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Relationship between Energy Consumption and Speed of the EMU

Hai-Bo ZHAO
CRRC Changchun Railway Vehicles Co., Ltd, Changchun,130000,China
email: zhaohaibo@cccar.com.cn

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Abstract. This paper analyzed the relationship between the application of EMU and energy consumption ; on the basis of introducing the EMU at home and abroad in detail in this paper, the analysis were done from traction fields and the comparisons of relationship between operation mileage of the EMU , time, speed, and energy consumption were finished . The optimal matching between the application of EMU and the energy consumption relation was obtained.

Introduction

In recent years the rapid development of the railway passenger transportation in our country, the demands for high speed passenger transportation cars and transportation facilities are increasing . In order to adapt to the development of market economy , meet the demand of labor force and population flow and keep the railway passenger transportation in the dominant position in the carriage of passengers, chosing high speed, safe, energy -saving, comfortable railway passenger transportation EMU is necessary. Reasonable selection of the EMU has important significance to save energy, improve the efficiency of transportation, relieve the strain on the car, reduce operating costs, improve equipment level of railway transportation and the social material civilization. Will also lead to the raw material (aluminum alloy) processing industry, electrical appliances and development of rail transportation and related industries, and become a new growth point of economy development. In order to reduce operation costs, the design of the foreign railway vehicles is designed to use their own special railways at present, this is not fit in with our national condition. On the base of analysing the EMU at home and abroad and from the Angle of energy，the optimal matching relationship between consumption of the EMU operation mileage and the operating time was analysed , thus achieved the purpose to reduce the energy consumption at the optimal speed and time[1][2].

The main parameters and application situation of EMU

1)EMUs in China are divided into diesel EMUs and distributed-power EMUs ,now the EMUS mainly refers to the power EMUS, now the running EMUs are:

2)CRH1 , which operation speed is 200 ~ 250 km/h.

3)CRH2 , which operating is 200 ~ 300 km/h.

3)CRH3 , which operation speed is 300 ~ 330 km/h .

4)CRH5 , which operation spees is 200 ~ 250 km/h.

5)CRH380, which urrently operation speed is 300 ~ 350 km/h.

The train whose speed is 200 or 300 km/h can run on the modified common railways, but when the speed reaches to300 km/h and higher, the EMUs must run on special strengthening high speed railway.

Table 1. The main parameters of CRH

Modle	CRH1	CRH2	CRH3	CRH5	CRH380BL	CRH380CL
Group	5M3T	6M2T	4M4T	5M3T	8M8T	8M8T
Length(m)	200	200	200	200	400	400
Vehicle weight (t)	470	440	490	493	1000	1000
Capacity (people)	670	610	794	608	1050	1050
Highest speed(km/h)	250	300	300	300	350	350
Total power (kw/column)	5500	4800	8800	5500	18400	19200

The comparison of CRH traction characteristic

Now choosing traction characteristics according to the characteristics of the traction motor, there are a few key points, namely, vehicle weight, start the traction, start acceleration, basic running resistance, constant power turning point, rated power, residual acceleration at high speed and so on, these are related to energy consumption. These are related to energy consumption. EMU traction characteristic curves under different speed levels are showned in figure 1.

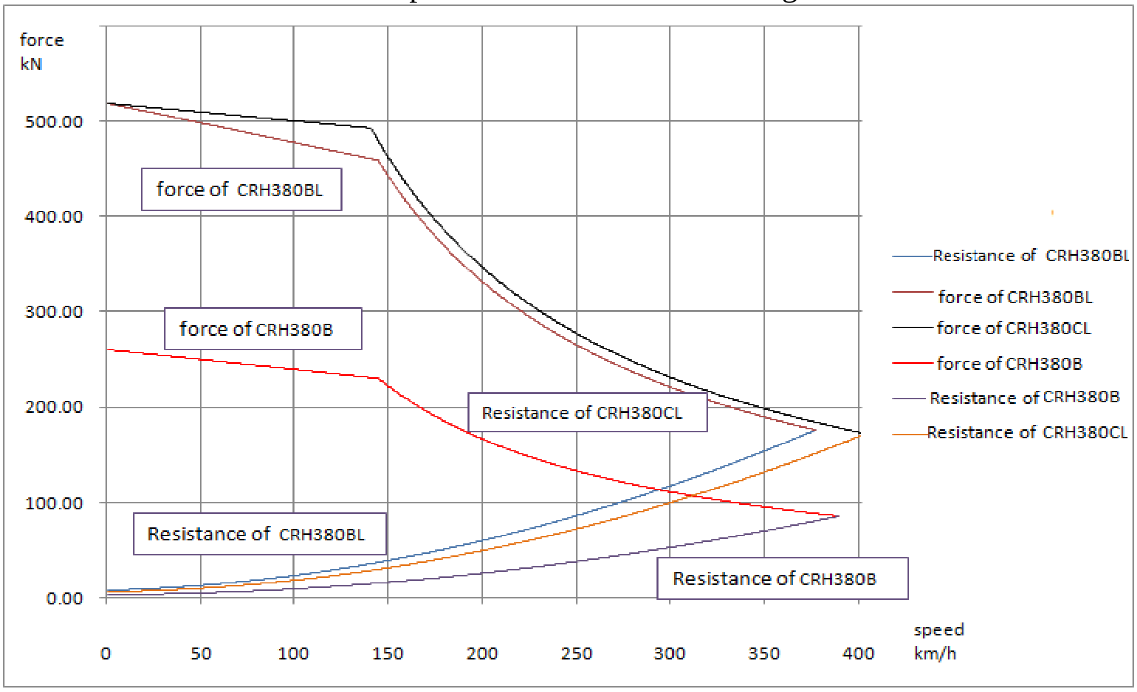

Figure 1. Traction characteristic curve of CHR

TABLE 2 TRACTION CHARACTERISTIC KEY PARAMETERS OF CHR

Models	CRH380B	CRH380BL	CRH380CL
marshalling weight (t)	522	1037	1058.4
starting traction (kN)	260	520	520
starting acceleration (m/s²)	0.49	0.49	0.49
basic running resistance	$3699.5+36.73*v+6.65*v^2$	$7680.6+192.554*v+13.5*v^2$	$5523.7+97.16*v+12.45*v^2$
turning point of constant power(km/h)	144	144k	140
total power（kw/column）	8800	18400	19200
residual acceleration(m/s²)	0.05	0.05	0.05

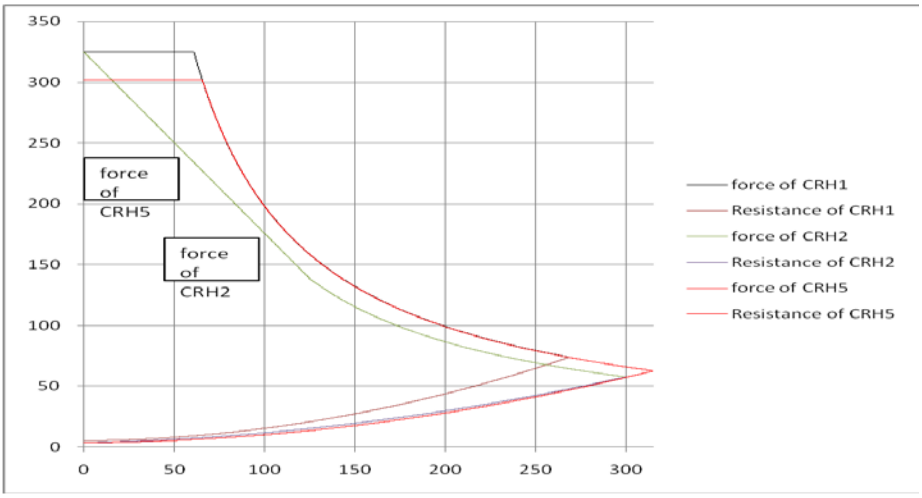

FIGURE 2. TRACTION CHARACTERISTIC CURVE OF 250 KM/H CHR

TABLE 3 TRACTION CHARACTERISTICS KEY PARAMETERS OF 250 KM/H HARMONY EMU

Models	CRH1	CRH2	CRH5
marshalling weight (t)	474	440	474
starting traction (kN)	325	325	325
starting acceleration (m/s²)	0.6	0.6	0.6
basic running resistance	5200+37.2*v+11.877*v²	3797.2+32.1*v+0.49*v²	5200+37.2*v+11.877*v²
turning point of constant power(km/h)	61	125	65
total power（kw/column）	5500	4800	5500
residual acceleration(m/s²)	0.03	0.06	0.07

The relationship between energy operators and operating hours

In the condition of traction, the power supply of EMU is AC 25kV 50Hz.In the condition of braking, it uses regenerative braking to feed back the energy to ac power grid[3][4].

The premises of the analysis are as follows: the EMU is on the straight line of 100 kilometers, starting-constant running at the highest speed-braking. In the whole operation process it does not take into account the driver control forms, gradient resistance, curve resistance and so on, during deceleration the maximum deceleration acceleration is $-1.0m/s^2$, ignore the parking of the air braking effect[4][5].

Table 4 Main characteristics key parameters of EMU

	CRH1	CRH2	CRH5	CRH380B	CRH380CL	
design weight	474	440	474	523	1058.4	t
tractive power	5500	4800	5500	8800	19200	kW
maximum velocity	250	250	250	350	350	km/h
running resistance(250km/h)	65	42	41	70	133	kN
time(0~250km/h)	404	342	315	487	440	s
distance(0~250km/h)	21	17	15	33	29	km
tractive energy consumption (0~250km/h)	618	456	482	1245	2346	kW.h
time(250km/h~0)	84	88	90	125	139	s
distance(250km/h~0)	3.2	3.4	3	6	7	km
renewable energy(250km/h~0)	(116)	(106)	(123)	(282)	(611)	kW.h

Conclusion

Compare the above analysis shows that the same level of speed EMUs running time per one hundred kilometers is basically the same, but the energy consumption of different EMU (equivalent to 8 grouping) is different. Shown in table5:

Table 5 The energy consumption of different EMUs

		CRH1	CRH2	CRH5	CRH380B	CRH380CL
100Km	**Energy consumption (kw.h)**	1865	1222	1274	2126	2096
	time(m)	27	27	27	20	20
200Km	**Energy consumption (kw.h)**	3694	2478	2412	41879	3834
	time(min)	51	51	51	36	36
500Km	**energy consumption (kw.h)**	9054	6026	5967	9912	9387
	time(min)	121	121	11	94	92
1000Km	**energy consumption (kw.h)**	18234	17518	11679	19349	18418
	time(min)	236	239	241	172	172

From the table above can get the following conclusion:

1)In the 250km/h level EMU, the energy consumption of CRH2 and CRH5 is basically the same. In the 350km/h level EMU, CRH380CL EMU consumes the least energy.

2) Different speed levels of EMU on the same line, 250km/h level EMU elapsed time is 26 minutes per hundred kilometers. It spent more than 350km / h EMU level five minutes. But the difference in energy consumption is very large, reaching 50% or higher.

3) The distance is about one hundred kilometers between two stations, such as the inter-city lines need a large volume of short circuits, suitable for locomotive speed of 250km / h speed level EMU. This speed level EMU have small impact on the line. The costs of line maintenance are significantly reduced, saving much energy up.

4) The distance is longer or about 1000 kilometers between two stations, such as Beijing-Harbin line, Beijing-Shanghai line and other lines, in order to save travelers the time of travelers, suitable locomotive speed is 350km / h speed level of EMU. The speed level of EMU (maximum axle load is about 16 tons) have small impact on the line, The costs of line maintenance are significantly reduced (compared to the locomotive of more than 20 tons axle load), considering from the concept of green, do more contribution to society.

5) The basic resistance of the train will determine the energy consumption of the vehicle, so the following train design process need to consider the aerodynamic focusing problems and then lower the minimum basic resistance, to achieve the purpose of reducing energy consumption.

Concluding remarks

Based on the description and analysis of main parameters of home and abroad EMU, focused on the domestic Harmony EMU in the condition of different operating mileage and different speed, compared and analyzed their energy consumption, the paper made the most optimal matching in four areas (operation mileage, hours of operation, operating speed and energy consumption), provide a basis to achieve high speed, economy, saving energy and safety of high-speed railway passenger transport.

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