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Automatic elimination of vibrations for a centrifuge

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ABSTRACT

This paper presents a centrifuge with a system of automatic elimination of vibrations of the centrifuge that are generated by its unbalance. The rotor of the centrifuge spins around an axis with a fixed point. Two or more balls inside the ring which is fixed to the rotor can automatically eliminate its vibrations. The balls, also called free elements, would be able to change their positions inside a ring in such a way to compensate the dynamic forces. This paper presents equations that define the behavior of the system and also the diagrams that present the vibration of the rotor and the behavior of the balls when the unbalance is present. This paper explains the final positions that the balls occupy and when they are dynamically stable.

1. Introduction

Simple centrifuges are used in chemistry, biology, and biochemistry for isolating and separating suspensions. They vary widely in speed and capacity. Commercial applications can be found for: drying clothes — usually with a water outlet, in water and wastewater treatment to dry sludges, used in the oil industry to remove solids from the drilling fluid. Other centrifuges separate isotopes, and these kinds of centrifuges are used in nuclear power and nuclear weapon programs. Gas centrifuges are used in uranium enrichment. The ultracentrifuge spins at high speeds, capable of generating accelerations as high as 1,000,000 g. The ultracentrifuge is balanced on a cushion of air and spins as the result of a jet of compressed air which touches the outer surface. The ultracentrifuge is widely used in the study of polymers, proteins, nucleic acids, viruses, and other organic macromolecules.

Medical centrifuges are devices that rapidly spin fluids to separate substances of different densities by using centrifugal force to produce a form of artificial gravity. Figs. 1 and 2 present a blood centrifuge. They are used in biological and chemical laboratories and in the medical field to prepare serums and plasma from blood. The most commonly used medical centrifuge is a bench-top ultracentrifuge.

Fig. 3 presents a centrifugal process for the extraction of red blood cells, proteins and other microscopic particles from the blood.

The separation of the layers depends on their density. When there are vibrations, then the layers can mix again. So, it is important that the centrifuge spins without vibrations. The distribution of mass for each start or during rotation is ever changing and produces unbalance. Therefore, traditional balancing methods cannot be applied. The centrifugal forces generate noise and vibrations; causing damages to other machines and even buildings. Dynamic reactions decrease the time

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Fig. 1. Laboratory tabletop centrifuge.

of using the equipment. The unbalance could be the cause of incorrect machine operation; exposing the operator to danger. The high rotational speeds of centrifuge motors create large amounts of kinetic energy. Uncontrolled release of this energy can result in centrifuge damage or even destruction. The slightest unbalance can cause catastrophic failure. The general description of the dynamic of rotors is presented in [1,2]. Different methods of elimination for the vibrations in mechanical systems are presented in [3–8]. Several studies have been conducted in order to eliminate the rotor unbalance with self balancing methods.

Fig. 2. Buckets with samples of other types of centrifuges.