Risk Analysis and Accident Causes of Mobile Phone Charger

Fengping He*
Fujian Polytechnic of Information Technology, Fuzhou, Fujian, China

*Corresponding author: hefengping2020@mitu.cn

Abstract. All kinds of mobile phone chargers in the actual use process, due to poor quality products or improper use will cause safety accidents, causing great harm, so this paper has great practical significance to study the use risk and accident causes of mobile phone chargers. First of all, through the failure of insulating materials between conductive parts of mobile phone charger, the use of substandard artificial plug-ins in the production of components, the use of waste circuit boards or circuit board aging, and the unqualified quality of high-frequency transformer, the use risk and reasons of inferior products are analyzed. Secondly, the risks and causes of improper use of mobile phone chargers are analyzed by analyzing the factors such as alternate mixing of different specifications of mobile phone chargers, using mobile phone while charging, and long-term plugging in the socket. Finally, three typical cases of accidents caused by the breakdown of the insulation between the conductive parts of the mobile phone charger, the excessive current at the output end, and the defects of the material are analyzed, which provides better technical support for better eliminating the hidden dangers of the mobile phone charger.

1. Introduction
With the development of the times and the progress of science and technology, a variety of mobile phone chargers emerge in endlessly. The original prototype of mobile phone charger is seat charger. There is a row of metal contact pieces in the battery slot. When using, the battery on the mobile phone needs to be removed and put into the corresponding charger battery slot to start charging. Then the appearance of travel charger can provide power for mobile phone at any time during the mobile process. Later, with the emergence of smart phones, the mobile phone charger was replaced by a USB charger composed of charging head and data cable. The internal part of mobile phone charger is composed of input rectifier, triode, high frequency transformer, high frequency oscillation, opt coupler feedback, and reference voltage source and output voltage regulator. In the process of charging, through the rectifier circuit, high-frequency transformer and voltage stabilizing circuit of mobile phone charger, the current is reduced from 220V AC to 5V DC, thus changing the form of electric energy [1-2]. The difference of output power is mainly due to the difference of high-frequency transformers. Under the same voltage u, the greater the current I is, the greater the output power P is. Different high-frequency transformers can accept different maximum currents. If the mobile phone charger is a poor quality product or has faults or is mixed with other products of different specifications, it may cause charging accidents. In recent years, such accidents occur frequently, which has aroused wide attention from all walks of life. Therefore, it is necessary to analyze the use risk of mobile phone charger and trace the cause of the accident, so as to better eliminate the hidden danger of mobile phone charger.
2. Risk analysis of mobile phone charger

2.1. Risk of using inferior mobile phone charger

Inferior mobile phone charger is used by many people who are greedy for small and cheap because of its similar appearance and cheap price. However, every year, there will be accidents due to the use of poor quality mobile phone chargers, which do great harm to the society. Why is the use of inferior mobile phone chargers a great risk, and there are many people regardless of the risk to use it? According to the survey of users of inferior mobile phone chargers, the proportion of four different reasons for purchase in the survey population is counted, as shown in Figure 1. Where, A: Is greedy for low price when buying; B: Can't distinguish between regular charger and inferior charger; C: Has been used before without any problems and continues to be used; D: Use of inferior charger for other reasons. Visible, the reason that most people buy inferior charger is greedy for cheap price.

![Figure 1. Proportion chart of four reasons for purchasing inferior charger.](image)

The main safety risks and causes of accidents in the use of inferior mobile phone chargers are as follows.

2.1.1. Failure of insulating materials between conductive parts. Poor quality mobile phone charger, the process of insulating materials between conductive parts is simple, the materials and performance indicators are not in line with national standards, and various defects will be formed in the dielectric during production, such as air gap, cracks, impurities, etc. In the process of using the charger, these insulating materials are vulnerable to a variety of factors (electricity, heat, and environment) and rapid aging, resulting in the decline of insulation level and the shortening of service life. The rapid aging of mobile phone charger insulation material is easy to make it in the process of power on, partial discharge first occurs in these defects, and the long-term partial discharge will produce a large number of free moving space charges, resulting in insulation material failure, and finally lead to partial damage and breakdown of the insulation material, followed by circuit breakdown between conductive parts The explosion or leakage of mobile phone charger is caused [3-4].

2.1.2. The manual plug-in that does not meet the standard is added when making components. The internal components of mobile phone charger are composed of several parts, such as diodes, triodes, integrated circuits, resistors, capacitors, etc. There are many kinds of mobile phone chargers, among
which there are many kinds of electronic chargers [5-6]. Every electronic component has its own unified standard, and some black heart manufacturers, for the sake of profit, participate in artificial plug-ins that do not meet the standard when making components. When the mobile phone charger with artificial plug-ins is used at the beginning, there will not be any big problems. However, with the passage of time and the increase of use times, these artificial plug-ins are easier to have problems than the standard components. Once the position replaced by the artificial plug-ins has problems, the overall electronic components will also have faults, resulting in the overall circuit short circuit So as to cause the explosion accident.

2.1.3. Use waste circuit board or circuit board aging. Circuit board is mainly composed of high molecular polymer (resin), glass fiber or kraft paper, high purity copper foil and printed components. According to the number of layers, it can be divided into single panel, double-sided board and multi-layer circuit board. The circuit board commonly used in mobile phone charger is single panel [7-8]. Any electronic product has a service life. When the electronic product is discarded, its circuit board will also be discarded, but the discarded circuit board can still be used before it is really discarded. Therefore, in order to save the production cost of mobile phone charger, some businesses recycle these discarded circuit boards at a low price and continue to assemble and use them on the mobile phone charger. In addition to the use of waste circuit boards, new circuit boards also use a certain proportion of bad waste boards and leftovers in the production process. These mobile phone chargers also have certain security risks.

2.1.4. The quality of high frequency transformer is unqualified. The importance of high-frequency transformer for mobile phone charger is self-evident. The high-frequency transformer produced by black heart manufacturers often uses copper-clad aluminum, while the mobile phone charger produced by regular manufacturers uses pure copper. The difference between the two is that pure copper has better and more stable conductivity, while copper-clad aluminum not only has poor conductivity, but also is unstable, which may cause under charging or overcharging in small cases, but may cause safety accidents in large cases due to the explosion of mobile phone charger.

2.2. Risk factors of improper use of mobile phone charger
In the investigation on the use of mobile phone chargers, the risk factors for improper use of mobile phone chargers include: alternate mixing of different specifications, using mobile phone while charging, long-term plugging in the socket, using in high temperature environment, using in humid environment, letting infants contact, and others, as shown in Figure 2. It can be seen that the proportion of the first three types is the highest, which are 26% mixed with different specifications alternately, 31% mobile phone while charging, and 30% long-term plug-in.

![Figure 2. Risk factors of improper use of mobile phone charger.](image)
2.2.1. Different specifications are mixed alternately. Sometimes for convenience, just find a charger to use; or the original charger is broken, directly buy a mobile phone charger that does not match the original model. Table 1 and table 2 show the charging test data of two well-known mobile phone chargers in the process of alternate mixing of different specifications.

Table 1. Charging test data sheet of brand 1 mobile phone charger.

| Starting condition       | Battery capacity | 3080mAh |
|--------------------------|------------------|---------|
| Mobile phone original charger | 5V/2A charger | 5V/2A (Mixed use) |
| Test time                | 30 minutes       | The power consumption of three brand 1 mobile phones is 30% |
| Initial power            |                  |         |
| Charger type             | 5V/2A (Original) | 5V/1A (Mixed use1) | 9V/2A (Mixed use2) |
| 30 min charge            | 28%              | 24%     | 36%    |
| Battery temperature      | 30.1%            | 29.8%   | 34.5%  |
| Charger temperature      | 38.0%            | 46.3%   | 39.6%  |

Table 2. Charging test data sheet of brand 2 mobile phone charger.

| Starting condition       | Battery capacity | 1560mAh |
|--------------------------|------------------|---------|
| Mobile phone original charger | 5V/1A charger | 5V/1A (Mixed use) |
| Test time                | 30 minutes       | The power consumption of two brand 2 mobile phones is 30% |
| Initial power            |                  |         |
| Charger type             | 5V/1A (Original) | 5V/2A (Mixed use1) | 5.1V/2.1A (Mixed use2) |
| 30 min charge            | 27%              | 30%     | 32%    |
| Battery temperature      | 33.3%            | 32.4%   | 34.3%  |
| Charger temperature      | 43.8%            | 43.6%   | 43.3%  |

It can be seen from table 1 and table 2 that when using the mobile phone charger, if the output current is large and the input current is small, both the temperature of the mobile phone charger and the surface temperature of the mobile phone are relatively stable, and there will not be a big gap. On the contrary, using a mobile phone charger with small output current to charge a high-power mobile phone will not only reduce the life of the charger, but also cause an explosion accident due to the high temperature of the charger.

2.2.2. Play with your mobile phone while charging. Many people have the experience that their mobile phone is running out of power, but they still need to use it, so they use it while charging it. In fact, in the long run, it will not only damage the mobile phone, but also cause danger. On the one hand, in the low temperature environment, the low temperature protection mechanism of lithium battery will make the mobile phone battery do not have chemical reaction, and the temperature of using the mobile phone while charging is rising, and if the temperature is too high, the lithium battery may be damaged, resulting in the hidden danger of mobile phone explosion. On the other hand, the long-term charging while playing mobile phone is easy to cause the aging of mobile phone charger circuit, resulting in overheating aging and short circuit. If short circuit occurs, it is likely to cause the spontaneous combustion of mobile phone and human burns. [8]

2.2.3. Plug in the socket for a long time. The purpose of people using it in this way is to prevent the mobile phone charger from changing randomly, and connect it to the charger directly when the mobile
phone is out of power. After the phone is fully charged, unplug it and leave the charger on the plug. Although the connector of the charger is not connected to the phone, the internal circuit of the charger is connected. Plug the charger into the plug for a long time, which also means that the charger always keeps working. The charging capacity of the charger itself will not only decline, but also accelerate the aging of the charger. Premature aging is easy to cause short circuit of the mobile phone charger. Moreover, when the charger is powered on, it will continue to generate heat. When the heat reaches a certain degree, it is easy to ignite and explode, causing potential safety hazards. [9]

3. Case analysis of mobile phone charger accident

3.1. Case 1: Insulation breakdown between conductive parts
On the evening of June 20, an accidental explosion occurred in Room 101, unit 1, a building in a town, a county, a city. The police finally determined that the cause of the explosion was that the owner of the house inserted the mobile phone charger into the socket, which led to the breakdown of the insulation between the conductive parts in the charger, causing the charger to explode, and the sparks generated by the explosion ignited flammable substances such as cloth sofa and it caused the accident. The scene of the accident is shown in Figure 3.

![Figure 3. Case 1 scene of mobile phone charger accident.](image)

In this case, the owner of the house did not use the mobile phone charger, but continued to plug it in and out. On the surface, it seemed that he was not charging the mobile phone. In fact, the charger was always in working condition. Long time work would make the interior of the charger hot all the time. However, the mobile phone charger was very small, and there was no room for heat dissipation. Therefore, after the heat reached the critical value, the coil would not work when the insulation layer is melted, the insulation between conductive parts is broken down by the current, resulting in short circuit, explosion and combustible combustion.

3.2. Case 2: Excessive output current
On June 27, an explosion occurred in a house in donggeduo village, jianmou District, a city. In the house, an 18-year-old Chen was found dead on the ground by his family. One part of his neck was injured by the explosion, and the wound was bloody. Not far from his neck, there was a rose gold burnt mobile phone, next to the mobile phone charger. According to the police's identification of the scene of the accident, the death of the deceased Chen was caused by using a low-power charger to charge a high-power mobile phone, and using a mixed charger instead of using the original or matching charger. The scene of the accident is shown in Figure 4.

![Figure 4. Case 2 scene of mobile phone charger accident.](image)
In this case, Chen's mobile phone is a flash charging mobile phone launched by a certain brand. When the mobile phone is charged, the input DC power reaches 9V / 2A, which is a mobile phone that needs to be charged by a high-power charger. After the charger at the scene of the accident is connected to the power supply, the output DC power is only 5V / 1A, which is only suitable for charging small power mobile phones. Chen mixed the mobile phone charger to let the mobile phone charger output if the terminal current is too large, the mobile phone charger will be overloaded and the internal components will explode, which will lead to accidents.

3.3. Case 3: Material defect
At about 2:00 a.m. on July 8, when Wu was charging his mobile phone with a mobile phone charger at home, he was shocked by a sudden current, and he fainted on the spot. According to her sister's recollection, she heard a scream from her brother Wu's room at more than 10 pm. When she arrived at Wu's room, she found that there was an explosion in Wu's room, and Wu himself fell unconscious. She called her family to call the police and sent Wu to the hospital. According to the investigation results of the accident, the USB connection of the Shanzhai charger in the accident was not tightly plugged, and the exposed metal connector was 3mm long, which was similar to the charger of an international famous brand. The scene of the accident is shown in Figure 5.

In this case, Wu was shocked and fell unconscious by the current directly transmitted to the mobile phone during the charging process of the mobile phone. Under normal circumstances, the charger will have leakage protection measures when transmitting the current, even if the leakage will not be directly
transmitted to the human body, and the cause of this kind of accident may be the defect of the material of the mobile phone charger. It is understood that the internal components of many Shanzhai mobile phone chargers are made of defective products extracted from waste industrial products. The materials made of such defective products have poor insulation, are prone to failure, and do not have good leakage protection measures. If this kind of cottage charger is used, when the charger is connected to the power supply, if a component fails, the current will be directly transmitted to the mobile phone by bypassing the transformer. Once the human body contacts the part of the mobile phone containing metal conductor, it will form a circuit and be directly shocked by the current, which will cause life-threatening.

4. Conclusions

All kinds of mobile phone chargers in the actual use process, due to poor quality products or improper operation, it may cause safety accidents, causing great concern of the society. Therefore, this paper explores the use risk and accident causes of mobile phone chargers.

(1) The main reasons for the safety risks and accidents of inferior mobile phone chargers are: the failure of insulating materials between conductive parts; the use of substandard artificial plug-ins when making components; the use of waste circuit boards or circuit board aging; and the unqualified quality of high-frequency transformers.

(2) The risk factors of improper use of mobile phone chargers include: alternate mixing of different specifications, using mobile phone while charging, long-term plugging in the socket, using in high temperature environment, using in humid environment, letting infants contact, and so on. The proportion of the first three is the highest, which are 26%, 31% and 30% respectively. The use scenarios and risk reasons of these three situations are analyzed.

(3) This paper analyzes three typical cases of accidents caused by breakdown of insulation between conductive parts of mobile phone charger, excessive current at output end and defects in material, which provides better technical support for better eliminating hidden dangers of mobile phone charger.

References

[1] Guo Xiugen. Discussion on smart phone fast charger [J]. Electronic world, 2021 (01): 94-96 + 100.
[2] Chun K.S.,Leng C.H.,M yan F.W.Y.,King P.S.,Zaman N.,Alwyn Yip Winn Sheng,Faizal Mohd. Bicycle Powered Mobile Phone Charger[J]. MATEC Web of Conferences,2021,335.
[3] Gao yunyun. Mobile wireless charger in popularity [J]. Contemporary students, 2020 (19): 16-17.
[4] Peng Rongcai. It's dangerous to keep the charger off for a long time [J]. Rural electrician, 2019,27 (11): 49.
[5] American College of Emergency Physicians; Generic mobile phone chargers escalate risk of burn, electrocution[J]. NewsRx Health & Science,2019.
[6] Zhang Jiaoyang, Yu Haiyang, Ma Xinlong. Design and Simulation of simple mobile phone charger based on Simulink [J]. Electronic world, 2019 (13): 105-109.
[7] Zhang Youyi. Capacitor damage leads to harmonic continuous burning charger [J]. Rural electrician, 2019,27 (04): 48-49.
[8] Yin Jingwen, Lin Jinghu, Jin Yonghao. Fire proof and energy saving mobile phone charger [J]. Application of electronic technology, 2019,45 (04): 131-134.
[9] Yin Jingwen,Lin Jinghu,Jin Yong gao. Fireproof and energy saving mobile phone charger[J]. Dianzi Jishu Yingyong,2019,45(4).