



# Research on Durability Test for Composite Pipe Fitting Materials of Automobile

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**Abstract.** The automobile industry is one of the most promising industries in China. The increase of the number of vehicles is accompanied by the increase of traffic accidents. Therefore, the application of composite pipe materials has a broad prospect and become the basis of the automobile industry. In this paper, the durability of the composite material is tested, and it is used in the manufacture of stainless steel pipe fittings of automobile, which can produce low-cost, high-performance and ideal automobile parts. The application of the composite material in automobile field can effectively improve the production efficiency and use efficiency.

**Keywords:** Automobile industry · Composite pipe fitting materials · Durability · Research

## 1 Introduction

It has been proved that the car was invented in 1976, although it is quite controversial. Since 1885, the invention of diesel engine, through the unremitting efforts of engineers and designers, can be said that the automobile industry has become the largest automobile industry in the world. The most complex industry.. the sustainable development of the industry needs to consider the factors of price, performance, safety, market demand, etc. from the distribution diagram of automobiles, it can be seen that the automobiles owned by every 1000 people are not only the needs of human production and life at present, but also the demand for automobiles in the future will increase greatly. With the rapid decline of automobile price and the increase of per capita income, the development of automobile industry is faster and faster. In these areas, the ecological environment is relatively different in China's national economic level and per capita income level. People's consumption of automobiles has gradually shifted from developed areas such as Beijing, Shanghai and Guangzhou to sub developed areas [1]. At present, there are fewer car owners in many coastal areas than in Beijing, but the per capita income of these areas does not affect the future development of the automobile industry. The population of these areas is far higher than that of Beijing, nearly 300 million, which is equivalent to that of developed areas.

Nowadays, the automobile industry is getting better and better, and people's consumption concept is also changing. China's automobile market has entered the new

normal of “micro growth”, and it is in urgent need of macro-control economy. The saturation of the primary and secondary markets and the change of consumer mentality have led to the golden age of double-digit growth in automobile sales. The most important thing is that the existing automotive energy absorption pipe is metal energy absorption box. Ordinary metal materials are usually very heavy, mainly rely on plastic deformation metal materials to manufacture and absorb energy, but their energy absorption rate is low, which can not meet the development trend of lightweight and safety of automobile. We must spend the most time to apply the capable materials to lay the foundation for the production of automobiles. Therefore, the price of composite pipe fitting materials is getting higher and higher, which has attracted attention in this field.

## 2 Research on Durability Test for Composite Pipe Fitting Materials of Automobile

The definition of composite pipe fittings is to establish an isotropic material model through the constitutive model of metal materials (elastoplastic material) and its failure theory. The composite pipe is developed and produced by few manufacturers, and it is widely used abroad [2]. The technical parameters of the composite pipe material are shown in Table 1.

**Table 1.** Technical parameters of the composite pipe material

Parameter	Fitting
Torus bending strength	$\geq 180$
Circular bending modulus of elasticity	$\geq 13$
Axial bending strength	$\geq 180$
Axial bending modulus of elasticity	$\geq 10$
Cyclic tensile strength	$\geq 130$
Elastic modulus of cyclic tensile	$\geq 13$
Axial tensile strength	$\geq 130$
Axial tensile elastic modulus	$\geq 13$
Fracture ELongation	$\geq 0.25$

The durability of the composite pipe material is reflected in the following points:

- (1) Excellent corrosion resistance and long service life  
The pipe fitting material has good corrosion resistance of many chemical fluids such as acid, alkali and salt. It can transport drinking water, rainwater, sewage and many chemical fluids. The designed service life is 50 years.

- (2) Excellent characteristics  
The composite pipe material has a smooth inner wall and a roughness coefficient of 0.0084. Automotive materials often suffer from the localized corrosion and become rougher, while composite pipe materials always maintain a smooth surface [3].
- (3) Health and safety, no pollution  
The composite pipe material used in the car is made of food grade materials and is hygienic and safe. The inner surface of the composite pipe fitting material is smooth, no scaling and no corrosion, and no secondary pollution to the water quality [4]. Metal or PCCP pipes will produce rust water over time, polluting water quality.
- (4) Good heat and frost resistance  
The temperature of the composite pipe material is generally between  $-40\text{ }^{\circ}\text{C}$  and  $70\text{ }^{\circ}\text{C}$ ; the composite pipe material made of special resin can be used up to  $120\text{ }^{\circ}\text{C}$ ; the composite pipe material has a small thermal expansion coefficient, and the thermal expansion coefficient of PE pipe is about 8 times of the composite pipe fitting materials [5, 6].
- (5) Good electrical and thermal insulation  
The composite pipe material is non-conductor, the pipe has good insulation and the heat transfer coefficient is small, so the heat preservation of the pipe is good with few heat loss [7, 8].

Different types of composite pipe materials have different properties and indicators, as shown in Table 2.

**Table 2.** List of indicators and specifications

Pipediameter (mm)	Wall thickness (mm)	Weight (kg/m)
68	9	11.75
70	10.5	13.48
73	9	12.12
76	7	13.25

At the same time, the composite pipe material and the metal pipe material are also very different in performance, as shown in Table 3.

**Table 3.** Performance comparison between composite pipe fittings and metal pipe fittings

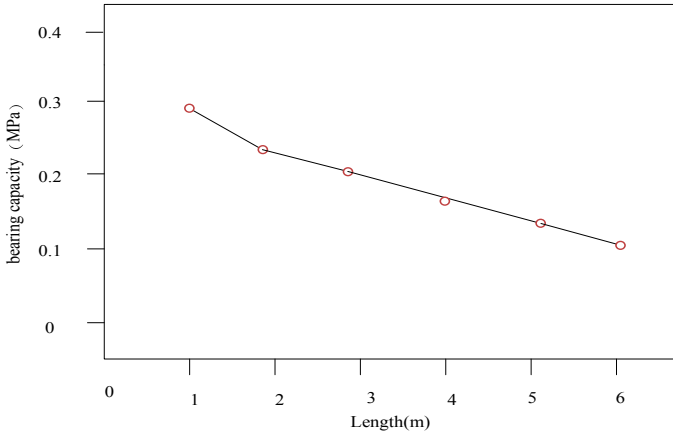
Comparison program	Metal pipe fitting material	Composite pipe fitting material
Designability	Isotropy	Anisotropy
Intensity	Low	High
Corrosivity	Poor corrosion resistance	No sign of corrosion
Flexible life	300–500	>10000
Wall signal line	Unachievable	Achievable

The composite pipe fittings with different lengths have different bearing capacities. The shorter composite pipes are reduced in thickness while increasing the thickness at both ends, which not only facilitates the connection with other composite pipes, but also satisfies the requirements of bearing, has certain operability and saves the cost of fittings.

It is assumed that the bearing capacity of the composite pipe fittings is  $P$ , the elastic modulus is  $E$ , the longitudinal moment of inertia is  $u$ , the length is  $L$ , and the thickness is  $D$ . Then:

$$P = \frac{2E}{1-u} \left( \frac{D}{L} \right) \quad (1)$$

When the thickness of the composite pipe is constant, the effect of the length on the bearing capacity is shown in Fig. 1.



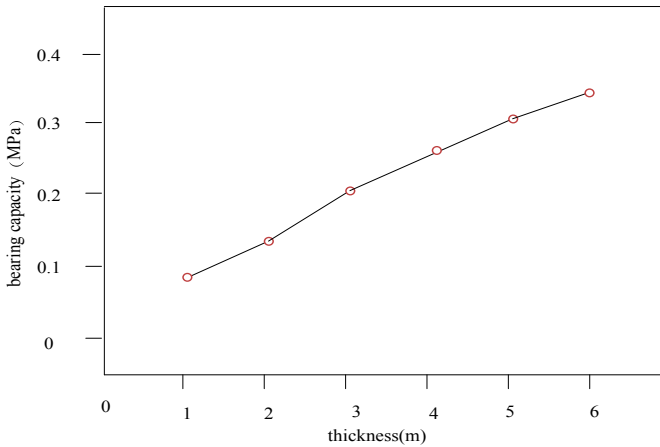
**Fig. 1.** Effect of the length on the bearing capacity of composite pipe fitting

It can be seen from the figure that as the length of the composite pipe is increased, the bearing capacity is gradually reduced and slowly decayed.

When the length of the composite pipe is constant, the effect of thickness on the bearing capacity is shown in Fig. 2.

It can be seen from the figure that as the thickness of the composite pipe is increased, the bearing capacity is gradually increased to become a slowly rising state [9, 10].

Therefore, the method of reducing the length of the pipe and increasing the thickness at the joint can ensure the bearing capacity and is also convenient to use.



**Fig. 2.** Effect of thickness on the bearing capacity of composite pipe fitting

The composite pipe material is characterized by light weight, smooth inner wall, low resistance and good corrosion resistance [11, 12]. The composite pipe adopts the international advanced composite material [13, 14]. The composite pipe has better thermal insulation performance, the inner and outer walls are not easy to corrode, the inner wall is smooth, and the resistance to the fluid is small; and because it can be bent at will, the installation and construction are convenient [15]. As an auto parts, composite pipe fittings have sufficient strength. This unique process has high production efficiency, easy process control and high composite quality.

### 3 Test Analysis

Computer simulation technology is widely used in various aspects of national defense, industry and other human production and life. The ultrasonic detection based on computer simulation technology is a commonly used technique for pipe fitting detection. It is the nature of the acoustics transmitted by ultrasonic waves, and the properties or characteristics of the pipe itself are tested to judge the durability of the pipe. The system chart of the ultrasonic detector is shown in Fig. 3 (Fig. 4).

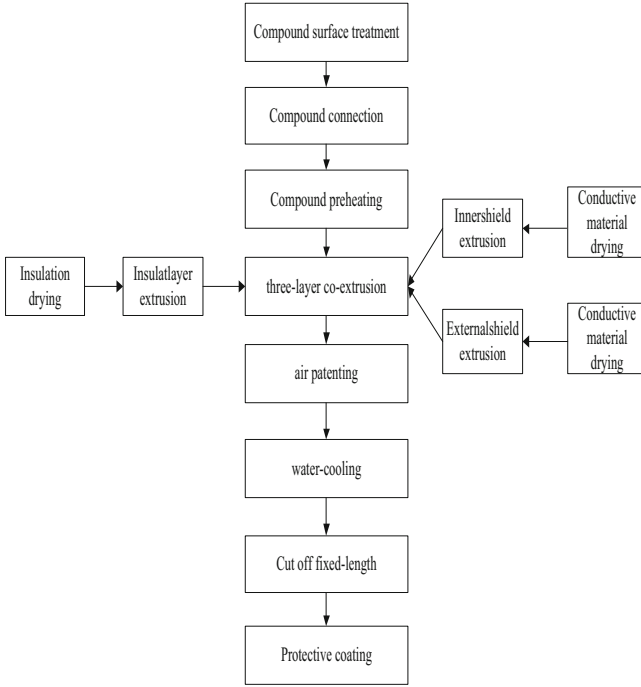


Fig. 3. Production process of composite pipe material

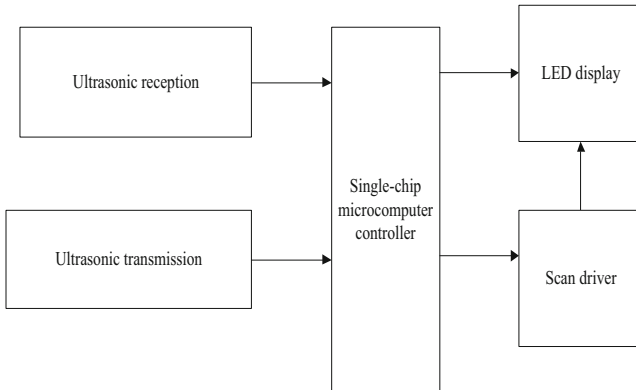


Fig. 4. System chart of the ultrasonic detector

Ultrasonic testing program:

```

Begin                //Set baud rate

pinMode(ting,OUTPUT); //Connect the pins of SR04
pinMode(echo,INPUT);  //Set input status

Serial.println("ultrasonic sensor");

digitalWrite(ting,LOW); //Generate a 10US high pulse to trigger Trigpin

delayMicroseconds(2);

delayMicroseconds(10);

digitalWrite(ting,LOW);

const int ting=2;    //Set SR04 to connect to Arduino
const int echo=3;    //Set SR04 to connect to Arduino
float distance;      //Define a floating point variable

void setup()

sbit Tr = P2^0;      //Ultrasonic trigger
sbit Ec = P2^1;      //Ultrasonic output
sbit key = P2^4;     //click the button
sbit encC = P2^5;    //38 decoder
sbit encB = P2^6;
sbit encA = P2^7;    //P0 port digital tube

                        //Defining variables

float L = 0;        //Distance length (mm)

unsigned char code LED[] = {0x3F, 0x06, 0x5B, 0x4F, 0x66, 0x6D, 0x7D, 0x07,
0x7F, 0x6F}; //Function declaration

Serial.print(distance);

Serial.print("cm");

```

```
serial.println();

while(!Ec);           //Wait high level

TR0 = 1;              //Open timer

while(Ec);           //Wait low level

TR0 = 0;              //Turn off the timer

void ultInit();       //Ultrasonic initialization

void ultStart();      //Ultrasonic trigger

void count();         //Calculate the distance

void show();          //Display distance on the screen

void delay();         //Delay function

P0 = LED[(int)L%10];

encC = 0; encB = 1; encA = 1;

P0 = LED[(int)L/10%10];

encC = 0; encB = 1; encA = 0;

P0 = LED[(int)L/100%10];

encC = 0; encB = 0; encA = 1;

P0 = LED[(int)L/1000%10];

encC = 0; encB = 0; encA = 0;

Serial.print(distance);

Serial.print("cm");

serial.println();

distance=outcomeH;    //The upper 8 bits of the measurement result
```

```

distance<<=8;      //The upper 8 bits put in the 16-bit
distance=distance|outcomeL;      //Combine with the lower 8 bits to become
16-bit result data
distance*=12;      //Because the timer defaults to 12 division
distance/=58;

Serial.print(distance);

Serial.print("cm");

serial.println();

void exter()

interrupt 0      // External interrupt is 0
outcomeH =TH0; //Take the value of the timer out
outcomeL =TL0; //Take the value of the timer out

End

```

It's assumed that the composite pipe length is  $L$ ,  $R$  is the mid-surface radius, and  $U$  is the pressure resistance.

$$\varepsilon_1 = \frac{X}{L} - \frac{Y}{L} \quad (2)$$

$$\varepsilon_2 = \frac{r}{L} \quad (3)$$

$$U = \int \int \int \left[ \varepsilon_1 + \varepsilon_2 + 2t\varepsilon_1\varepsilon_2 + \frac{1-t}{2}r \right] dt \quad (4)$$

The test was carried out by the above formula, and the result is shown in Fig. 5.

It can be seen from the figure that in the same time, the compressive capacity of the composite pipe material used by the automobile is much higher than that of the conventional material, and the higher the pressure resistance, the higher the durability.

The pipe produced under the condition of energy saving, non-toxic and non-polluting equipment is a new environmentally friendly product. There are no special requirements for water, electricity, gas and raw materials used in production, which is easy to solve in China. In the production process, no water is needed, which reduces the consumption and pollution of water; the product has the characteristics of good durability, corrosion resistance, convenient connection and firmness, which prolongs

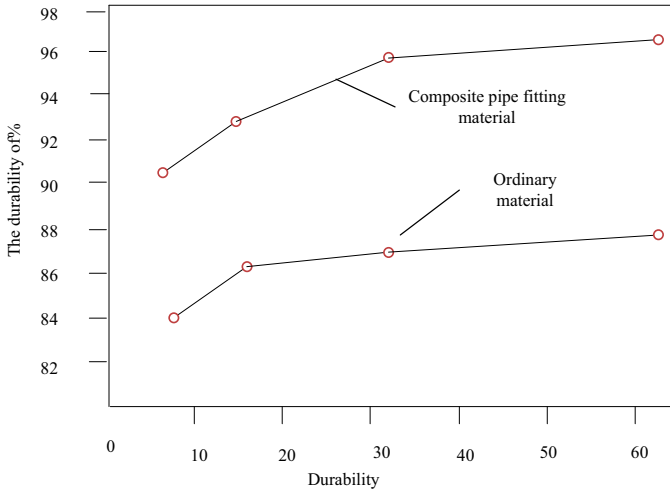


Fig. 5. Durability of two materials for automobiles

the service life of the structure and broadens the adaptability of structure to the environment, thus saving material consumption, manpower and material resources, reducing resource consumption. After the waste is crushed and processed, it can be recycled as raw materials without polluting or burdening the environment. Therefore, in this project, the (3R principle) eco-industrial characteristics such as “reduce” of resources, “reuse” of waste and “recycle” of pollutant discharge are fully reflected in this project. In the production process, no waste water (no water in the production process) and waste, a large amount of water is needed in the process of producing ordinary pipes, and clean production and environmentally friendly production are realized.

Compared with metal pipe fittings, composite pipe fittings have great advantages in terms of corrosion resistance and bending degree. Therefore, we should wait for the application of composite pipe fittings in the automotive industry. There are still many problems in the research of composite pipe fitting materials in the automotive industry. Although progress has been made, the latter research and testing will be strengthened. It is recommended that manufacturers can learn from foreign research results and technical means of composite pipe fitting materials, learn from each other’s strengths, and promote the rapid development of China’s automobile industry.

#### 4 Conclusions

In order to reduce the occurrence of accidents, the conclusion of this study is: on the one hand, the government must establish strict automobile safety performance standards; on the other hand, automobile manufacturers should take measures to pay attention to the quality of products, especially in terms of crashworthiness and durability, composite pipe materials can improve the durability of automobiles, while

reducing the weight of automobiles. In general, China's automobile industry still has a lot of room for development, and composite pipe will play a great role in the specific application field of the automobile industry in the future.

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