

Development and Verification of Vehicle Environmental Adaptability Test in the Middle East

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Abstract

In recent years, China's automobile industry has witnessed rapid development, with the export volume of automobiles experiencing explosive growth. The Middle East region is one of China's important overseas markets, and its unique vehicle performance and adaptability under road, climate, environment and other conditions have become a key factor for domestic automakers in the process of overseas product development. This article focuses on the research and analysis of the environment, driving scenarios, and user habits in the Middle East region, with the expectation of providing reference for the vehicle adaptability development and testing work in this region.

Keywords

Automobile; Environmental Adaptability Test; High Temperature Environment; Development Verification.

1. Introduction

With the deepening of the "Belt and Road" initiative, the Middle East, as an important cooperation partner of China, has witnessed a significant increase in the number of domestically produced cars exported to the region, and Middle Eastern customers are paying more and more attention to the comprehensive performance of domestically produced cars.

The Middle East is a geopolitical region covering the Arabian Peninsula, Asia Minor, Egypt, Iran, the Levant, Mesopotamia and other parts, with a total area of more than 7 million square kilometers, of which Saudi Arabia is the largest Middle Eastern country. The Middle East spans a wide range of latitudes, with a large difference in distance from the sea, different terrain heights, and diverse terrain types and mountain trends, which has formed diverse regional and climatic characteristics. The diverse environment has many impacts on the performance of the whole vehicle, mainly reflected in the aging of parts, the heat dissipation effect of the power system, oil lubrication and evaporation, power battery safety, and related line safety. In view of this, it is highly necessary to carry out the development and verification of the environmental adaptability of the whole vehicle. This article focuses on the actual conditions of the Middle East, especially Saudi Arabia and the United Arab Emirates in terms of climate conditions, vehicle use scenarios, road characteristics, charging services, user habits, and in-vehicle infotainment systems, in order to provide a reference for the development and verification of vehicle adaptability.

2. Introduction to Automobile Environmental Adaptability Test

2.1. Environmental Adaptability Test Concept

In view of the potential impact that regional differences and changing climate conditions may have on vehicle performance, in order to ensure that vehicles can demonstrate stable and excellent comprehensive performance in all parts of the world, automobile manufacturers will carry out a series of targeted tests and verification activities during the vehicle development process to evaluate the adaptability of vehicles in different natural environments, which are

collectively referred to as vehicle environmental adaptability tests in the industry. Through these tests, manufacturers can proactively identify and address performance fluctuations that may be caused by environmental factors, thereby ensuring the reliable operation of vehicles under various extreme conditions.

2.2. Environmental Adaptability Test Type

The environmental adaptability test of automobiles covers performance tests under a series of extreme conditions such as high temperature, low temperature, high altitude, low altitude, dryness, humidity, rain, ice and snow, desert and corrosive environments. In order to ensure that the car can demonstrate excellent overall performance in various environments and to improve the overall quality of the product and user satisfaction, automobile manufacturers usually conduct these tests that are closely related to the environment before the car is officially launched on the market. In these tests, atmospheric temperature, air humidity and altitude have a particularly significant impact on the overall performance of the car. Therefore, many automobile manufacturers will attach great importance to and conduct high temperature, plateau, and cold tests, namely the "three highs" environmental adaptability tests, during the production and development stage as well as prior to the launch, to conduct comprehensive and in-depth testing and verification of the comprehensive performance of the automobile.

3. Key Points of Adaptive Development in the Middle East

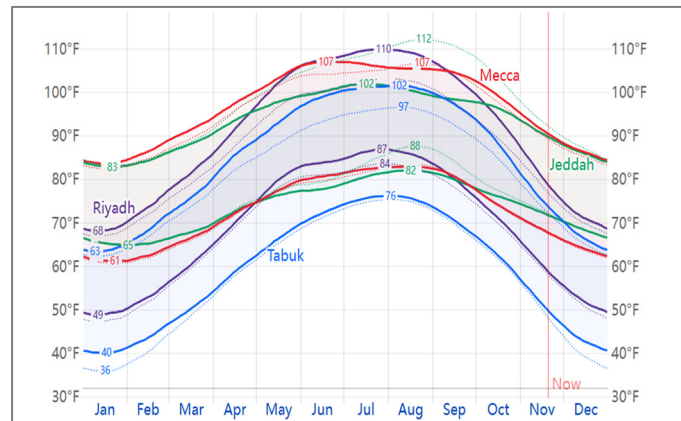
In general, there are three main climate types in the Middle East: tropical desert climate, temperate continental climate, and Mediterranean climate. Tropical desert climate is the most common, with typical characteristics of high average temperature, strong solar radiation during the day, and little precipitation throughout the year. Due to the geopolitical risks in the Middle East all year round, for safety and testing requirements, domestic mainstream automakers have chosen to conduct vehicle adaptability tests in the Kingdom of Saudi Arabia and the United Arab Emirates (UAE).

3.1. High Temperature Environment Adaptability Development

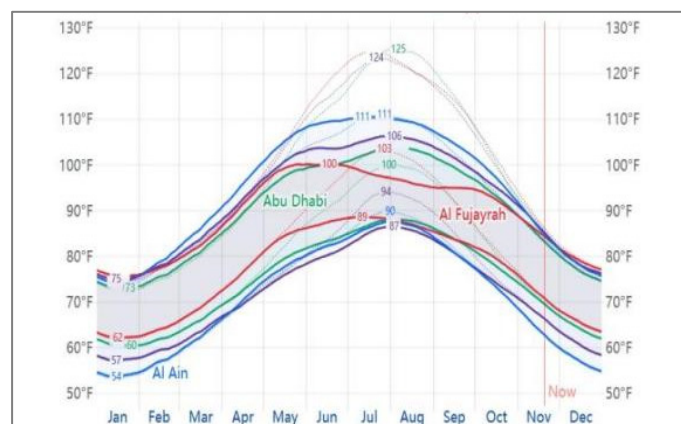
3.1.1. High Temperature Environment Analysis

Saudi Arabia and the United Arab Emirates both have tropical desert climates with high annual average temperatures. However, Saudi Arabia is hot and dry in summer, mild in winter, and has an average annual rainfall of no more than 200 mm. Representative cities include Riyadh, Jeddah, and Dammam, with the highest summer temperature reaching over 50 °C. The United Arab Emirates is hot and humid in summer, with high humidity and strong solar radiation, a maximum temperature of 51°C, and a mild winter climate. Representative cities include Abu Dhabi, Dubai, and Al Ain.

Figure 1 shows the monthly average temperature data of major cities in Saudi Arabia and the United Arab Emirates over the past 10 years. As shown in Figure 1(a), the monthly average temperature in Riyadh and Jeddah from May to September is above 35°C, and the monthly average temperature from June to August is above 37.8°C. As shown in Figure 1(b), the monthly average temperature in Abu Dhabi, Al Ain, and Dubai from May to September is also above 35°C, and the monthly average temperature from June to August is above 40°C. Therefore, automobile adaptability tests in the Middle East are generally scheduled between mid-June and the end of August, with a few scheduled in May and September.



(a) Saudi Arabia's monthly average temperature over the past 10 years



(b) Monthly average temperature in the UAE over the past 10 years

Figure 1. Average monthly temperatures in Saudi Arabia and the United Arab Emirates over the past 10 years

3.1.2. Analysis of the Impact of High Temperature Environment on Vehicle Performance

In a high-temperature environment, the temperature rises quickly and is difficult to decrease. Therefore, how to quickly reduce the temperature inside the car under high temperature and maintain it at a relatively comfortable level is an important consideration in the development of automotive air-conditioning performance. For fuel vehicles and hybrid vehicles, high temperatures cause the intake air temperature and fuel temperature to rise, affecting the engine's output power and thus affecting the vehicle's power performance. For hybrid and pure electric vehicles, high temperature will also affect the charging and discharging power and thermal management performance of the power battery. In addition, the non-metallic materials used in automobiles will also suffer from aging problems under high temperature conditions, and the materials in the car will also emit harmful aldehyde substances.

In short, high temperature conditions have a significant impact on the vehicle's power performance, safety performance, refrigeration performance, thermal management performance, braking performance and other properties. Therefore, the development of automotive high-temperature environment adaptability in the Middle East is particularly important.

3.2. Driving Environment Adaptability Development

In addition to the high temperature environment, the actual driving environment in the Middle East is also different from that in China in many aspects, such as fuel quality, the layout of

charging piles, traffic signs, road environment, lane markings and local users' driving habits. This section will briefly introduce various aspects of the driving environment in Saudi Arabia and the UAE.

3.2.1. Passenger Car Emission Standards

The Middle East has more than 50% of the world's oil reserves and is rich in energy resources. Therefore, the environmental protection and automobile emission regulations of various countries are often not as strict as the emission standards of the EU and China. Except for developed countries such as Saudi Arabia and the United Arab Emirates, the overall progress is relatively slow. In most regions, the gasoline grades are synchronized with the international standards, but some regions still have some low-grade gasoline, such as 91 octane gasoline. However, in recent years, the Middle East has also attached more and more importance to environmental protection issues, and some countries and regions are also stepping up efforts to improve oil quality and emission standards.

3.2.2. Charging Station Type

In recent years, the Middle East has gradually realized the urgency of energy transformation, and has announced national energy transformation strategies. New energy-related industries are developing rapidly. As illustrated in Table 1, by 2024, the UAE will have about 620 charging stations, of which fast charging accounts for about 32% and slow charging accounts for about 68%. They are basically concentrated in public places, shopping malls, office buildings, residential areas and highway service areas. It is expected to reach 1,000 by 2025. Saudi Arabia has a relatively small number of charging stations, about 100, of which fast charging accounts for about 16% and slow charging accounts for about 84%, and the damage rate of charging piles is extremely high. In addition, Saudi Arabia's current charging stations are mainly concentrated in large cities such as Riyadh and Dammam. In October 2023, the Saudi Public Investment Fund (PIF) and the Saudi Electricity Company (SEC) announced the establishment of an electric vehicle infrastructure company and planned to install 5,000 fast charging piles in more than 1,000 locations by 2030. The charging stations in Saudi Arabia and the UAE involve multiple brands, including but not limited to: Tesla, ABB, ChargePoint, Siemens, Efaced, EVBox, Wanbang Digital Energy Co., Ltd, etc.

Table 1. Statistics of charging piles in Saudi Arabia and the United Arab Emirates

nation	Charging stations	Fast charging ratio	Slow charging ratio
United Arab Emirates	620	32%	68%
Saudi Arabia	100	16%	84%

3.2.3. Special Traffic Sections

Saudi Arabia and the United Arab Emirates are both home to deserts, plateaus, mountains and other terrains. Therefore, there are large differences in topography in some areas, and there are many long, straight, steep slopes, and large-span speed bumps, as shown in Figure 2. These roads have a significant impact on the braking performance, power performance, refrigeration performance, and intelligent driving of the vehicle. In addition to the impact of the high temperature environment, they should be considered as the key factors in the adaptability test. Long straight and steep road : The uphill and downhill sections of Taif Mountain Road in Jeddah, Saudi Arabia, have an altitude difference of about 2,500 meters, about 80 bends, ups and downs of about 55 kilometers, the maximum slope can reach 20%, and the average slope of the mountain road is 8%. Another is the mountain road in Ras Al Khaimah, UAE, with an altitude difference of about 1,700 meters, about 40 bends, ups and downs of about 25 kilometers, the

maximum slope can reach 15%, and the average slope of the mountain road is 5%. The speed limit at the foot of Taif Mountain is 80km/h, and the speed limit is 30km/h when approaching the mountain bends.

Large-span speed bumps: Saudi Arabia has a dense coastal road surface with raised speed bumps . There are road raised speed bumps every 800 meters or so along the more than 10 kilometers of coastal roads (the speed bumps are about 200mm high, 800mm wide, and span the entire road) . Most of the speed bumps are made of concrete, so they are basically forced to slow down . In addition, there are no warning signs at the speed bumps and no warnings on the ground. It is not easy to observe in advance, which can easily cause sudden deceleration or forced driving over the speed bumps. For vehicles with small ground clearance, it is easy to cause bottoming, and bottom protection should be considered during the development process. In addition, such speed bumps with weak signs also have a certain impact on intelligent driving solutions.



Figure 2. Illustration of some mountain roads and speed bumps in Saudi Arabia and the United Arab Emirates

3.2.4. Special Traffic Signs and Lane Markings

Traffic signs and traffic signs in Saudi Arabia and the United Arab Emirates are relatively complete and similar to domestic road traffic signs. Most roads use clear signs and markings to indicate driving direction, speed limit, road conditions and other information. However, some urban roads in Saudi Arabia have problems such as unclear lane lines, speed limit signs in Arabic, and white circular ground nail lane lines, as shown in Figure 3. Original Equipment Manufacturers should take this into consideration when developing intelligent driving solutions.



(a) Arabic language logo (b) Highway speed limit signs (c) “Ground spike” lane markings

Figure 3. Schematic diagram of some roads in Saudi Arabia

3.2.5. Special Driving Habits

Popular vehicle types in Saudi Arabia and the UAE include sedans, SUVs, full-size large SUVs and pickup trucks. The Middle East accounts for about 30% to 35% of the global oil production, and the local oil price is lower than that in China. Therefore, most drivers in the Middle East are accustomed to driving aggressively, and when performing operations such as overtaking, they

almost use full throttle to reach the desired speed as soon as possible. When driving at high speeds, the following distance is very close, there is no defensive driving habit, and the frequency of horn use is high. Some drivers choose to refuel when the vehicle is in the starting state. In addition, due to factors such as high temperature, the frequency of use of openable sunroofs is very low.

3.2.6. In-vehicle Infotainment Systems and Other Special Situations

The communication signals in Saudi Arabia and the UAE are mainly 4G/5G. In Saudi Arabia, STC, Zain and Mobily are the main communication operators, among which STC occupies more than half of the market share, showing its leading position in the Saudi communication market. In the UAE, the two operators, Etisalat (now branded as e&) and du, occupy the vast majority of the market, with a combined share of more than 97.5%.

According to overseas market research, the mainstream multimedia in-vehicle apps in Saudi Arabia include Carplay, DAB, Radio, etc., and Google Maps is mostly used for navigation.

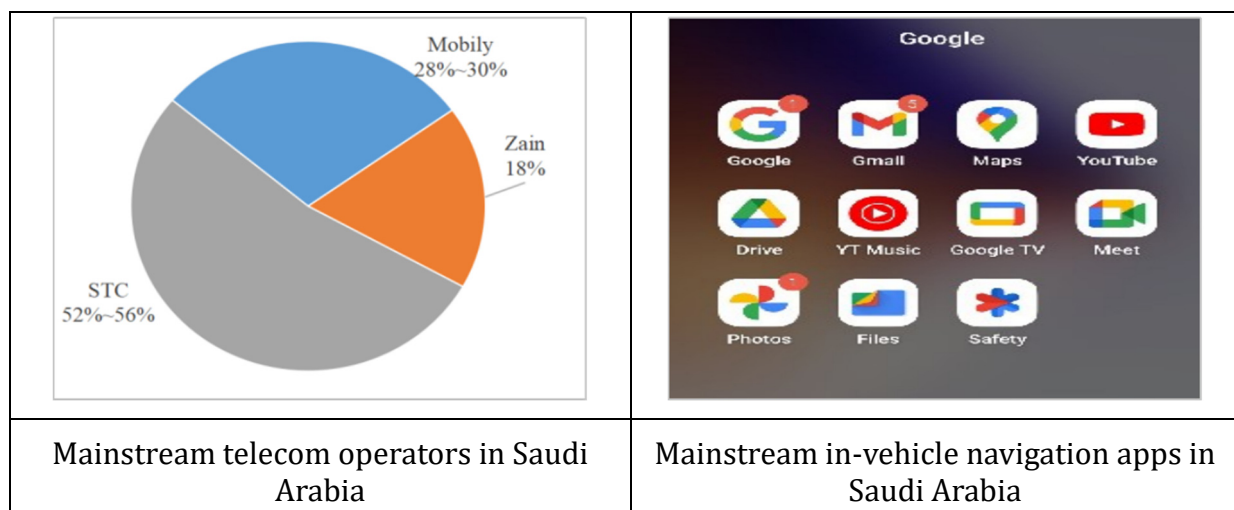


Figure 4. Mainstream telecom operators and in-vehicle navigation apps in Saudi Arabia

4. Comparison with the Domestic Environment

Table 2. Comparison of High Temperature Environments between China and the Middle East

environment	nation	area	Climate conditions	Topographic features
High Temperature	China	Turpan	28-48 °C (temperate continental climate)	dominated by basins with low altitude
		Hainan	28-32°C (tropical monsoon climate)	mountains and hills with not high altitude, averaging more than 100 meters
		Yuanjiang	23-34°C (low-latitude plateau monsoon climate)	the terrain is complex and diverse, with the highest altitude at 2,580 meters
	middle East	Saudi Arabia	36-51°C (tropical desert climate)	deserts, plateaus, mountains, etc., with a local elevation difference of up to 2,500 meters
		United Arab Emirates	32-50°C (tropical desert climate)	plains, mountains and depressions, with a local elevation difference of up to 1,700 meters

Adaptability tests for high temperature environments have been conducted in many areas in China, such as Turpan, Hainan and Yuanjiang. As illustrated in Table 2, it can be seen that in

terms of temperature conditions, the Turpan area in Xinjiang, China is similar to Saudi Arabia and the United Arab Emirates, but the extreme temperature in Turpan is slightly lower than these two. In terms of topography, the main high-temperature test areas in China are at a lower altitude than Saudi Arabia and the United Arab Emirates. It is worth noting that the climate characteristics of Saudi Arabia, the United Arab Emirates and other Middle Eastern regions seem to combine the characteristics of Yuanjiang and Turpan, that is, these areas may experience both high temperature and high humidity, and may also encounter high temperature and dry environments. In some areas, only a few dozen kilometers apart, two completely different climatic conditions, high temperature and high humidity and high temperature and dryness, may exist at the same time.

5. Conclusion

As a key link in measuring the comprehensive performance of automobiles, the automobile environmental adaptability test is not only crucial to ensure products meet customer needs and improve automobile quality, but also plays an important role in enhancing market competitiveness. With the rapid rise of my country's independent automobile brands on the international stage, overseas exports continue to rise, which puts higher requirements on the environmental adaptability of automobiles. This article focuses on overseas vehicle adaptability tests, especially for Saudi Arabia and the United Arab Emirates, two representative countries in the Middle East, and deeply analyzes the unique characteristics of their natural environment and driving environment, and compares their high temperature conditions and road characteristics with those of the main test sites in China.

In summary, the Middle East, with its vast territory and diverse climatic conditions, has fostered a rich and varied environmental landscape, which has posed a more severe challenge to China's automobile export products, and has also pointed out the direction for further improving the global adaptability of China's automobiles. In the future, in-depth research on the environmental characteristics of target export countries will be an important topic for China's automobile industry to continually expand overseas markets and enhance international competitiveness.

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