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Performance analysis of un-equal rotor and stator length switched reluctance motor

Mohammed Moanes Ezzaldean Ali, Nadheer A. Shalash
College of Electrical Engineering, University of Technology-Iraq, Baghdad, Iraq

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ABSTRACT

The performance of the SRM is influenced by several design parameters, including the lengths of the rotor stack and stator stack. Typically, the SRM is designed with equal rotor and stator lengths. However, there are some limited exceptions where the motor has a rotor that is longer or shorter than the stator; such a motor can achieve a reduction in one or more of the following: iron loss, copper loss, weight, inertia, and cost. To evaluate the performance of the SRM when the stator and rotor lengths are unequal, a 3D-model of the 6/4 SRM was developed using Ansys Motor-CAD software. In this work, two cases were investigated: the first case involved configurations where the stator was shorter than the rotor, and the second case involved configurations where the rotor was shorter than the stator. In both cases, other motor dimensions and variables were held constant. The simulation results show that certain performance indicators of the motor are not negatively affected, where they remain almost constant or even change positively, while other performance indicators are negatively changed, these changes are not significant when the differences between the stator and rotor lengths are within 10%. The cases of unequal length of stator and rotor can be considered as a new option that is manipulated to achieve the optimal design of the SRM, especially for low cost, low inertia, and high-speed applications.

Corresponding Author:

Mohammed Moanes Ezzaldean Ali
College of Electrical Engineering, University of Technology-Iraq
Baghdad, Iraq
Email: mohammedmoanes.e.ali@uotechnology.edu.iq

1. INTRODUCTION

With the development of computers and power electronics, researches have been directed towards reluctance motors, especially switched reluctance motors (SRM). SRMs have the advantages of reliability and the ability to operate in four quadrants over a wide-speed range. Also, low cost, rugged construction, and simple structure are key advantages of this motor. These features have made SRMs common in commercial and industrial applications [1]. The performance of the SRM is influenced by several design parameters, including the lengths of rotor stack and stator stack [2]-[6]. The lengths of the motor (stator and rotor) are decided by the nature of the application and space constraints. For servo applications, the motor length is usually 1-3 times the motor diameter, while it is 0.25-0.7 times the diameter for non-servo applications [1]. A longer stator and rotor increase the surface area available for magnetic field interaction. This increased area allows greater torque to be developed, which contributes to higher power output. On the other hand, longer motors provide additional space for windings and can lead to increased losses (copper and iron losses) which can offset some of the gains in power output. If the motor is designed to be long, care must be taken to avoid magnetic saturation, which can limit the effectiveness of the increased length in producing additional power [3], [7].

Normally, the SRM is designed with equal rotor and stator lengths. However, there are some limited exceptions where the motor has a rotor that is longer or shorter than the stator, an example is the Omni+ Series SRMs, where the rotor is shorter than the stator. These motors are frameless, high torque density, low cogging direct drive motors manufactured by Celera Motion [8]. In addition, custom switched reluctance motors for applications like compressors may require inequality to meet specific performance criteria. This paper examines the changes in SRM performance when the stator is shorter than the rotor or when the rotor is shorter than the stator.

In reviewing previous publications, the authors believe that this study is the first on this topic. This may be due to the rarity of SRMs in which the rotor is not of the same length as the stator. In addition to that, there is another important reason which is such a study requires a three-dimension FEM analysis of the motor, which is complicated and time consuming [5], [9]-[13]. This paper is organized on the following lines: Section 2 represents the structure of the SRM. Performance indicators of the SRM are presented in section 3. The methodology of this study and how the results were obtained is discussed in section 4. Section 5 represents the results and discussions of: 1-stator shorter than rotor case, and 2- rotor shorter than stator case. Finally, section 6 presents the conclusions of this paper.

2. STRUCTURE OF SWITCHED RELUCTANCE MOTOR

The switched reluctance motor is a machine with double salience stator and rotor poles; it operates without any mechanical commutation components. This structure contributes to the production of a high output torque [14]-[16]. The most common combinations of stator and rotor poles are 6/4 and 8/6. A typical 6/4 SRM is shown in Figure 1. The stator has excitation windings around its poles; the windings are connected in opposite pairs in order to form phases. The windings for each phase are independently connected to a switching circuit for its commutation [7], [17]. The rotor may be external but is usually situated inside the stator. The stator and rotor are assembled from steel laminations of the same grade and thickness. In SRM, the stator and rotor poles are symmetrical about the center lines, they are also equally spaced around the stator and rotor [13], [18], [19]. The number of stator and rotor poles, as well as the pole-arc angles of the stator and rotor poles, are selected to meet the desired machine performance. Other dimensions in an SRM have a significant impact on its performance; these dimensions are stator outer diameter, stator yoke thickness, stator pole length, air gap length, rotor diameter, rotor pole length, and rotor yoke thickness [20]. Furthermore, the performance of the motor is affected by the change in the length of the stator and the rotor; this issue will be investigated in this work.

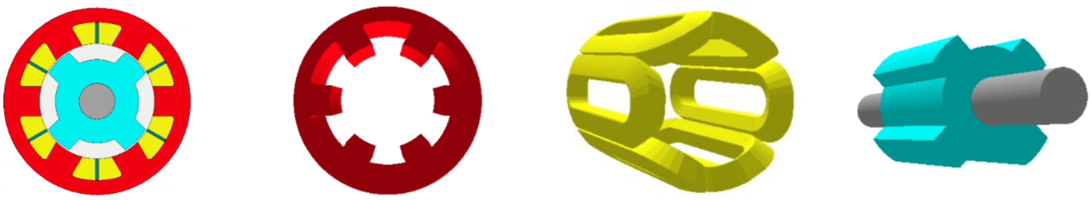


Figure 1. Switched reluctance motor: (a) cross section view, (b) stator core, (c) winding, and (d) rotor

3. PERFORMANCE INDICATORS OF SWITCHED RELUCTANCE MOTOR

The key performance indicators of the switched reluctance motor include the torque density, the torque ripple, losses, and efficiency. Torque in an SRM is developed by the alignment tendency of the rotor to adopt a position of maximum phase inductance or minimum reluctance, and by doing so converting some of the field energy to motion energy [9], [21]. Based on the total work performed over one complete machine revolution, the average torque is expressed as (1) [7].

$$T_{ave} = \frac{\delta W_m N_s N_r}{2\pi} \quad (1)$$

δWm is the work done by the machine cycle, N_s and N_r are the stator and rotor number of poles, respectively. In this issue, the motor length is a fundamental parameter and it directly impacts the average torque because more length allows more energy to be converted into the machine. The instantaneous torque developed is time-varying: it is directly related to the rate of change of inductance. Torque ripple (T_{ripple}) is defined as the difference between the instantaneous maximum torque (T_{Max}) and minimum torque (T_{Min}) [1]. The torque ripple is calculated as (2).

$$T_{ripple} = T_{Max} - T_{Min} \quad (2)$$

The percentage of torque ripple is expressed by (3) [1].

$$T_{ripple}(\%) = \frac{T_{ripple}}{T_{ave}} \times 100 \quad (3)$$

The output power (P_{out}) is the product of the angular velocity (ω) and the average torque [1], [2]. The output power is expressed as (4).

$$P_{out} = T_{avg} \times \omega \quad (4)$$

The unsaturated values of the aligned inductance (L_a) and the unaligned inductance (L_u) are fundamental in SRM, they play an important role in both torque and torque ripple [21]-[23]. The phase inductance of SRM depends on both the current and the rotor position. In this context, the motor dimensions also have a significant role; the length of the stator and rotor are among the dimensions that affect the value of L_a and L_u [7], [24].

As for any electric machine, various losses occur in the switched reluctance motor, these losses are copper, iron core, and mechanical losses. Copper losses (P_{cu}) depend on the RMS phase current and the phase resistance (R_{ph}), taking into account the number of phases (m). The copper loss is calculated using (5).

$$P_{cu} = mI_{ph}^2 R_{ph} \quad (5)$$

The evaluation of iron losses (P_{iron}) is performed through the Bertotti-based modified Steinmetz model, which decomposes the total loss into hysteresis (P_h), classical eddy current (P_e), and excess loss (P_a) components [25]. The iron loss is expressed as (6).

$$P_{iron} = P_h + P_e + P_a = k_h f B^n + k_e f^2 B^2 + k_a f^{1.5} B^{1.5} \quad (6)$$

Where f is the frequency, B is the flux density, n is Steinmetz coefficient and k_h, k_e, k_a are material-specific coefficients. The efficiency (η) is the ratio of the output power to the total electrical input power (P_{in}). The motor efficiency is calculated as (7).

$$\eta = \frac{P_{out}}{P_{in}} = \frac{P_{out}}{P_{out}+P_{cu}+P_{iron}+P_{mech}} \times 100\% \quad (7)$$

Motor length causes a major impact on the losses and the motor efficiency where the stator length has the greatest influence on copper losses, since the longer the stator core, the longer the mean length of the winding [7]. Moreover, iron losses are related to the length of both the rotor and the stator, as these losses are directly proportional to the volume of iron in the motor cores [1]. In terms of mechanical losses (P_{mech}), a longer rotor experiences higher windage losses and mechanical vibrations which leads to increased friction losses, especially at high speeds [3], [6] (mechanical losses are not considered in this study).

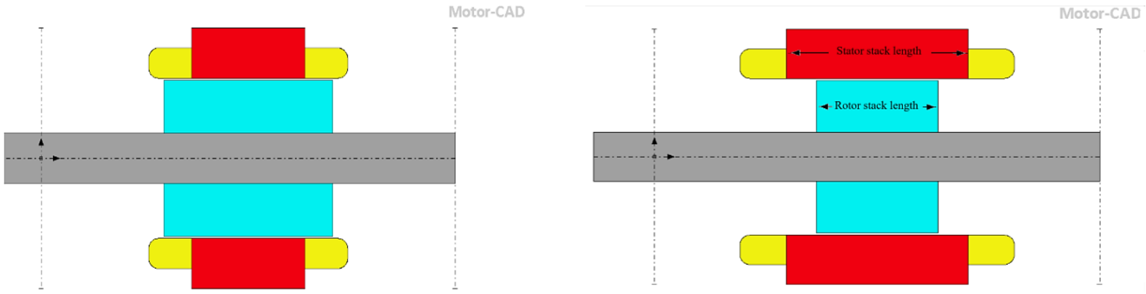
4. METHODOLOGY

This study investigates the impact of unequal stator and rotor stack lengths on the performance of the switched reluctance motor. The main steps of the adopted approach can be summarized as follows: Initially, a baseline 6/4 switched reluctance motor with equivalent stator and rotor stack lengths was designed utilizing Ansys Motor-CAD. All geometric dimensions, winding parameters, material properties, and operating conditions were defined and kept constant throughout the study. The parameters of the SRM are listed in Table 1.

A three-dimensional finite element electromagnetic model of the SRM was developed to ensure a realistic evaluation of the motor performance under unequal stack length conditions. A sensitivity analysis was performed by systematically varying the stack lengths while maintaining all other parameters unchanged. This analysis does not aim to provide refinement for a particular application; rather, it is intended to demonstrate the feasibility of the proposed development [10]. Two distinct cases were investigated: i) stator stack length shorter than rotor stack length, and ii) rotor stack length shorter than stator stack length. For each case, the stack length was varied from 60 to 90 mm in predefined steps. Figure 2 shows an axial view of uneven rotor and stator length SRM.

Table 1. Parameter of the SRM

Parameter	Value	Unit	Parameter	Value	Unit
Stator poles	6		Rotor pole angle	30	degree
Stator pole angle	30	degree	Rotor slot depth	10	mm
Stator lamination diameter	130	mm	Pole taper angle	0	degree
Stator bore	80	mm	Shaft diameter	25	mm
Stator pole depth	15	mm	Air-gap length	1	mm
Stator pole taper angle	0	degree	Rotor poles	4	
Stator pole radius	2	mm			



(a) (b)

Figure 2. Uneven rotor and stator length SRM: (a) stator shorter than rotor and (b) rotor shorter than stator

Electromagnetic simulations were carried out for each configuration to extract key performance indicators, including aligned and unaligned inductances, torque characteristics, torque ripple, air-gap flux density, copper losses, iron losses, efficiency, power factor, and rotor inertia. Finally, the obtained results were analyzed and compared with the baseline design in order to quantify the influence of unequal stator and rotor lengths on the overall motor performance. The observed variations were then categorized and discussed to identify acceptable design ranges and potential benefits of adopting unequal stack lengths in practical SRM applications.

5. RESULTS AND DISCUSSION

5.1. Stator shorter than rotor case

Figure 3 shows the change in aligned and unaligned inductance when the stator length is reduced. Reducing the stator length from 90 to 60 mm results in a 32.72% reduction in aligned inductance and a 30.33% reduction in unaligned inductance. The inductance ratio (aligned inductance/unaligned inductance) decreases slightly, from 4.808% to 4.645%.

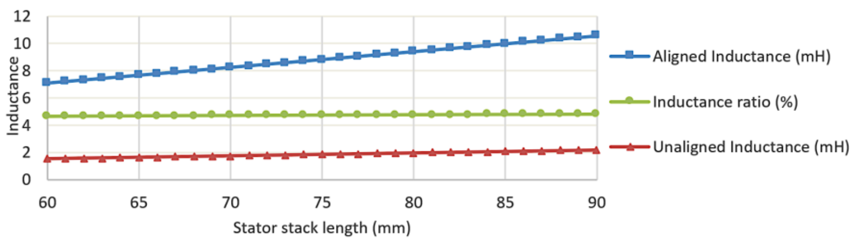
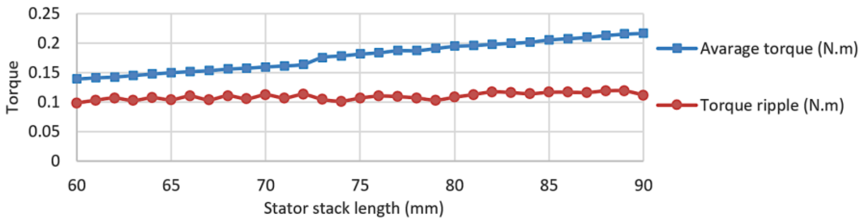


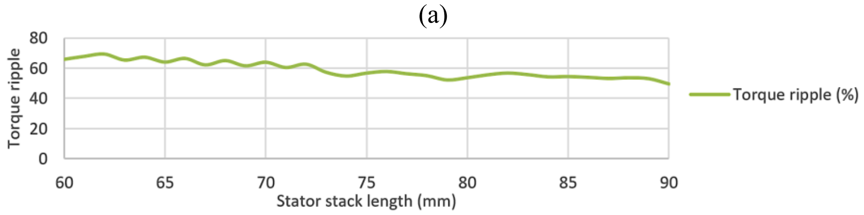
Figure 3. Motor inductances versus stator stack length

Figure 4(a) shows the average torque and torque ripple when the length of the stator stack is decreased, while Figure 4(b) shows the percentage of torque ripple (torque ripple/average torque) versus stator length. It has been observed that the average torque is reduced by 34.8%. There is also a decrease in the torque ripple values, while the percentage ripple exhibits a slight increase up to a stator length of 79 mm. However, below this length, there is a significant increase in the percentage ripple.

Figure 5 clearly shows that reducing the length of the stator decreases both the iron and copper losses of stator. However, this reduction in length has no effect on rotor losses. Here, a 15.79% reduction in the total losses is achieved. In Figure 6, it is clear that both input and output power decrease as the stator length decreases due to the lack of area for magnetic interaction. This figure also shows a remarkable result: the motor efficiency is not significantly affected, but only decreases from 84.3% to 80.7%. Figure 7 shows the power factor of the motor versus stator length. The power factor decreases as the stator length is reduced, with a total reduction of 16.4%. Peak and mean values of airgap flux density are shown in Figure 8; it is clear that reducing the length of the stator does not change the flux density.



(a)



(b)

Figure 4. Motor torque versus stator length: (a) average torque and torque ripple and (b) percentage torque ripple versus stator length

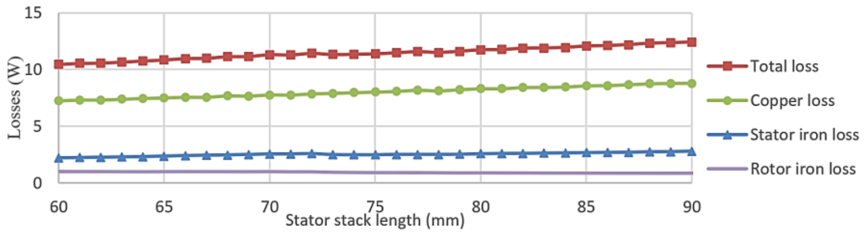


Figure 5. The motor losses versus stator stack length

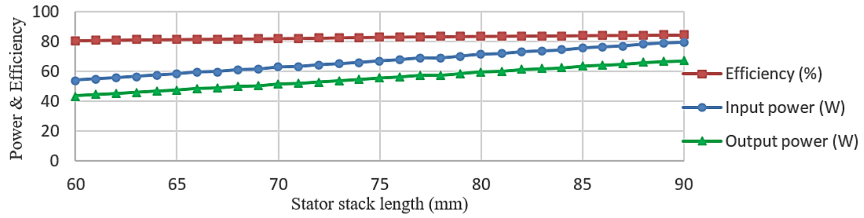


Figure 6. Input and output powers and efficiency versus stator stack length

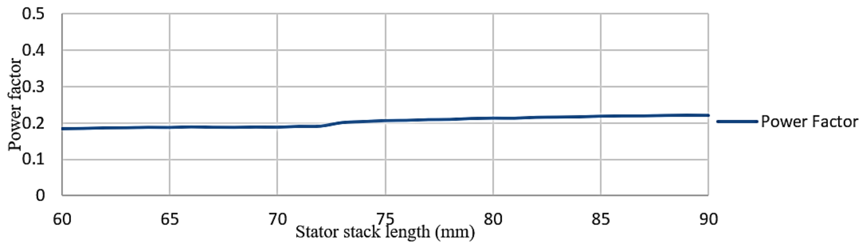


Figure 7. Power factor versus stator stack length

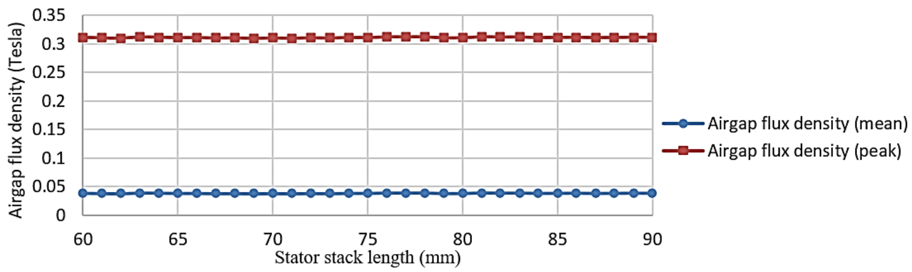


Figure 8. Air-gap flux density versus stator length

5.2. Rotor shorter than stator case

Figure 9 shows the change in aligned and unaligned inductance when the rotor length is reduced. Reducing the rotor length from 90 to 60 mm results in a 32.72% reduction in aligned inductance and a 30.33% reduction in unaligned inductance. The inductance ratio (aligned inductance/unaligned inductance) changes, slightly, from 4.808% to 4.653%. Figure 10(a) shows the torque results for the motor when the length of the rotor stack is decreased, while Figure 10(b) shows the percentage value of torque ripple.

It has been observed that the average torque is reduced by 34.9% but the torque per rotor volume remains constant. There is also a decrease in the torque ripple values, while the percentage ripple (Figure 10(b)) exhibits a slight increase up to a rotor length of 80 mm. However, below this length, there is a significant increase in the percentage ripple.

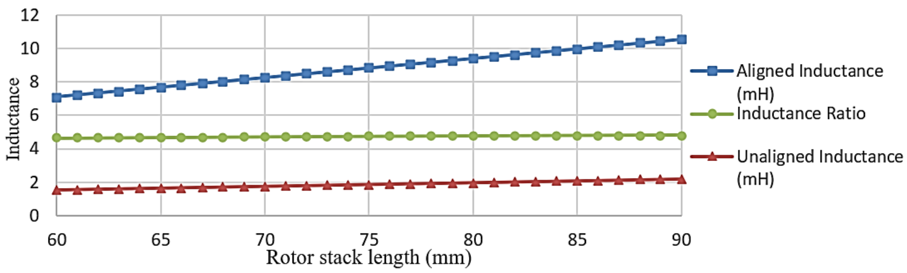


Figure 9. Inductance versus rotor length

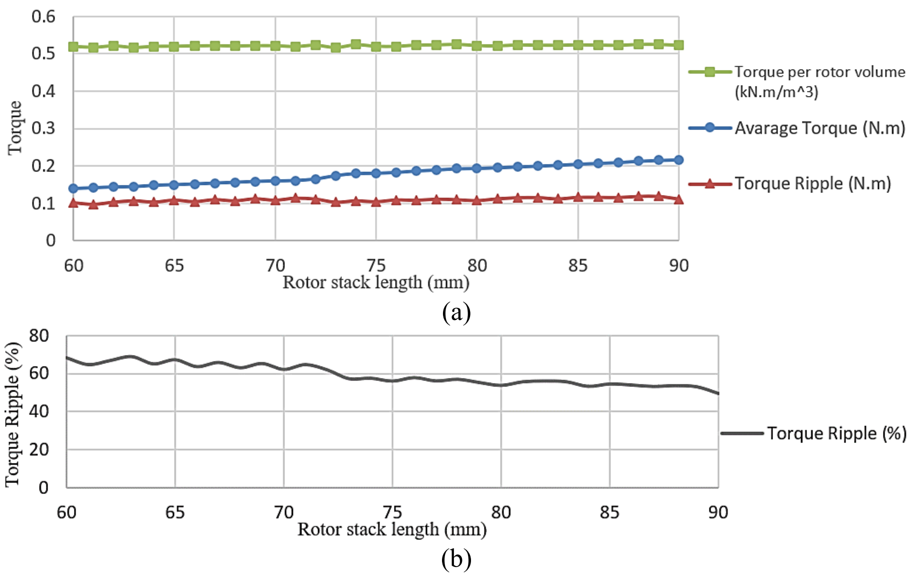


Figure 10. Motor torque versus rotor length: (a) average torque and torque ripple and (b) percentage torque ripple versus rotor length

Figure 11 shows that reducing the length of the rotor decreases the iron loss in rotor. Also, it is clear that reduction of rotor length has no effect on the copper loss but it leads to increased fringing flux and higher stator flux densities. This results in exacerbated alternating flux conditions in the stator, which increases its iron losses. The total losses increase slightly by 3.9%.

In Figure 12, it is clear that both input and output power decrease as the rotor length decreases due to the lack of area for magnetic interaction. This figure also shows that the decrease in efficiency is more pronounced than in the case where the stator is shorter than the rotor. Figure 13 shows the power factor of the motor versus rotor length. The power factor decreases as the rotor length is reduced, with a total reduction of 16.4%, which is the same drop for stator shorter than rotor case. Peak and mean values of airgap flux density are shown in Figure 14; it is clear that reducing the length of the rotor does not change the flux density.

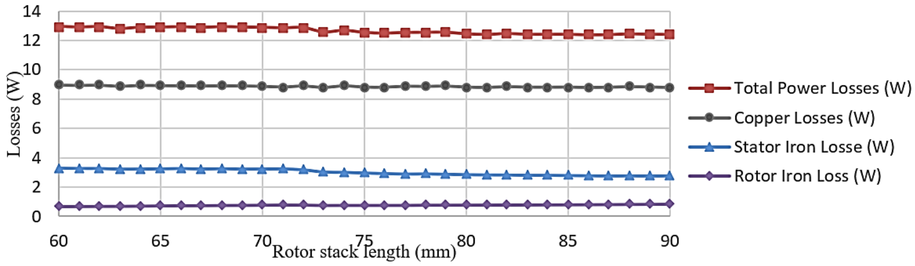


Figure 11. The losses of motor versus rotor length

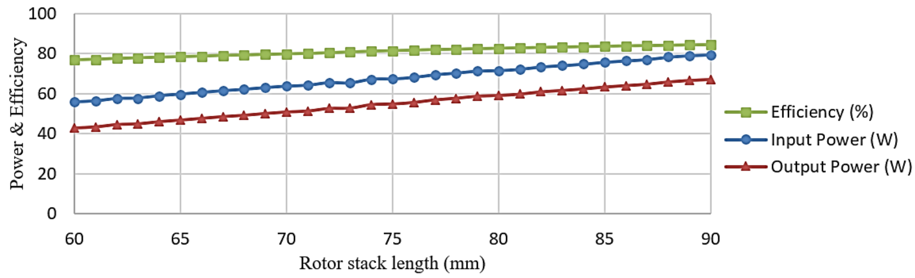


Figure 12. Input and output powers and efficiency versus rotor stack length

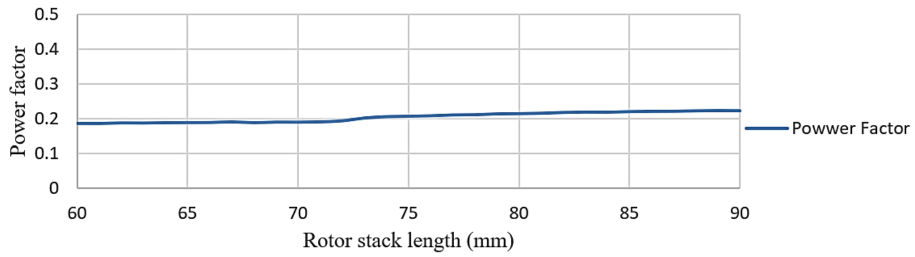


Figure 13. Power factor versus rotor stack length

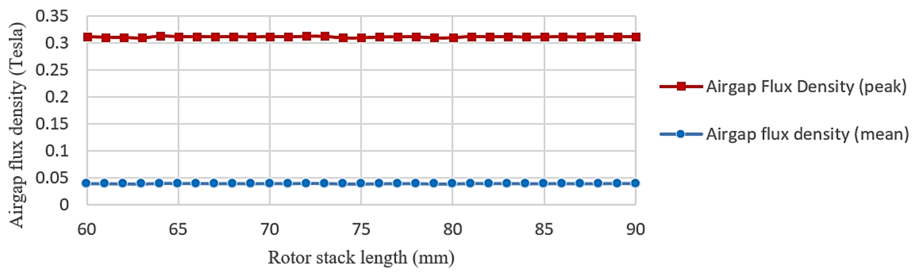


Figure 14. Air-gap flux density versus rotor stack length

Figure 15 shows the linear decrease in inertia with decreasing rotor length. A low inertia rotor is desirable in fast-response applications. Table 2 summarizes the key results for both study cases. In this table, the terms "stator shorter than rotor" and "rotor shorter than stator" denote the cases in which the short component is reduced to the minimum investigated length (60 mm), and the reported results correspond to the machine performance under this minimum stack-length condition. The qualitative terms used to indicate the relative magnitude of change are almost constant (±0-2%), negligible change (±2-5%), slight (5-10%), moderate (10-20%), and large (>20%). These descriptors provide a clear and consistent interpretation of performance variations across both configurations.

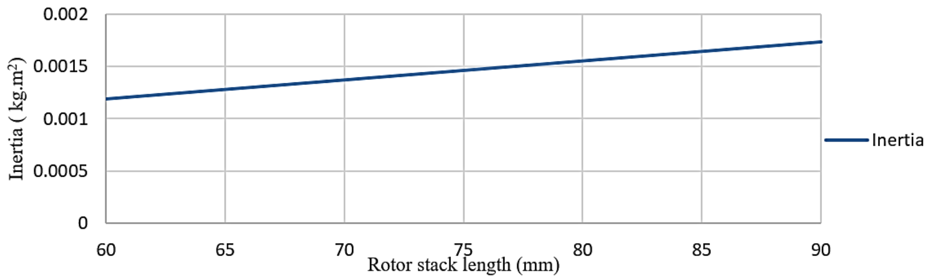


Figure 15. Rotor inertia versus rotor stack length

Table 2. Summary of results

Indicators	Stator shorter than rotor	Rotor shorter than stator
Aligned inductance	Large decrease	Large decrease
Unaligned inductance	Large decrease	Large decrease
Inductance ratio	Almost constant	Almost constant
Average torque	Large decrease	Large decrease
Torque ripple	Slight decrease	Slight decrease
Percentage ripple	Large increase	Large increase
Copper loss	Moderate decrease	Almost constant
Stator iron loss	Moderate decrease	Moderate increase
Rotor iron loss	Moderate increase	Moderate decrease
Input power	Large decrease	Large decrease
Output power	Large decrease	Large decrease
Efficiency	Slight decrease	Slight decrease
Power factor	Moderate decrease	Moderate decrease
Airgap flux density (mean)	Almost constant	Almost constant
Airgap flux density (peak)	Almost constant	Almost constant

6. CONCLUSION

This paper analyzes a rare instance in SRM design in which the length of the stator does not equal the length of the rotor. The objective of this analysis is to illustrate the implications of such a development. Shortening the stator reduces the overall weight while shortening the rotor reduces the weight and inertia of the motor, making it ideal for high-speed or portable applications. The shorter stack uses less material, reducing manufacturing costs. Furthermore, custom SRMs may require unequal stator and rotor stack lengths to meet specific performance criteria. The simulation results are clear: certain performance indicators of the motor are unaffected and remain almost consistent even when the length of the stator or rotor decreases to 60 mm, which represents a decrease of 33%. These indicators include inductance ratio, efficiency, torque ripple and peak and mean airgap flux density. However, reducing the length of the stator or rotor negatively affects other performance indicators. These include: aligned and unaligned inductances, average torque, percentage torque ripple, and input and output powers. However, these changes are acceptable if the difference between the stator and rotor lengths is within 10%. The worst-case scenario was a 10.9% drop in output power when the rotor was 10% less length than the stator. As demonstrated above, the case of unequal length of the stator and rotor can be posited as a potential solution to achieve the optimal design of the SRM especially for low-cost, low-inertia, and high-speed motor applications. For future studies, it is recommended to extend the analysis by considering thermal effects and mechanical losses, since these factors may further influence the optimal selection of stack lengths. Furthermore, combining the unequal-length concept with advanced optimization algorithms could lead to more comprehensive performance improvements.

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AUTHOR CONTRIBUTIONS STATEMENT

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Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Mohammed Moanes Ezzaldean Ali	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Nadheer A. Shalash						✓		✓	✓	✓	✓			

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

All data supporting the findings of this study are available within the article. Further information and supporting materials can be provided by the corresponding author, [MMEA], upon reasonable request.

REFERENCES

[1] R. Krishnan, *Switched reluctance motor drives*. CRC Press, 2017, doi: 10.1201/9781420041644.
[2] J.-R. Riba, A. Garcia, and I. Romero, "An educational tool to assist the design process of switched reluctance machines," *International Journal of Electrical Engineering & Education*, vol. 54, no. 1, pp. 35–56, Jan. 2017, doi: 10.1177/0020720916659502.
[3] A. Fenercioglu, M. Ş. Kurt, A. Şahin, H. Z. Keleş, and T. Kocaer, "Effect of rotor geometry on performance of 6/4 switched reluctance motors," *DÜMF Mühendislik Dergisi*, pp. 459–469, Jun. 2021, doi: 10.24012/dumf.955418.
[4] M. Anand, S. Jebarani Evangeline, W. D. Priya, and S. C. Selvi, "Design, FEM analysis and development of switched reluctance motor electric drive for tri-wheeler e-vehicle application," *Automatika*, vol. 65, no. 3, pp. 813–829, Jul. 2024, doi: 10.1080/00051144.2024.2330281.
[5] T. J. E. Miller, "Electronic control of switched reluctance machines," in *Newnes Power Engineering Series*, vol. 136, no. 1, pp. 23–42, 1998.
[6] U. Shiurkar and R. Autee, *Analysis of switched reluctance motor*. Oxford Book Company, 2019.
[7] R. Esteves Araújo and J. Roberto Camacho, Eds., *Modelling and control of switched reluctance machines*. IntechOpen, 2020, doi: 10.5772/intechopen.82219.
[8] A Novanta Company - Celera Motion, "Omni+ series products datasheet." 2022. [Online]. Available: https://www.celeramotion.com/frameless-motors/products/direct-drive-frameless-rotary-motors/torque-plus/omni-plus/.
[9] P. Upadhyay and K. Ragavan, "Design of two-phase switched reluctance motor (SRM) for two-wheel electric vehicle and torque-density based comparison with three-phase SRM," *IEEE Transactions on Industry Applications*, vol. 60, no. 3, pp. 3912–3919, 2024, doi: 10.1109/TIA.2024.3371394.
[10] Z. Yueying, Y. Chuantian, Y. Yuan, W. Weiyan, and Z. Chengwen, "Design and optimisation of an in-wheel switched reluctance motor for electric vehicles," *IET Intelligent Transport Systems*, vol. 13, no. 1, pp. 175–182, 2019, doi: 10.1049/iet-its.2018.5097.
[11] D. B. Minh, L. D. Hai, T. Le Anh, and V. D. Quoc, "Electromagnetic torque analysis of SRM 12/8 by rotor/stator pole angle," *Engineering, Technology and Applied Science Research*, vol. 11, no. 3, pp. 7187–7190, 2021, doi: 10.48084/etasr.4168.
[12] M. El-Nemr, M. Afifi, H. Rezk, and M. Ibrahim, "Finite element based overall optimization of switched reluctance motor using multi-objective genetic algorithm (NSGA-II)," *Mathematics*, vol. 9, no. 5, p. 576, Mar. 2021, doi: 10.3390/math9050576.
[13] G. Davarpanah and J. Faiz, "A novel structure of switched reluctance machine with higher mean torque and lower torque ripple," *IEEE Transactions on Energy Conversion*, vol. 35, no. 4, pp. 1859–1867, 2020, doi: 10.1109/TEC.2020.2990914.
[14] G. Watthewaduge, E. Sayed, A. Emadi, and B. Bilgin, "Electromagnetic modeling techniques for switched reluctance machines: state-of-the-art review," *IEEE Open Journal of the Industrial Electronics Society*, vol. 1, pp. 218–234, 2020, doi: 10.1109/OJIES.2020.3016242.
[15] G. Watthewaduge and B. Bilgin, "Reluctance mesh-based magnetic equivalent circuit modeling of switched reluctance motors for static and dynamic analysis," *IEEE Transactions on Transportation Electrification*, vol. 8, no. 2, pp. 2164–2176, 2022, doi: 10.1109/TTE.2021.3132885.
[16] D. K. Yankov and T. G. Grigorova, "A nonlinear model for a three-phase 12/8 switched reluctance machine," *International Journal of Power Electronics and Drive Systems*, vol. 13, no. 3, pp. 1576–1587, 2022, doi: 10.11591/ijpeds.v13.i3.pp1576-1587.
[17] A. Brouri, L. Kadi, A. Tounzi, A. Ouannou, and J. Bouchnaif, "Modelling and identification of switched reluctance machine inductance," *Australian Journal of Electrical and Electronics Engineering*, vol. 18, no. 1, pp. 8–20, 2021, doi: 10.1080/1448837X.2020.1866269.

[18] A. Tzouvaras, G. Falekas, and A. Karlis, "System-level optimization in switched reluctance machine design—current trends, methodologies, and future directions," *Applied Sciences*, vol. 15, no. 11, p. 6275, Jun. 2025, doi: 10.3390/app15116275.

[19] M. Abdalmagid, E. Sayed, M. H. Bakr, and A. Emadi, "Geometry and topology optimization of switched reluctance machines: a review," *IEEE Access*, vol. 10, pp. 5141–5170, 2022, doi: 10.1109/ACCESS.2022.3140440.

[20] G. Davarpanah and S. Mohammadi, "A new switched reluctance motor with embedded permanent magnets for transportation electrification," in *IECON 2024 - 50th Annual Conference of the IEEE Industrial Electronics Society*, IEEE, Nov. 2024, pp. 1–5, doi: 10.1109/IECON55916.2024.10905122.

[21] A. K. Sahu, M. Masoumi, F. Juarez-Leon, C. J. Sensor, S. MacDonald, and B. Bilgin, "Modal characterization of a 12/8 switched reluctance motor stator-housing assembly," *IEEE Transactions on Transportation Electrification*, vol. 11, no. 1, pp. 2886–2896, Feb. 2025, doi: 10.1109/TTE.2024.3430201.

[22] S. Mohanty, S. M. Parida, C. Biswal, and P. K. Rout, "Performance evaluation of switched reluctance motor configurations for simulation of torque ripple phenomena," in *2022 2nd Odisha International Conference on Electrical Power Engineering, Communication and Computing Technology (ODICON)*, IEEE, Nov. 2022, pp. 1–5, doi: 10.1109/ODICON54453.2022.10010020.

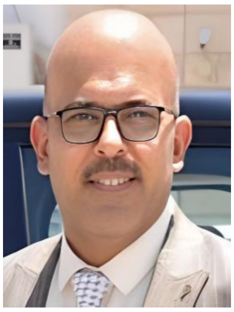
[23] O. Zayed, M. Omar, M. Bakr, M. Narimani, A. Emadi, and B. Bilgin, "Switched reluctance motor design for an EV propulsion application," in *IECON 2021 – 47th Annual Conference of the IEEE Industrial Electronics Society*, IEEE, Oct. 2021, pp. 1–6, doi: 10.1109/IECON48115.2021.9589953.

[24] A. Abdel-Aziz, M. Elgenedy, and B. Williams, "Review of switched reluctance motor converters and torque ripple minimisation techniques for electric vehicle applications," *Energies*, vol. 17, no. 13, p. 3263, Jul. 2024, doi: 10.3390/en17133263.

[25] D. M. Ionel, M. Popescu, M. I. McGilp, T. J. E. Miller, S. J. Dellinger, and R. J. Heideman, "Computation of core losses in electrical machines using improved models for laminated steel," *IEEE Transactions on Industry Applications*, vol. 43, no. 6, pp. 1554–1564, 2007, doi: 10.1109/TIA.2007.908159.

BIOGRAPHIES OF AUTHORS

Mohammed Moanes Ezzaldean Ali received the B.Sc., M.Sc., and Ph.D. degrees in electrical engineering from the University of Technology-Iraq, in 1994, 1997, and 2009, respectively. Since May 2006, he has been with the Department of Electrical Engineering, University of Technology, where he was an assistant lecturer, became a lecturer in 2009, and an assistant professor in 2018. His current research interests include electro heat (induction heating), electrical machines, and drives. He published more than forty technical papers. He can be contacted at email: mohammedmoanes.e.ali@uotechnology.edu.iq.



Nadheer A. Shalash received the B.S. degree (2003), the M.Sc. degree (2008) from the University of Technology-Iraq. The Ph.D. degree in electrical power engineering/UMP (Malaysia) in 2015. He was a lecturer at AL-Ma'moon University College from 2008 to 2023. Currently, he is an assistant professor in the Department of Electrical Engineering, at the University of Technology-Iraq. He can be contacted at email: 30256@uotechnology.edu.iq.