iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** X **Month of publication:** October 2021

DOI: https://doi.org/10.22214/ijraset.2021.38427

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue X Oct 2021- Available at www.ijraset.com

Analysis of Slip Ring Induction Motor Drive Using Slip Power Recovery Scheme with Inverter and Chopper Control for Id Fan in Power Plant

Manish Kapse[1], Pratik Ghutke[2]
[1]PG Student, Dept. of Electrical Engineering, TGPCET Nagpur, Maharashtra, India
[2]Asst. Professor, Dept. of Electrical Engineering, TGPCET Nagpur, Maharashtra, India

Abstract: Induction motors are used as industrial drive and for various applications in power plant due to their rugged, robust and simple construction as well as low cost. The speed control of SRIM is dexterous by slip power recovery scheme consisting of inverter control, chopper control, and rotor resistance control techniques. This paper presents the boost in the performance characteristics and energy saving of SRIM drive by inverter and buck-boost chopper based slip power recovery scheme (SPRS). The simulation model of a WRIM drive using inverter and based buck-boost chopper control has been executed in the Simulink platform. The simulation results using inverter and chopper control have been studied. The active power and reactive power have been taken as parameter for analyzing the energy saving by the drive. The simulation result has shown that inverter chopper control SPRS large amount of energy saving.

I. INTRODUCTION

Induction motor drives with speed control have massive applications in the modern industrial set up. In industry near about or greater than 75% of the load today in any country consists of induction motors. Slip ring induction motor drives have found great applications due to the availability of easiest speed control by varying rotor resistance, slip power easily available from slip rings and possesses high starting torque. Slip power can be recovered by static converters-inverter method instead of dissipating power in the rotor resistance. High performance induction motor drive application requires high efficiency, low cost and simple control electric circuit for the wide range of speed control. At the present time, slip power recovery drives (SPRD), is generally used for the wide range of speed control applications for large-capacity pumps and fan drives, variable-speed wind energy systems, ship-board variable speed/constant frequency system, etc. A representation diagram of a SPRD is shown in Fig 1. It comprises of a wound rotor induction motor, a diode bridge rectifier, a thyristor bridge inverter, a large filter inductor and a 3-phase recovery transformer. A slip power recovery scheme drive transfer power that is normally dissipates in the rotor resistance of an induction machine fed back to the ac mains supply to save energy. In distinction with the stator-voltage-controlled induction motors, the ratings of the rotor side converter, inverter and transformer circuit in SPRD is intended to be smaller rating and less expensive as these apparatuses have to deal with the slip power only (less rating voltage, current and power). Huge literature is available on slip power recovery drives. Many Authors presented motor performance using slip recovery systems and proposed new slip recovery scheme for improved efficiency and power factor. In 1988 Krause et al. presented reference study of slip power recovery drive. Akpinar and Pillai, in 1990 presented a paper on modelling and analysis of slip power recovery scheme for induction motor. Many authors suggested performance enhancement, harmonic analysis and commutation angle analysis of slip power recovery drive.

II. PERFORMANCE ANALYSIS OF THE DRIVE

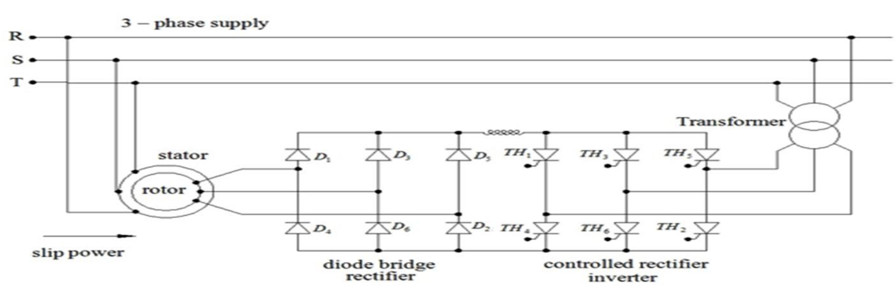

Figure -1: Schematic of Slip Power Recovery Drive (SPRD)

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue X Oct 2021- Available at www.ijraset.com

Assuming ideal filtering ($L_d = \infty$) and negligible rotor leakage reactance, the rotor currents are alternating square pulses of ($2\pi/3$) radians period. The rms value of the rotor current (I_2) is ($\pi/3$) times the rms value of the fundamental component current (I_{2f}) (Lavi et al. 1996). Neglecting the thyristors voltage drops, the average counter EMF (V_i) of the inverter equals to

$$V_i = \frac{3\sqrt{6}}{\pi} \cdot \frac{V}{m} \cos\alpha \qquad (1)$$

And converter voltage, Vr equals to

$$V_r = \frac{3\sqrt{6}}{\pi} \cdot \frac{sV}{n} \qquad (2)$$

Where, m is the source to converter side turn-ratio of the recovery transformer α is the firing angle of the inverter, V is the line-to-line source voltage, n is the stator to rotor turns ratio of the motor and s is the motor slip.

Since in steady state V_r and V_i and must balance, therefore

$$s = \frac{n}{m}\left|\cos\alpha\right| \qquad (3)$$

Thus, speed of the induction motor rotor can be controlled by varying inverter firing angle α. The thyristor inverter bridge recovers slip power from rotor when $(\pi/2) < \alpha < \pi$ and can deliver energy to the rotor when $\alpha < \pi/2$.

The power equation for each rotor phase gives

$$E_{2f} I_{2f} = \left[R_2 I_2^2 + \frac{1}{3} R_d I_d^2 \right] - \left[\frac{1}{3} (1.35 \frac{V}{m} \cos\alpha - V_{pec}) \times I_d + P_{mech} \right] \qquad (4)$$

Here, R_d is the effective resistance of filter inductor, V_{pec} is the voltage drop in the power electronics components and Id is the average dc current through filter inductor. The cumulative mechanical torque produced by the rotor is the summation of torque produced by the fundamental component of rotor current and the torque produced by the rotor harmonic currents. Assuming that the torque is produced by the fundamental component of rotor current I_{2f} only, the rotor mechanical power is given by

$$P_{mech} = \left[(R_2 + 0.5 R_d) I_{2f}^2 \frac{1-s}{s} \right] - \left[\left(1.35 \frac{V}{m} \cos\alpha - V_{pec} \right) \frac{I_d}{3} \frac{1-s}{s} \right] \qquad (5)$$

Here, ($0.5*R_d$) is the filter inductor resistance referred to rotor side.

Slip power (sP_g) is given by

$$sP_g = V_i I_d = 1.35 \frac{V}{m} \cos\alpha \, I_d \qquad (6)$$

$$P_{mech} = (1-s) P_g = T_e \omega_r = T_e \omega_s (1-s) \frac{2}{P} \qquad (7)$$

The rotor electromagnetic torque is given by,

$$Te = \left(\frac{P}{2} \right) \frac{P_g}{\omega_s} \qquad (8)$$

From equations (3), (6), (7) and (8), the torque is given as:

$$Te = \left(\frac{P}{2} \right) \frac{1.35V}{\omega_s n} I_d \qquad (9)$$

Hence, torque is proportional to inductor current I_d. This current depends upon the difference between V_d and V_r. So, for a stable value of, α the torque-slip characteristics of the drive is almost linear and look like to the separately excited dc motor. The power flow diagram of the slip ring induction motor with SPRD has been shown in Figure 2.

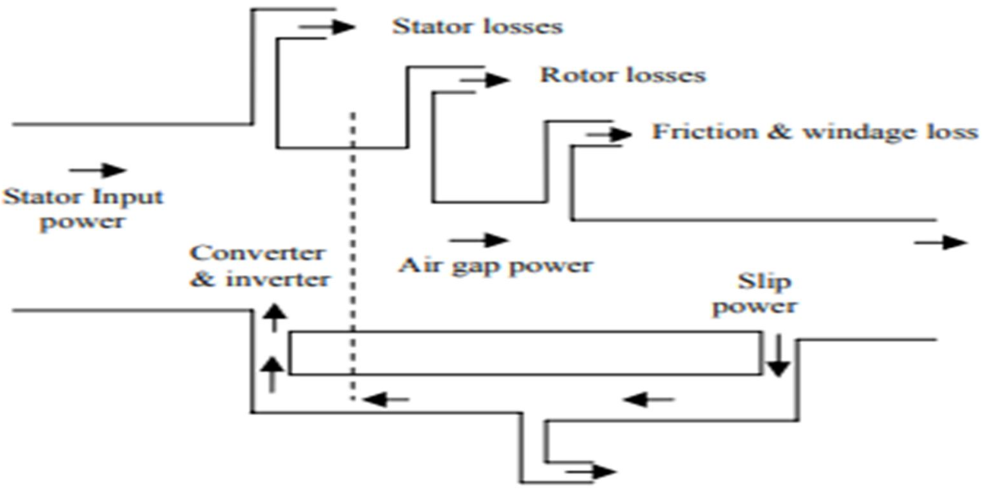

Figure -2: Power flow diagram of the SPRD

To study the performance of the SRIM drive, a simulation block-set in Matlab/Simulink has been implemented. A 1300KW, 6600V, 993 RPM, 50 Hz slip ring induction motor used as for ID fan has been used for the simulation. Provision has been made to measure active power, reactive power, stator current, speed and torque of the motor. Facility has also been made to measure different voltages and currents of the scheme wherever required.

III. CONCLUSIONS

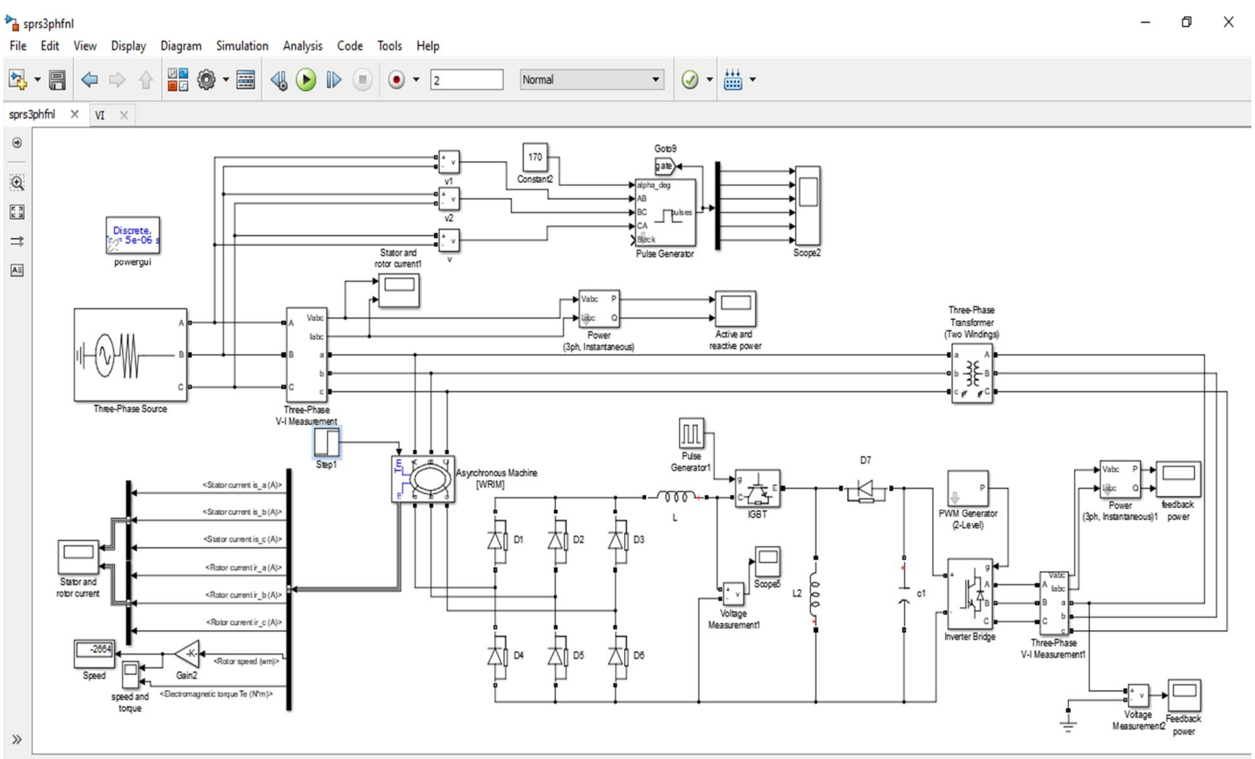

Figure -3: Matlab simulation of SPRD

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue X Oct 2021- Available at www.ijraset.com

Simulation results illustrate that at different load torque, active and reactive power required by Slip Ring Induction Motor Drive is different. Figure 4 shows that by varying firing angle speed of the induction motor also varied.

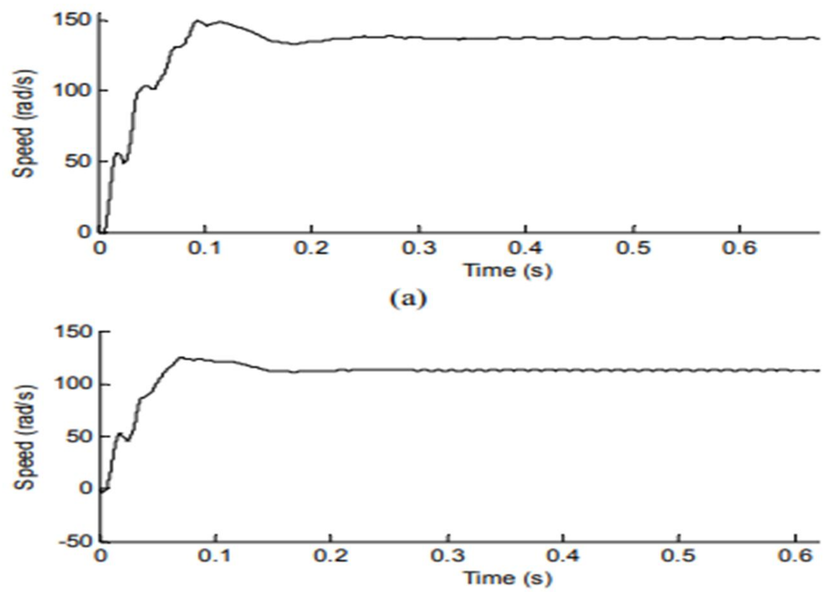

Figure -4: Motor speed at (a) 92 degree (b) 100 degree firing angle

Figure -5 shows active power and reactive power required by induction motor after applying slip power recovery scheme. From the table 1 we can observe that when machine feeds active power to the supply it takes more reactive power from supply. Because of this reactive power consumption by SRIM, the overall power factor of the scheme becomes low.

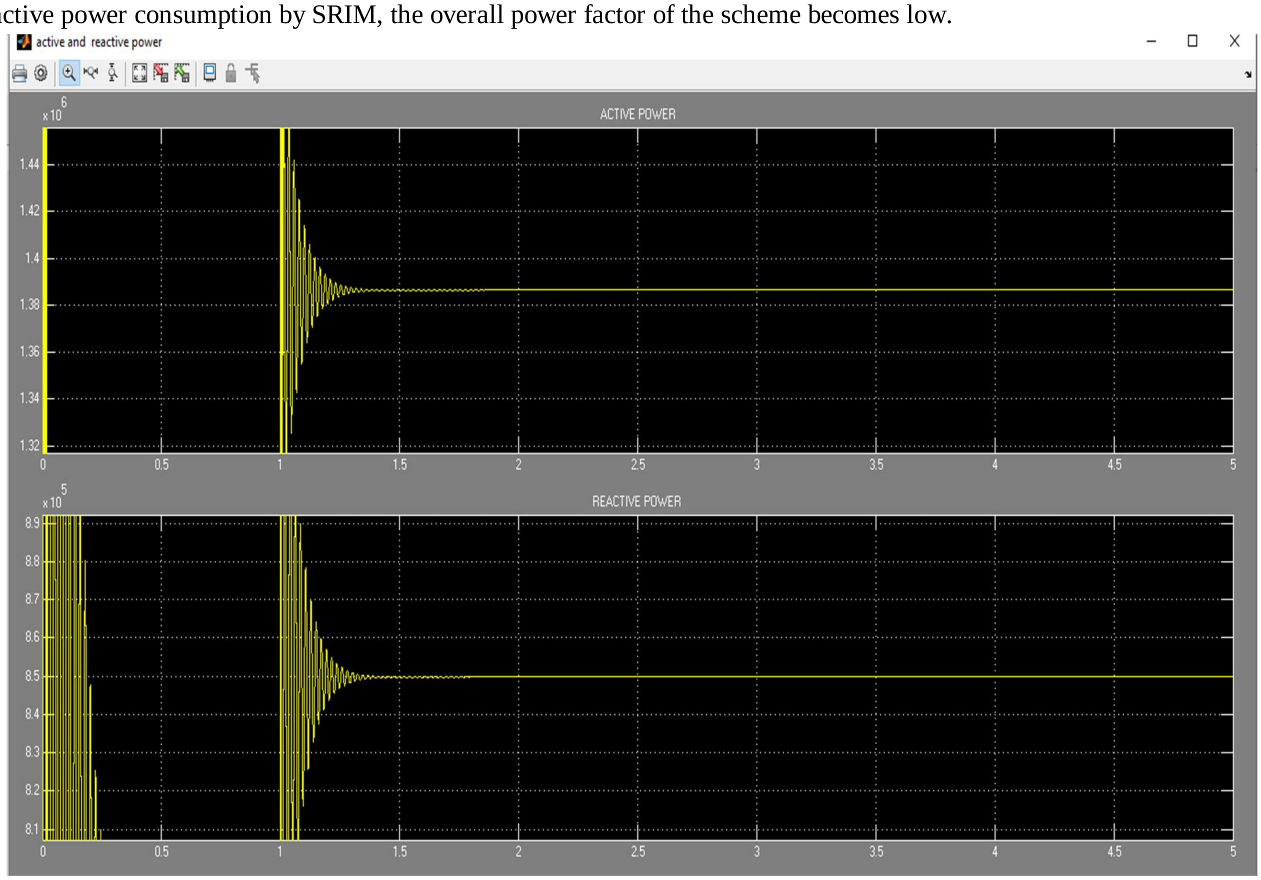

Figure -5: Recovered Active, Reactive power and power factor

IV. RESULTS

Table 1. Analysis of Result

Sr. No.	Torque (N-m)	Active and reactive power required without SPRS	Active and reactive power required with SPRS	Percentage Power saving (%)
1	12501	$P = 14 \times 10^5$ watt $Q = 8 \times 10^5$ VA	$P = 12 \times 10^5$ watt $Q = 8.5 \times 10^5$ VA	14.28
2	10000	$P = 10 \times 10^5$ watt $Q = 8 \times 10^5$ VA	$P = 9.7 \times 10^5$ watt $Q = 10.05 \times 10^5$ VA	11.81
3	8000	$P = 8.7 \times 10^5$ watt $Q = 8 \times 10^5$ VA	$P = 8 \times 10^5$ watt $Q = 11.8 \times 10^5$ VA	8
4	6000	$P = 65 \times 10^5$ watt $Q = 8 \times 10^5$ VA	$P = 6 \times 10^5$ watt $Q = 13.6 \times 10^5$ VA	7.6

The slip recovery energy method for the speed control of three-phase wound rotor induction motor has been examined and tabulated.

REFERENCES

[1] Leonharn, W., 1985. Control of Electric Drives., Springer Verlag, Berlin.
[2] Krishnan, R., 2001. Electric Motor Drives, Modeling and Analysis. Prentice Hall, Inc.
[3] Stiebler, M., 2010. Doubly-fed asynchronous machine for low voltage drives. Electrical Machines, 2010 XIX International Conference on Electrical Machines, Vol. 1, No. 6, pp.6-8.
[4] B. A. T. Al Zahawi and B.L. Jones, “Rotor Rectifier on Slip Ring Induction Motor Performance in Recovery Drives," Canadian Electrical Journal, Vol 12, No 1, 1987, pp 24-32.
[5] J.E. Brown, W. Drury, B.L. Jones and P. Vas, "Performance of the Transient State of a Static Kramer Drive," Proc lEE, Vol 133, Pt.B, No. I, Jan 1986, pp 21-30.
[6] S.R. Doradla, K.E. Hole and S. Chakravorty, "A New Slip Energy Recovery Scheme with Enhanced Supply”.
[7] Akpinar E, Pillay P. “Modeling and analysis of slip energy recovery induction motor drive”. IEEE Trans Energy Conversion 1990; 5(1):203–10. [29]
[8] Akpinar E, Pillay P. “Starting transients in slip energy recovery induction motor drives-part-2: performance and flowchart”. IEEE Trans Energy Convers 1992; 7(1):245–51.
[9] Liao F, Sheng JI, Thomas AL. “A new power recovery scheme for doubly fed, adjustable-speed induction motor drives”. IEEE Trans Ind Appl 1991; 27(4):728–33.