Proceedings of ISAP2012, Nagoya, Japan

2E2-2

Effect of Metal Plate on Position Error Tolerance in Wireless Power Transfer

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Abstract

Wireless power transmission techniques have been attracting attention in recent years. In the practical application, however, several problems are still remaining. Especially, the effects of metals around coils are not evaluated enough. In this paper, the effect of metals around the coils on position error tolerance has been investigated. As results of the analysis, it is clarified that the position error tolerance can be improved by attaching the metal cover to the coil.

1. Introduction

In recent years, wireless power transmission techniques have been attracting much attention [1]. In this paper, magnetic resonance method is focused because the power transmission with high efficiency is possible even though the distance is relatively long [2]. Figure 1 shows an example of charging the car. A receiver coil and a transmitter coil are attached on bottom of the car and on the ground, respectively. The receiver coil should be set just above the transmission coil for realizing the effective charging , however, it is very difficult. Deviation of the two coil position is called "position error" in this paper. Transmission efficiency is decreased due to the position error. Moreover, in a practical environment, it is expected that metal plates are located in the bottom of the car. However, the effects of the metal plates around the coils are not evaluated enough. In this paper, the effects of metal plates around the coil on the position error tolerance have been investigated.

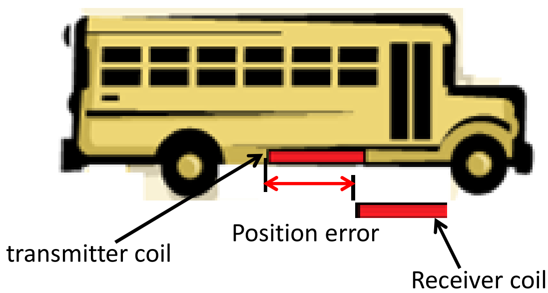
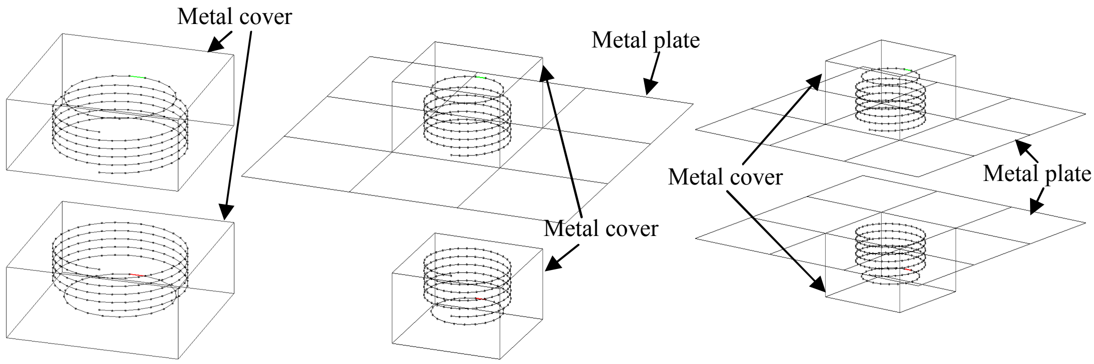


Figure 1: Example of Car Charging

2. Analysis condition and evaluation method

2.1 Analysis condition

Figure 2 shows the bird's eye view of structures for analysis model. Figure 2(a) is the model that the coil is covered with a metal. Figure 2(b) is the model with a metal plate in the receiver side in addition to the metal cover. The metal plate in the receiver side is supposed to be a bottom of the car. Figure 2(c) is the model with the metal plate in both side of the receiver and the transmitter in addition to the metal cover.



(a) Metal cover

(b) Metal cover and metal plate in receiver side

(c) Metal cover and metal plates

Figure 2: Structure of Analysis Model

2.2 Evaluation method

The following Figs.3 and 4 are simple examples for explaining the evaluation method in this paper. Figure 3 is a sample model of coil [1]. The under side is the transmitter and the upper side is the receiver, respectively. Moreover, deviation of the central axis of the transmitter coil and the receiver coil is called position error in this paper. Figure 4 is an example of the calculated result. The horizontal axis indicates the position error and the vertical axis indicates the power transmission efficiency. In this paper, position error tolerance is evaluated by the maximum position error in which 90% of transmission efficiency is maintained. Large value of the maximum position error means the high tolerance to the position error between the transmitter and the receiver.

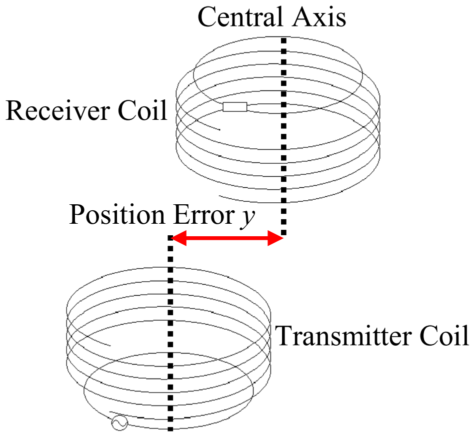


Figure 3: Sample Model

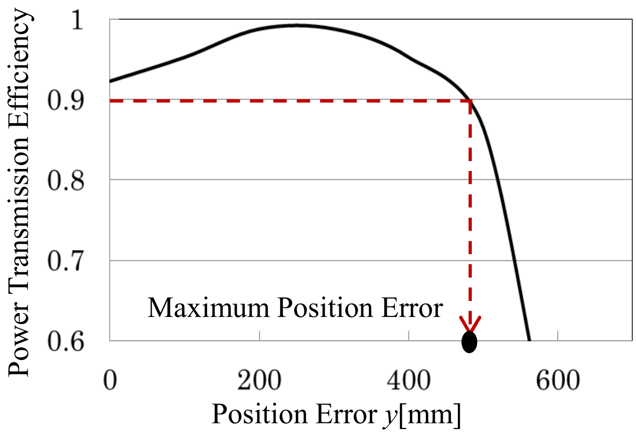


Figure 4: Position Error Tolerance

3. Effect of Distance between Coil and Metal Cover on Position Error Tolerance

Figure 5 shows details of the analysis model [3][4]. Both of the transmitter and receiver is composed of a coil, a loop and a metal cover. The distance between the coil and the metal cover is defined as “S”. Table 1 shows analysis conditions.

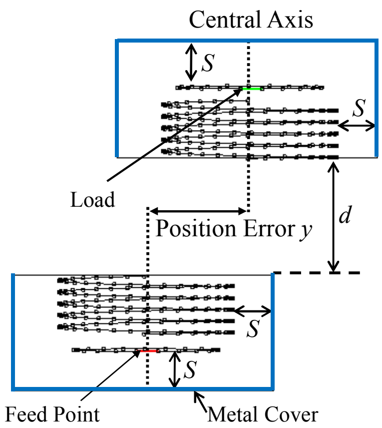


Figure 5: Analysis Model (with Metal Cover)

Table 1: Analysis Conditions

Feeding voltage[V]	1
Load resistance[Ω]	50
Coil radius[mm]	300
Reel number of the coil	5
Transmission distance *d*[mm]	600

Figure 6 shows the relationship between S and maximum position error. The horizontal axis S is the distance between the metal cover and the coil. The vertical axis is the maximum position error in which 90% of transmission efficiency can be maintained. The position error tolerance becomes higher as the spacing of the coil and the metal cover is expanded. Figures 7(a) and 7(b) shows the magnetic field strength around the coils when S is 10mm and 100mm, respectively. Certainly, when the magnetic field strength is in case of S = 100mm strong compared to the case of S = 10mm.

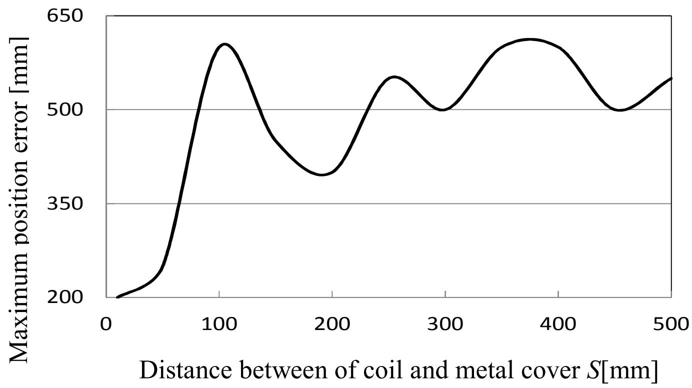


Figure 6: Relationship between S and Maximum Position Error

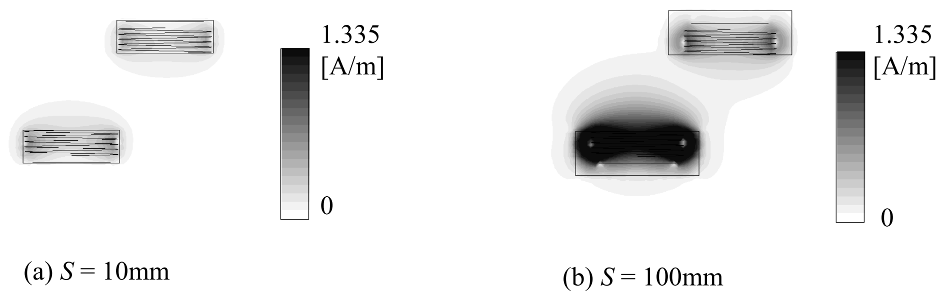


Figure 7: Magnetic Field Strength around Coil

4. Effect of additional metal plate on position error tolerance

Figure 8 shows details of the analysis model when the metal plates are located in addition to the metal cover. Shape of the metal plate is square. Table 2 shows analysis conditions. Figure 9 shows compare of position error tolerance. The horizontal axis and the vertical axis are the position error and the power transmission efficiency, respectively. Model (a), (b) and (c) is corresponding to

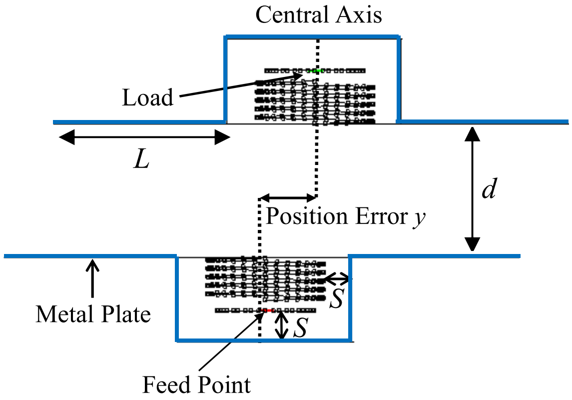


Figure 8: Analysis Model(with Metal Plate)

Table 2: Analysis Conditions

Feeding voltage[V]	1
Load resistance[Ω]	50
Coil radius[mm]	300
Reel number of the coil	5
Metal plate side length L[mm]	800
Transmission distance d[mm]	600
Distance of coil and cover S[mm]	100

the model (a), (b) and (c) in Fig.2, respectively. The result in case of only the coils (no metals) is also shown in the figure for reference. Position error tolerance is improved when the coil is covered with a metal in the all model. Especially maximum position error of model (a) is about 1.3 times compared to that of "only coils".

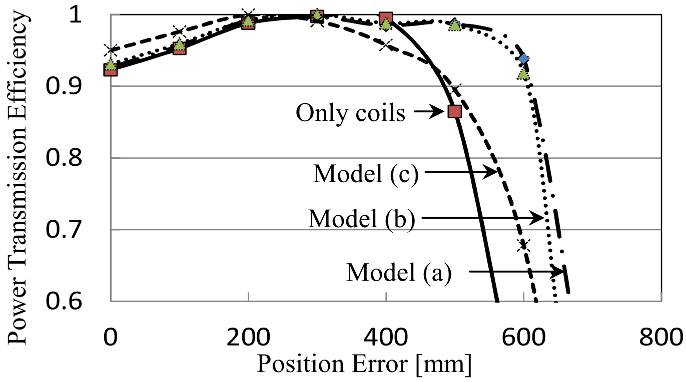


Figure 9: Compare of Position Error Tolerance

5. Conclusion

The effect of metal cover and petal plate around the coils on transmission efficiency in wireless power transfer was investigated. It was shown that the distance between the coil and the metal cover affect greatly on transmission efficiency. It was also clarified that the magnetic field strength could be increased and the position error tolerance could be improved by attaching the metal cover around the coil. Especially, maximum position error to maintain the 90% of the efficiency in case of model (a) was about 1.3 times compared to that of case of "only coils".

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