Physical Modelling in Geotechnics
© 2022 KOREAN GEOTECHNICAL SOCIETY (KGS), Seoul, Korea, ISBN 978-89-952197-7-5

Retrofit of the centrifuge engine line of the Uni-Eiffel GeoCentrifuge

P. Gaudicheau, A. Néel, M. Blanc & L. Thorel,
GERS-CG, Univ Gustave Eiffel, IFSTTAR, F-44344 Bouguenais, France

F. Lecoq & F. Pringue
Flipo-Richir, F-59113 Seclin, France

ABSTRACT: The French geotechnical centrifuge located in the Nantes' Campus of the University Gustave Eiffel (formerly Ifsttar and LCPC) required an upgrade of its engine line and its control command, almost all the components dating from 1985. Thanks to 21st century technologies, upgrades have been made both on the motor (a 450kW Siemens low-voltage motor with a regenerative drive system) and on the control system, moving to digital world. Detailed description of the operations and the new performances of the geotechnical centrifuge are presented.

Keywords: upgrade, engine line, centrifuge, regenerative drive

1 INTRODUCTION

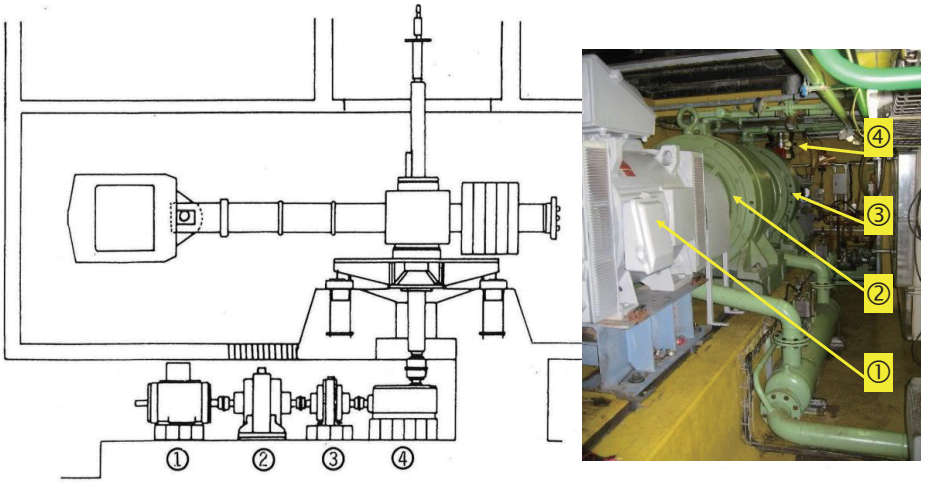
The geotechnical centrifuge, inaugurated in 1985 and located on the Nantes Campus of the Gustave Eiffel University, is undergoing a makeover: its motorization line, comprising several original elements and its "control-command" have been replaced and simplified: an electric motor with Siemens variator replaces the old original two-speed motor, the brake and the clutch. The reduced number of mechanical elements induces better efficiency and coincides with a technological leap allowing to go from "analog" to "digital", all simplifying operation and future maintenance.

The retrofit of old centrifuges is a way of increasing the life of those versatile research tools for geotechnical applications (e.g. Bowman et al. 2020, Chen et al. 2018).

2 EXISTING DEVICES & CONTROL SYSTEM

The existing engine line (*ante 2021*) included (Fig.1):
① A 2 speeds asynchronous A.C. engine (1000rpm and 1500rpm) with a nominal power of 410kW (under a 380V voltage), maximal torque 4760Nm;
② An eddy current clutch;
③ An eddy current brake;
④ A ~7:1 gear reducer.

The three last elements were water cooled. This solution of driving had been selected mainly because it generated a minimum of electric interferences which was essential with low level signals on the models. The characteristics of the drive unit had been determined for a run up time to 100×g of 3min, with a linear variation of centrifuge acceleration with time beyond 10×g. The estimate of the power was derived from a theoretical



①Asynchronous electric engine,

② Eddy current clutch,

③ Eddy current brake,

④ gear reducer

Fig.1. The former engine line (modified from Corté and Garnier, 1984)

approach assuming that the spinning air body had a tangential velocity proportional to the axis (Corté, 1984).

The rotation speed was servo-controlled (Fig.2) with a 6000 points optical tachometer, providing an accuracy on the centrifuge acceleration value better than ±1% over a period of 24h (Corté, 1984).

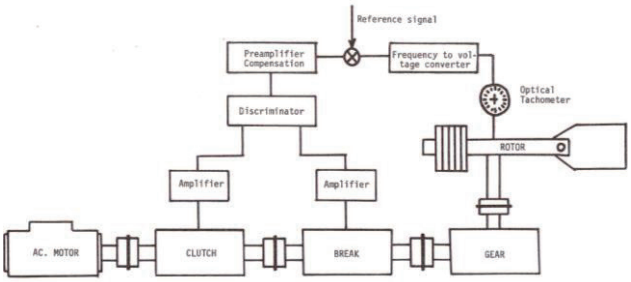


Fig.2. The former servo loop diagram (Corté, 1984)

Each subsystem of the drive unit was equipped with its own protection and safety functions which could automatically cause the motor to stop in case of anomaly. The state of all the safety functions was displayed in the control room (Fig.3) and could be remote tested.

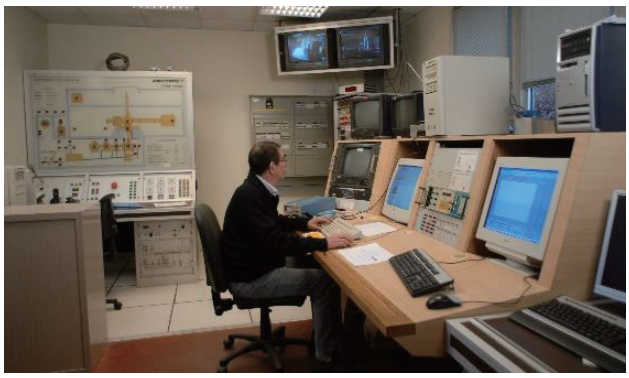


Fig.3. The former control room (†Gérard Rault *circa 2011*)

Unbalance of the rotor was continuously measured with strain gauge bridges placed on the four supporting parts of the bearing system (Corté, 1984).

3 RETROFIT

The retrofit operation has been launched in 2019 and the public contract has been officially attributed to Flipo-Richir© in july 2020. Due to the pandemic, the dismantling phase started in April 2021, followed by the installation of the new engine, frequency variator and man-machine interface. The official reception has been done only in November 2021, a delay being necessary for providing and replacing identically unexpected the failed coupling connection.

3.1 Electric engine

Comparing the previous installation (Fig. 1) with the new one (Fig.4), the engine line has been simplified by removing elements ② (clutch) and ③ (brake), and replacing ① (electric engine). The new engine is a 1CV3403C Siemens electric Motor 450kW running at 1054rpm.

Fig.4. New engine (top) and remaining gear box (bottom) in the pit.

3.2 Frequency variator and automate

The variator Schneider Altivar process ATV980 2015/2040 560kW type low harmonic automate (Regenerative drive system), is located in the pit (Fig.5).

The new automation system made by Beckhoff controls the variator of the motor and the security of the system. It is installed in the motor room with a 7'panel touch screen to facilitate the maintenance. So, the centrifuge can be controlled by a computer installed in the control room, and connected to the automation system by only one ethernet cable instead of several dozens of cables in the old system. A special Man-Machine Interface has been developed, based on web page on the automation system.

3.3 Simplifications

The retrofit of the engine line, 36 years old, has been the opportunity to jump in another generation of electrical devices, simplifying the general engine line:

- The cooling system (49kW) is now over designed for the remaining elements, as the clutch (440kW) and brake (750kW) have been removed.
- The installed power has been reduced by 1.15MW.
- The electric engine, connected to an assumed infinite electric network deliver additional power to the network during deceleration phases (up to 30kW).
- All the analogical electronics has been removed, a new and convenient interface being available

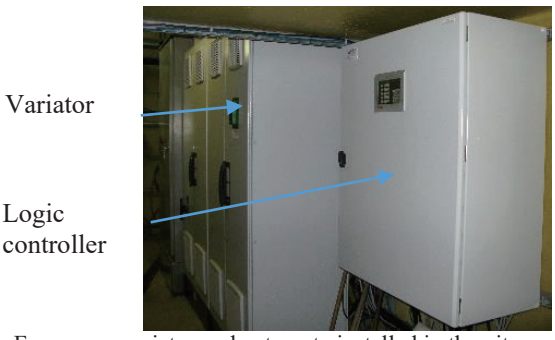


Fig.5. Frequency variator and automate installed in the pit.

Fig.6. The new control room (*since 2021*). The centrifuge parameters are controlled on the computer, the former board being only maintained for decorating (top) and the tests parameters (jacks, data acquisition system…) are controlled and recorded on several screens and computers (bottom).

4 CONCLUSIONS

After 36 years of use (11196h of rotation), the electric engine of the Uni Eiffel GeoCentrifuge has been replaced, as well as the connections and the control-command system. The new motor offers the opportunity to reduce the installed power by more than 1MW, occurring savings of electric current and a better carbon balance.

ACKNOWLEDGEMENTS

The retrofit of the engine line has been possible thanks to the Pays de la Loire Region (France) and to the CPER PRIIC-Mer governmental funding, combined with the European Regional Development Fund (FEDER). They are greatly acknowledged, as well as the colleagues from the service in charge of markets of the University Gustave Eiffel.

REFERENCES

Bowman A.J., Tessari A.F., Price C. 2020. Retrofit, redesign, and restructuring of a large geotechnical centrifuge research center. ECPMG2020, Laue & Bansal (eds.) 2p. http://ltu.diva-portal.org/smash/record.jsf?pid=diva2%3A1404151&dswid=-5699

Chen S.S., Gu X.W., Ren G.F., Zhang W.M., Wang N.X., Xu G.M., Liu W., Hong Z.J., Cheng Y.B. 2018. Upgrades to the NHRI-400 g-tonnes geotechnical centrifuge. In Physical modelling in geotechnics. McNamara et al. (Eds.), 495-500.

Corté J.F. 1984.Presentation of the LCPC centrifuge. Int. Symp. Geotechnical centrifuge model testing. April 3-5, Tokyo, Japan. 6p.

Corté J.F., Garnier J. 1984. The LCPC centrifuge. Presentation of the installations. Rapport des laboratoires GT5, LCPC; 17p. https://www.ifsttar.fr/fileadmin/user_upload/editions/lcpc/ERLPC/ERLPC-GT-LCPC-GT05.pdf (in French)