Electrical Regenerative Braking With Permanent Magnetic System – A Critical Analysis

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ABSTRACT

In this work an attempt is made to show that the braking of an electric drives in industries and automobiles using permanent magnets which produce energy while braking and it is a similar one to that of the existing electric regenerative braking. Also to show permanent magnetic system is a better one than existing electromagnetic brake, eddy current brake and electric brakes, etc.

Keywords

Magnetic braking of electric drives, braking of motor with permanent magnets, magnetic field braking, magnetic repulsion braking, electric regenerative braking, contactless braking system with permanent magnets.

1. INTRODUCTION

At present several types of electric drive braking systems are in existence, some of such braking systems are, Mechanical Braking is also called as friction brake, in which a tangential force is applied to the rotor, kinetic energy dissipated in the form of heat. Generally these brakes are made up of carbon, cast iron...etc. The most disadvantage of this system is regular replacement of brakes, energy dissipating in the form of heat, which is not an eco-friendly thing. In Electrical braking system there are three sub-methods in existence, namely plugging, dynamic brake/rheostat brake, and electric regenerative brake, d.c injection, eddy current brake. The electric regenerative brake is a more advantageous method among the three, due to the re-generating of energy by converting the motoring action into generator which is not done by the remaining methods. It is a non-pollution one, economical and also no regular maintenance is required for it. An eddy current brake, like a conventional friction brake, is responsible for slowing an object, such as a train or roller coaster. However, unlike electro-mechanical brakes, which apply mechanical pressure on two separate objects, eddy current brakes slow an object by creating eddy currents through electromagnetic induction which create résistance, and in turn either heat or electricity. The magnetic field is also being provided with permanent magnets in eddy current braking. These are classified into Circular eddy current brake, linear eddy current brake. The eddy current brake does not have any mechanical contact with the rail, and thus no wear, and no noise or odor. The eddy current brake is applied for automobiles at high speeds both for emergency braking and for regular braking. [1]. The functioning of eddy current brake can be available in one the three regions namely low speed, critical speed, and high speed regions: the low-speed region when the magnetic induction caused by the eddy current pattern is negligible compared to the original induction and the air gap magnetic induction is then slightly less than that generated at zero speed; the critical-speed region, which is the speed zone at which the maximum drag force is exerted and the induction caused by the eddy current pattern is no longer negligible compared with the zero speed induction; and finally the high-speed region, where the mean magnetic induction in the air gap tends to decrease further and, as the speed increases to infinity, the original magnetic induction will be completely canceled out by the induced eddy currents.[2]. To avoid the disadvantageous of friction brakes and as a better alternative, the integrated brake is found, which is a combination of both friction brake and eddy current brake. [3].The eddy current brake is directly controlled by its excitation magnetic field. The response time of an eddy current brake is very fast when compared to the response time of mechanical systems, the former is counted in milliseconds and the later is counted in tenths of seconds. This is particularly true of power assisted and pneumatic brake systems. [4].

2. PERMANENT MAGNETIC BRAKE SYSTEM-CRITICAL ANALYSIS

Now a day's permanent magnets are used widely for various applications in industries, aerospace, domestic, due to their special features of having free magnetic energy without any external source as an input.[5]. Application of RE-TM (Rare earth-Transition) type magnets allow to obtain good magnetic properties, to improve mass-to-performance ratio and to simplification the construction of devices. [6-9].The permanent magnetic system is a better alternative braking of an electrical drive, when compared with that of the existing electromagnetic brakes and eddy current brakes. The characteristics and properties vary with the different kinds of an alloy which are used in the manufacture of different permanent magnets and play a vital role in applications. In this method the brake is applied to the drive or machine with the help of permanent magnets. The selection of these magnets depends on the properties of the individual magnet, graphically is shown in fig (1).

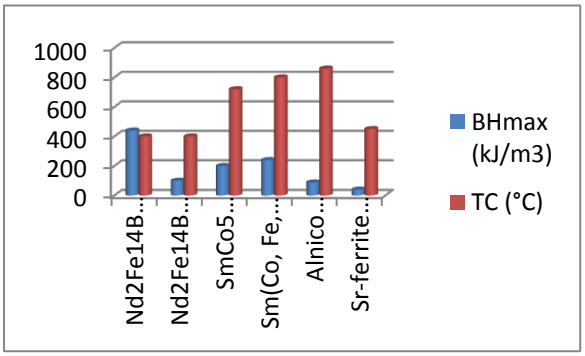

Fig.1.properties of different permanent magnets.

Here it suggested that Alnico, Neodymium permanent magnets are used, where alnico permanent magnet is fixed to the rotor of drive with proper insulation. Since Alnico permanent magnet has high curie temperatures of any magnetic material, around 800 degrees Celsius, although the maximum working temperature is normally limited to around 538 degree Celsius. Hence the Alnico magnets can exhibit magnetic property at very high temperatures also. [10].This is a required property for a permanent magnet because, difference in temperature will cause disturbance in magnetic strength. [11].Then while rotation a lot of heat is generated commonly which can be resisted by Alnico permanent magnets perfectly, shown in fig (2).

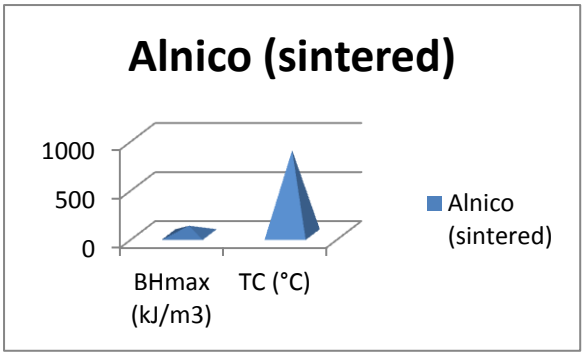

Fig.2.Alnico temperature, magnetic strength properties.

The Neodymium(Nd2Fe14B) magnet is a movable one, is fixed with the same pole at outside of the rotor to apply the brake, because a neodymium is the most widely used type of rare earth magnet.[12].Neodymium magnets have higher remanence, much higher coercivity and energy product, but often lower Curie temperature than other types and it is alloyed with terbium and dysprosium in order to preserve its magnetic properties at high temperatures. Nd-Fe-B magnets are prone to corrosion in damp air and this is a major factor in limiting their overall usability. [13], shown in fig (3).

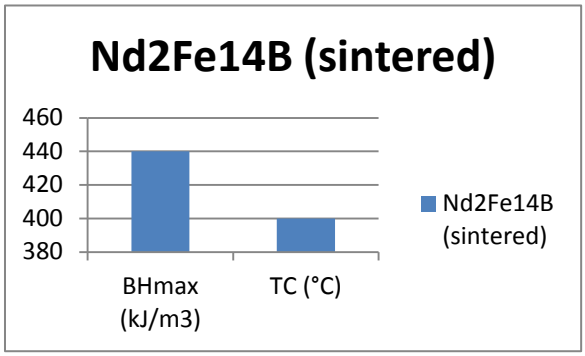

Fig.3.Neodymium temperature, magnetic strength properties.

The comparison of both Alnico and Neodymium permanent magnets of temperatures, magnetic field densities are shown in fig (4).

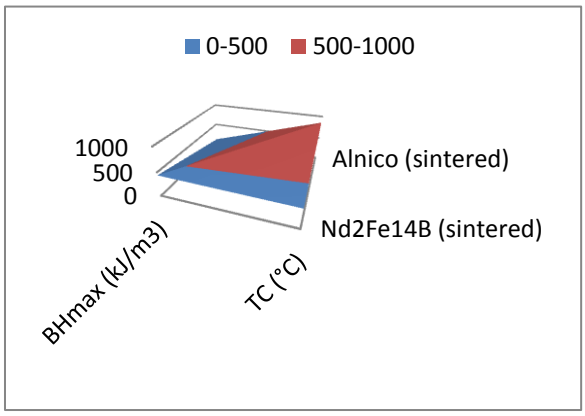

Fig.4.Comprision of Neodymium and Alnico permanent magnets temperature's, field strength's.

and also coercive forces with respect to distance is shown in fig(5).

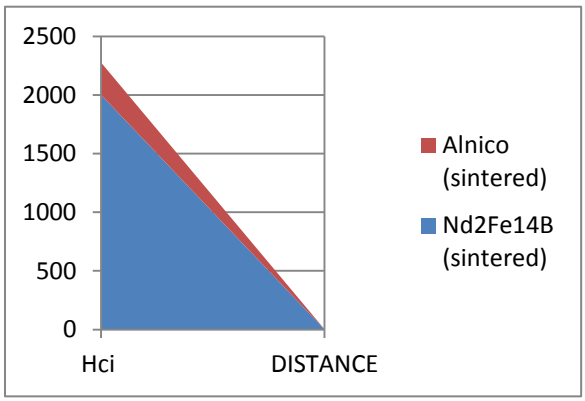

Fig.5.Charcterstics of corsive forces between Alnico and Neodymium permanent magnets for a distance of 1M.

The fixed permanent magnet rotates with the rotor in running position. At the time of braking outer permanent magnetic field is applied, both the permanent magnets are nearer to each other having same polarities, and then there is a

repulsion of magnetic field takes place. Hence the motor moves in opposite direction then the motor action turns into the generator action and the produced energy is stored, which is similar to the existing electrical regenerative braking method.

In this method no more of heat will be dissipated, the quick braking can be possible with in less time, energy can be saved by regeneration similar in electrical regenerative technique, regular maintenance expenditure will reduce, and the total size of braking system is portable and compact in size.

3. CONCLUSION

The electrical braking, eddy current and mechanical braking's are functioning effectively in braking of drives in automobiles and industries. But these braking systems are having some limitations which are noted in introduction. Where as in the permanent magnetic brake system, no such limitations are present. Hence this system is considered to be a better braking system than all.

4. REFERENCES

[1] "Wirbelstrombremse im ICE 3 als Betriebsbremssystem hoher Leistung" ("Eddy-current brake in the ICE 3 as high-efficiency service brake system", by Jürgen Prem, Stefan Haas, Klaus Heckmann, in "electrische bahnen" Vol 102 (2004), No. 7, pages 283ff

[2] Henry A Sodano and Jae-Sung Bae, "Eddy Current Damping in Structures", The Shock and Vibration Digest, Vol. 36, No. 6, November 2004 pp.469–478.

[3] Gay,S.E.; Ehsani,M. Vehicle Power and Propulsion, 2005 IEEE Conference , "Optimized design of an integrated eddycurrent andfricti on brake for automotive appl-ications",pp.290-294.

[4] Robert Bosch GmbH, Bosch Automotive Handbook. Warrendale, PA: Society of Automotive Engineers, 2004.

[5] Ormerod, J., Taylor, R., and Roozee, J., "Improvements and Applications of Permanent Magnet Materials in Automotive Sensors," SAE Technical Paper 920171, 1992, doi:10.4271/920171

[6] D.C. Jiles, Recent advances and future directions in magnetic materials Acta Materialia 51 (2003) 5907-5939.

[7] D.C.Jiles, C.C.H. Lo, The role of new materials in the development of magnetic sensors and actuators, Sensors and Actuators A, 106 (2003) 3–7.

[8] B. ĝlusarek, Dielektromagnets NdFeB, Wrocáaw, 2001 (in Polish).

[9] C. Gaona-Tiburcio, F. Almeraya-Carderon, J.G. Chacon-Nava, J.A. Matutes-Aquino, A. Martinez-Villafane, Electrochemical response of permanent magnets in different solutions, Journal of Alloys and Compounds, 369 (2004) 78-80.

[10] Hubert, Alex; Rudolf Schäfer (1998). *Magnetic domains: the analysis of magnetic microstructures*. Springer. p. 557. ISBN 3-540-64108-4.

[11] Campbell, Peter (1996). *Permanent magnet materials and their application*.

[12] UK: Cambridge University Press. P.5. ISBN 0-521-56688-6.

[13] Fraden, Jacob (2010). *Handbook of Modern Sensors: Physics, Designs, and Applications, 4th Ed.* USA: Springer. pp. 73. ISBN 1441964657.

[14] Dark, M.; Dobrzanski, L.A .(2007)."Corrosion of Nd-Fe-B permanent magnets". *Journal of Achievements in Materials and Manufacturing Engineering* **20** (1–2).

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