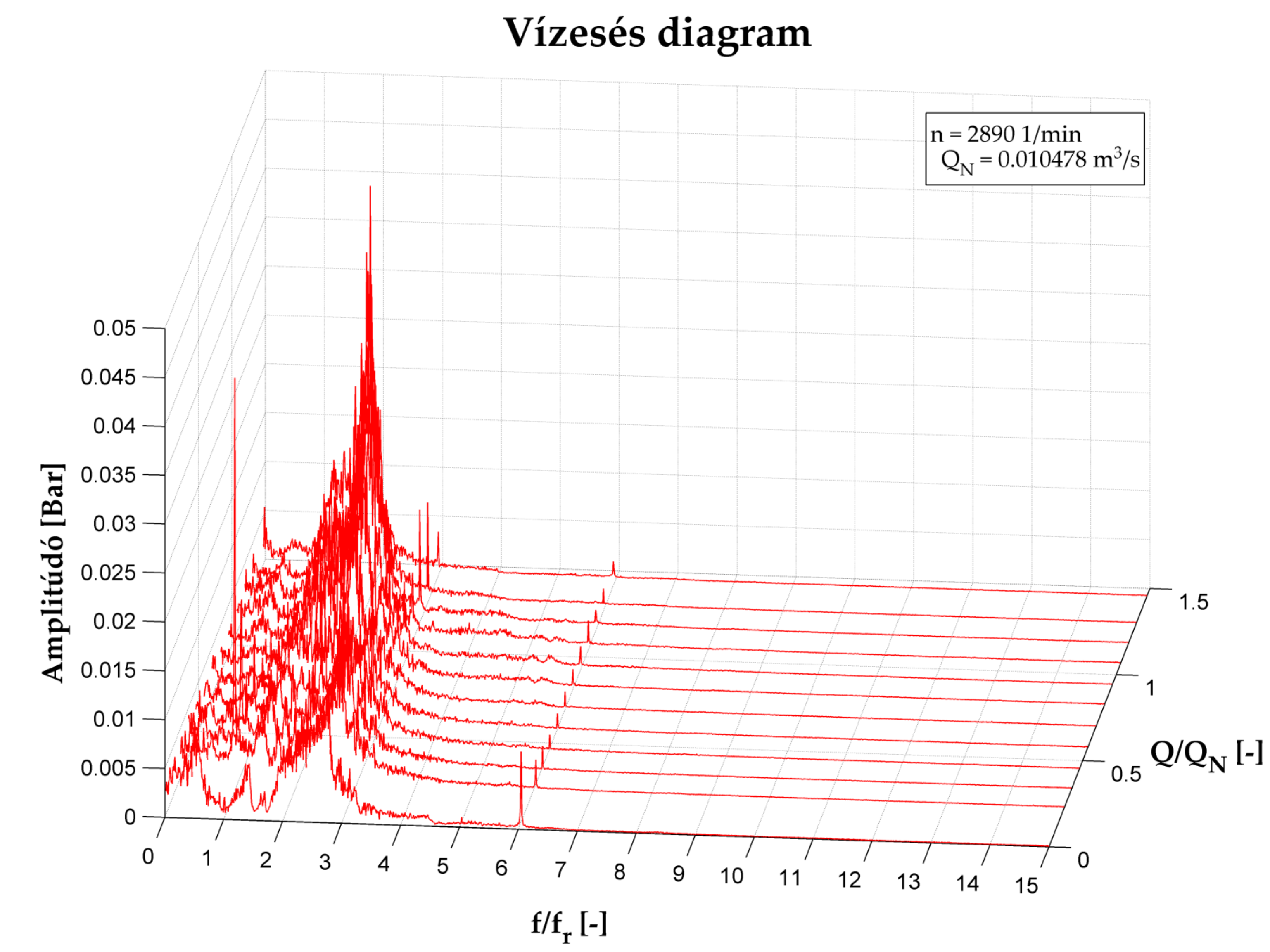
7. Pump (B), n=2650 1/min

- Similar conclusion as before!



7. Pump (B), n=2890 1/min

- Similar conclusion as before!



7. Pump (B), n=3000 1/min

- Similar conclusion as before!