PERMANENT MAGNET MOTOR ESP TECHNOLOGY AND ITS APPLICATIONS

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ABSTRACT

Permanent Magnet Motor (PMM) Electric Submersible Pumps (ESPs) are an emerging technology in artificial lift compared to traditional Induction Motor (IM) ESPs, which have been in use since the 1920s (Wrighton et al., 2023).

The adoption of PMM-ESPs is on a rise in both new and mature wells providing higher power density, improved efficiency, and lower operational costs, as proven by the published field case studies. This poster explores the benefits of PMM-ESPs and their role in modern artificial lift operations in terms of its effects on the environment, personnel safety, and finances.

INTRODUCTION

The electric submersible pump (ESP) as an artificial lift method has been in use for the past 8 decades, operating mainly on induction motors (IM) (Harris et al., 2017). However, due to the power consumption and economical disadvantages presented by IM-ESPs, major developments towards streamlining ESPs using permanent magnet motors (PMM) (Mansir et al., 2021).

IM operates based on electromagnetic induction where AC current passing through the stator's coiled windings creates a rotating magnetic field inducing voltage. The current is, then, generated by the produced magnetic field that interacts with the stator's field, creating torque and rotation (Albori et al., 2023). In contrast, the PMM has permanent magnets in its rotor which generates the rotating magnetic field by itself without the need for induced current (Xiao et al., 2019). The differences are seen in Figure 1.

ADVANTAGES

The reason behind the recent spikes in PMM-ESP applications is a result of the operational advantages that PMMs have over IMs. One of the main sources of energy loss, heat, in induction motors is losses in rotor windings; since PMMs use permanent magnets, they do not have any energy losses there, Figure 3 (Refaie et al., 2013). Moreover, using strong magnets allows for a more compact rotor, hence, motor design with a smaller OD allowing a bigger airgap downhole which is highly beneficial for limiting heat generation (Xiao et al., 2019). PMM-ESPs have 40% shorter motor length making them highly suitable for deviated wells (Yicon).

RISKS

Like any other piece of machinery, using PMM-ESPs comes with their own risk. According to Dakai Yin, when dealing with PMM-ESPs, safety risks are the top priority. PMMs, depending on its speed, can generate up to 240 volts which poses safety risks compared to IMs which are unable to generate enough power to be lethal (Ken et al., 2023). Movement of fluid in the pump causes greater risks in PMMs than IMs (Nicholson et al., 2021). To explain, fluid movement through pump can be a source of shaft rotation and electricity generation when the ESP is not on (Levare).

EFFECT OF TEMPERATURE

The Arrhenius thermal aging model can be used to predict the life degradation of the PMM insulation.

$$L = L_0 e^{\frac{E_a}{k}\left(\frac{1}{T} - \frac{1}{T_0}\right)}$$

L = expected insulation life

L_0 = reference life,

k = Boltzmann's constant

E_a= activation energy

T_0= reference temperature

T = absolute temperature

This model can be used to prove that the insulation in PMMs last longer than that of IMs depending on the wellbore conditions.

FIELD APPLICATION

Permanent magnet motor powered ESPs are in operation in fields all around the world.

1. Sangasanga Field, Indonesia

Results: 24% - 41% power consumption reduction, and consistent performance without any trips (Rasyid Ridlah et al., 2024). The motor design is seen in Figure 2.

2. Tello Field, Colombia

Results: energy consumption reduction from 625kWh to 478kWh, CO_2 emission reduction of 200 tons per year, and financial gain by installing only one PMM instead of 3 IMs (Vargas et al., 2024)

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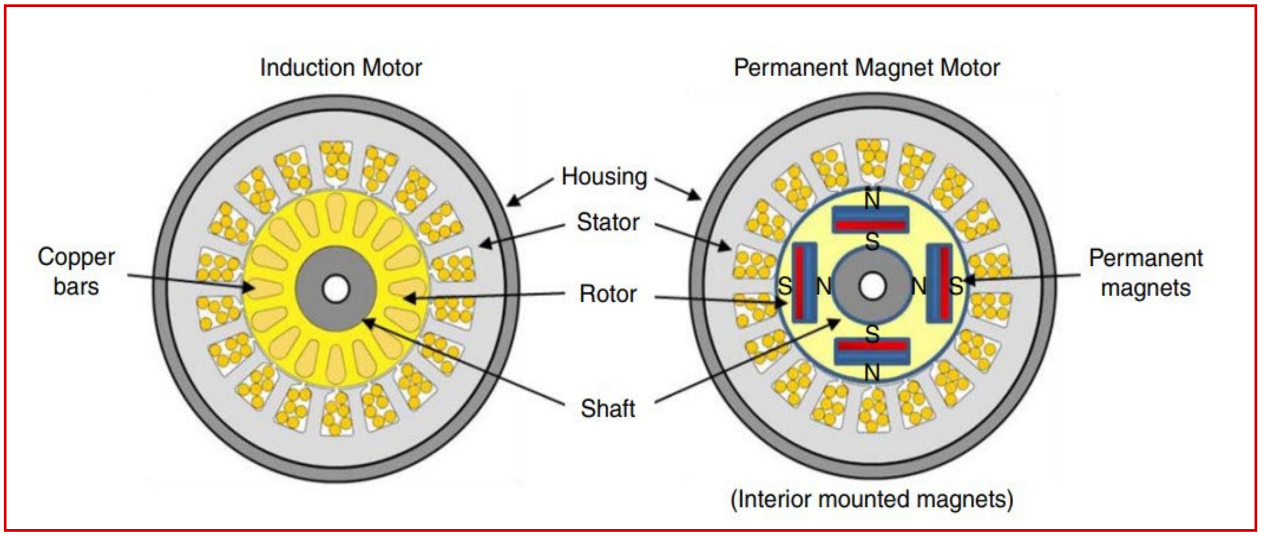

Figure 1 Differences Between IM and PMM (Refai et al., 2013)

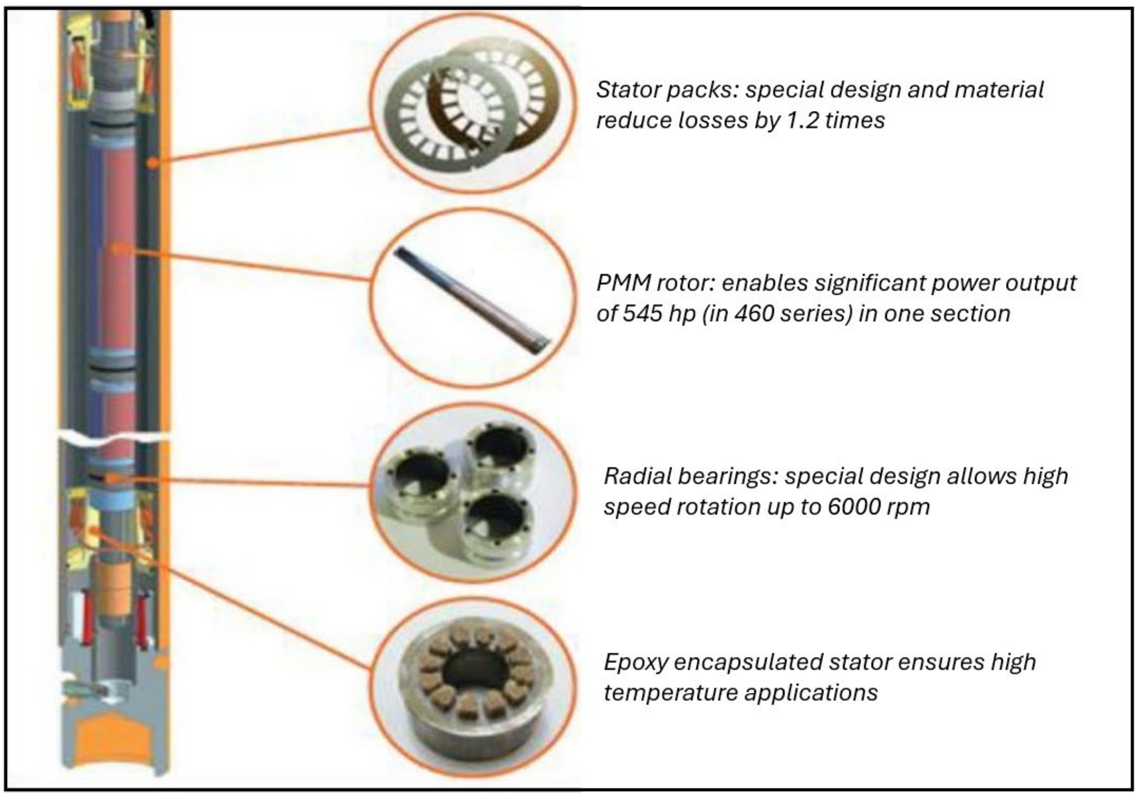

Figure 2. PMM-ESP Design for Sangasanga Oilfield (Ridlah et al., 2024)

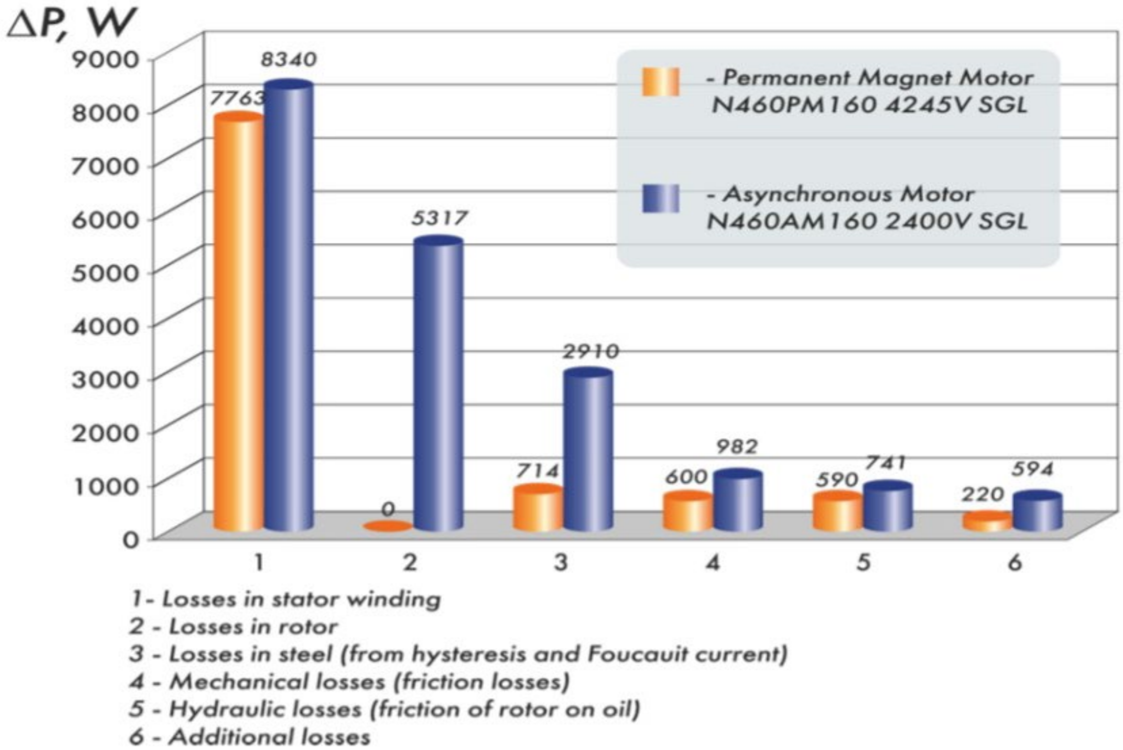

Figure 3. Sources of Power Losses in Motors (Xiao et al., 2019)