Power consumption for alternative maglev systems

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Two alternative systems for a high speed train are being developed in W. Germany, namely, the electrodynamic system of levitation utilising superconducting magnets and the long-stator synchronous motor for propulsion (e.d.s.), and the electromagnetic attraction system of suspension using controlled electromagnets combined with either the short-stator linear induction motor or the long-stator synchronous motor for propulsion (e.m.s.).

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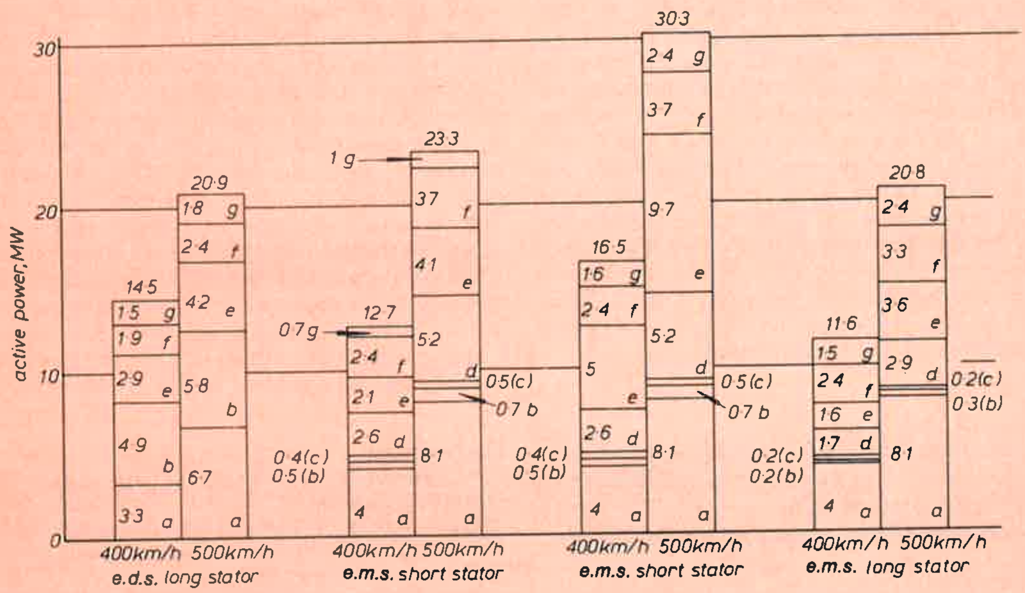
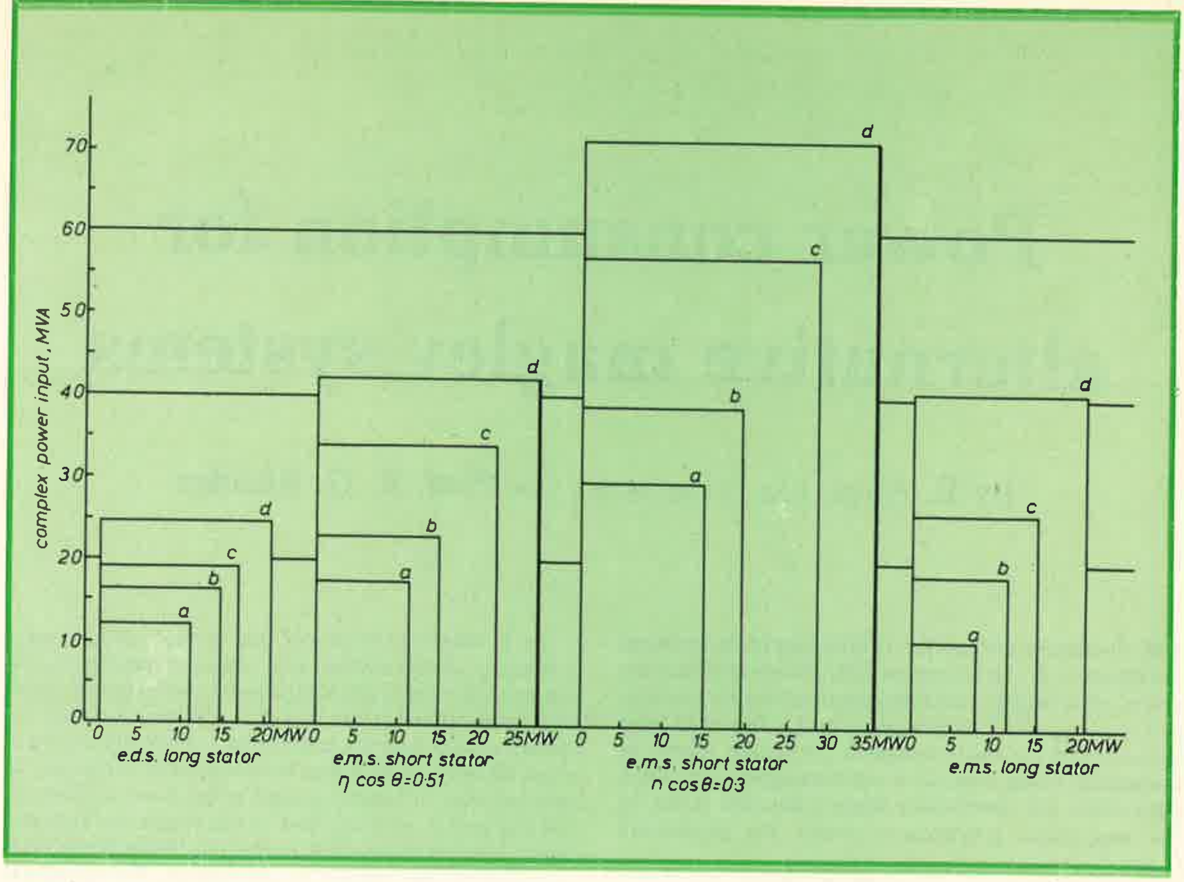
In a recent publication[1] the design details, performance characteristics and power requirements of these systems have been contrasted and compared, and the general conclusion was that the development of either system had not proceeded sufficiently far for a clear decision to be taken between them. However, it was felt that the figures quoted in the above references for the power consumption of the respective systems are somewhat misleading, in that only the active power supplied to the vehicle is considered. The complex power requirements at the wayside substations, on the other hand, have been ignored. However, when these are taken into account, particularly for the case of the linear induction machine(l.i.m.), it has a marked effect when the total powers are compared.



1 Total active power of systems. D.C. distribution and pickup loss not included for both e.m.s. short stator (η = 0·78 and η = 0·6, respectively)

a Aerodrag
b Magdrag (lift & guidance)
c On-board systems drag
d Remaining subsystem drag
e Subsystem losses
f Residual acceleration
g Losses from residual acceleration



2 Total Complex and active power of systems
a 400 km/h, steady state
b 400 km/h, accelerating
c 500 km/h, steady state
d 500 km/h, accelerating

The purpose of this study was to obtain a more realistic assessment of the respective overall power requirements from published figures[2–5] for the competitive systems, and the aggregated powers are presented in the form of the block diagrams shown in Figs. 1 and 2. In assembling this data, it was discovered that very little factual information on power factor and efficiency could be found for the e.m.s. propulsion systems. However, for the purpose of calculating the complex power requirements for the short-stator l.i.m., two designs were considered with efficiencies of 0·78 and 0·60, respectively, and efficiency/power factor products of 0·51 and 0·30.

In the determination of the overall power consumption of the respective systems, the following energy requirements were considered:

- aerodynamic drag
- magnetic drag resulting from both lift and guidance
- on-board systems drag, i.e. the power supplied to the vehicle for on-board systems
- remaining steady-state drag, i.e. cooling air inlet drag
- steady-state losses (due to motor inefficiency)
- residual acceleration, i.e. extra power to accelerate against headwinds, gradients etc.
- losses from residual acceleration.

In Fig. 1 the total composite active-power requirements of the different systems have been plotted for the two speeds 400 and 500 km/h, respectively, and, in Fig. 2, both the total complex and active power requirements are presented.

It is clear from these results that the e.d.s. system with the long-stator motor (l.s.m.) propulsion requires considerably less energy than the other variants of the e.m.s. system under these assessed operating conditions. It seems equally obvious that the short-stator l.i.m. would be quite unsuitable for operational speeds of 500 km/h and even very doubtful for 400 km/h. Although the e.m.s. long-stator system would appear to have reasonable characteristics at 400 km/h, it becomes seriously degraded at 500 km/h. But it is felt that, because of the relatively meagre published information on this system, not very much reliance can be placed on these results. It can be concluded, therefore, that from the available published evidence on the relative power requirements of these proposed systems, the e.d.s. (cryogenic) design with l.s.m. propulsion (long stator) would appear to have the most promise for the required operating speeds of 400 to 500 km/h.

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