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Overview and comparison of vibrator technologies for formworks

Since the 1950's, the activities of Bosch have included the development and production of vibrators for precast element formworks. And since 1995, Brecon has taken over the further development of these technologies under license from Bosch. Much experience with the different technologies (pneumatic, electrical and electromagnetic) and applications in the low (approx. 3,600 rpm) and high (from approx. 4,500 rpm) frequency ranges has also been gained during this period. This report describes the advantages and disadvantages of the different techniques and shows which frequency range gives the best results for concrete compaction. The possibilities of conversion to the new SL technology is also discussed.

In precast element production, some parameters are of crucial importance to the production process.

- The main parameters when using a vibrator are the rotational frequency and the force produced by the motor. These form the basis for selecting the appropriate vibrator for the formwork. If the vibrator does not operate at the appropriate parameters, under certain circumstances the formwork will be too heavily loaded and may be damaged. If the vibration energy is too small, the optimum result will not be obtained during vibration.
- The ability to adjust a vibrator substantially increases flexibility during production. Thus compaction can also be carried out at the optimum vibration frequency with concretes of different quantities and consistencies.
- During the production of exposed surfaces in particular, uniform, reproducible vibration where demixing and occluded air is avoided as far as possible is important.
- In many plants, the noise emission of vibration is an important subject
- The financial aspect has been considered as well: how much investment a technology requires and how high the subsequent costs are.

Pneumatic and electrical vibrators have been considered which are commonly used for concrete compaction.

Pneumatic vibrators

Pneumatic vibrators are connected via a high-pressure hose system to a central compressor which supplies a constant air pressure. The vibration is adjusted via stop valves which are operated mechanically.

The imbalance of compressed air vibrators is usually not adjustable but can only be operated according to a characteristic of centrifugal force over speed. Even with this characteristic, it is difficult to adjust the speed precisely. A drop in system pressure due to other consumers in the plant, for example, can cause the rated output to vary or prevent it from being reached.

Pneumatic vibrators are available for low speeds (LF) and for extremely high speeds (HF) up to 15,000 rpm. However, these speeds are no longer relevant for the concrete compaction. In general, higher speeds usually result in a huge decrease in efficiency and a substantial increase in noise level. Thus the energy balance which is in the ratio of 1:5 is also less favourable than with electrical vibrators, but this is not crucial since the running times are short.

However, pneumatics vibrators have certain cost benefits, although the initial investment in a compressor and air supply lines is not insignificant. If it is assumed, however, that the basic system is already there, then it is substantially better to acquire further compressed-air vibrators than to convert to their electrically operated counterparts.

Conclusion:
particularly for low budget projects, there is no doubt that this type of vibrator can be justified. However, cutbacks must be expected in handling and profit.

Single-phase electrical vibrator

With single-phase electrical vibrators, the centrifugal force can normally be adjusted. These produce less noise than compressed-air vibrators. The speed can also be changed electrically during operation. Electrical vibrators, however, have the lowest power, which means that the speed can drop significantly under load and the vibration force decreases quadratically with the speed. Another disadvantage is that the voltage in the vibrator is supplied via carbon brushes.

Conclusion:
Only in areas where a 3-phase voltage supply still does not exist, such as in parts of North America where the voltage supply is 115V, is the single-phase electrical vibrator a sensible alternative.

Three-phase electrical vibrators

Vibrators in the form of three-phase, alternating current, synchronous motors have became the standard for concrete compaction in most industrialised regions throughout the world. One reason for this is that the vibration energy which they deliver is highly stable. Drives using adjustable frequency converters have also become established for vibrators since the end of the 1980's. Electrical speed regulation has opened up a whole field of additional possibilities for simplifying working processes in the concrete plant: radio controllers, PLC controllers, integration into machine controllers and automatic control loops or mobile control solutions.

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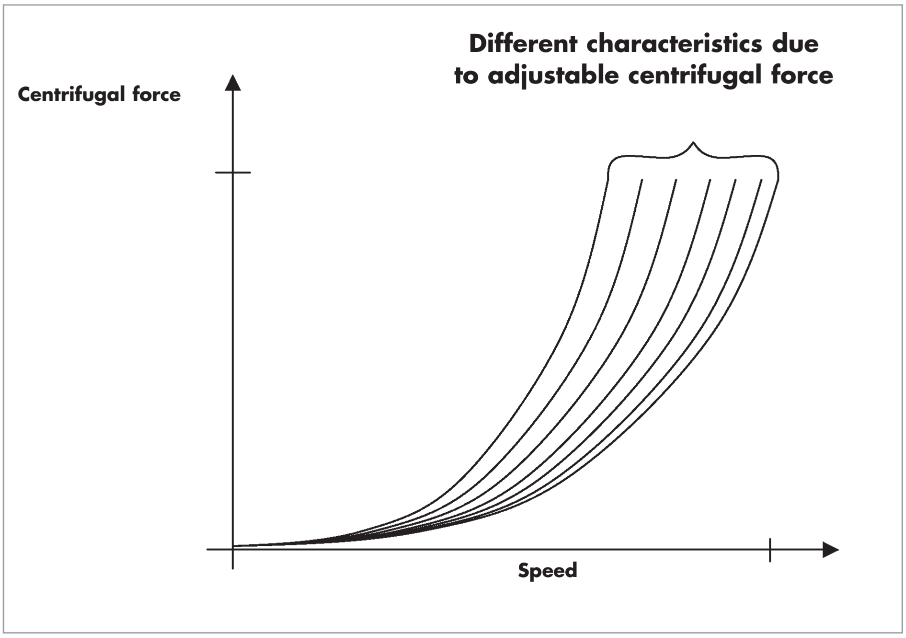

Once the optimum adjustment for the centrifugal force delivered by the electrical vibrators for a particular formwork has been determined, the vibration can always be repeated with exactly the same adjustment. On the other hand, the vibration energy can be quickly adjusted to altered conditions even during the concreting process. Electrical vibrators also have advantages over pneumatic vibrators in terms of noise emission, and this is improved even more with the new SL technology (see below).

Low-frequency (LF) compaction

LF compaction systems with speeds of up to 3,600 rpm are mainly used today for the compaction of earth-moist concrete, where the aim is for the vibrators to have a beating effect on the concrete. Using LF for the compaction of wet concrete is outdated because the compacting effect is rather small. Even with very long vibration times the result tends towards demixing rather than satisfactory compaction.

A theoretical advantage of LF compaction is that these types of vibrators can be run directly from the mains power supply. A controller is not absolutely necessary and the centrifugal force on the vibrator can still be adjusted precisely.

High-frequency (HF) compaction

HF vibration is now generally accepted for wet concrete compaction. The optimum speeds lie between 4,500 and 6,000 1/min. Occasionally, with high pipe moulds for example, significantly higher speeds up to 12,000 1/min. can also reasonably be used. HF vibrators need an electronic frequency controller for operation, or a motor frequency inverter such as those which were typically in use up the end of the 1980's.

The optimum frequency and required total centrifugal force is determined both by the formwork and the quantity of wet concrete to be compacted. Other factors are the composition and the slump of the concrete as well as the effects of the environment such as temperature etc.

High frequency compaction with synchronous operation (SO)

SO vibrators are a further development of HF vibrators. This technology ensures that all vibrators on the formwork are running at absolutely identical speeds. This prevents the setting up of low-frequency beats which contribute to the noise emission by the swelling and fading of humming. This produces smooth, level surfaces at a reduced noise level.

	Repitition of result	Quality of Compaction	Handling	Investment Costs	Operating Costs	Noise reduction
Pneumatic Vibrators	-	-	-	++	+	-
Single Phase Electric Vibrators	-	+	+	+	+	+
3 Phase Electric Vibrators (low freq)	+	+	+	+	+	+
3 Phase Electric Vibrators (high freq)	++	++	++	-	+	+
3 Phase Electric Vibrators (synchro)	+++	+++	++	-	+	++

Different types of external vibrating systems produce different results

<u>Conclusion:</u>
the best results today for precast element production are produced by high frequency compaction, powerful three-phase electrical vibrators and controllable speeds. The user must decide for himself whether the advantages in terms of handling, result and noise emission are worth the extra costs of an electrical vibrator system.

Different types of external vibrating systems produce different results. ■

Further information:

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