Hybrid Power Determination

Comment from JAPAN

Hybrid system power
TP1 = R1+R2

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Concept from EVE-31-05e
Hybrid system power(TP1) = R1 + R2

Pending issues for TP1
- Double counting of engine output (R1) in series hybrid.
- In case of multiple inverters in a series hybrid, necessity of measurement power for each inverter individually.
- Definition of R1 and R2 in power split hybrid.

Japan proposes solutions.
Basic concept

Elements of system power determination

Hybrid system power = $R_1 + R_2$

Conventional ICE power rating

$R_1$

Additional power for hybridization

$R_2$

Fig. 1

The system power rating should be comparable to the traditional engine-based power rating of conventional vehicles.

Fig. 2
R1+R2 concept can be applied to every kind of hybrids.
**Basic concept**

**Definition of R1 and R2**

**Conventional ICE power rating**

R1

**Fig. 1**

**Transmission**

AT CVT DCT etc

R1

ENG

**Fig. 2**

**Additional power for hybridization**

R2

Battery

INV1

MOT

K1

K2

R2

**Note:** R1 does Not include any losses downstream of engine

R1 should be comparable to the traditional engine-based power rating of conventional vehicles.

R1 and R2 can be defined by the origin of energy.

R1 = ICE originated power

R2 = Battery originated power
Case 1  Series Hybrid

Conventional ICE power rating
R1

Fig. 1
R1 = ICE originated power

Elements of series hybrid

ECVT  Additional power for hybridization
R2

Fig. 2
R1 = ICE originated power  R2 = Battery originated power

Series hybrid is summation of  R1 and R2.
Case 1 Series hybrid

Series-Hybrid

\[ TP_1 = R_1 + \text{REESS power} \times K_1 = R_1 + R_2 \]

From this formula,

\[ R_2 = \text{REESS power} \times K_1 \]

Fig. 1 Series Hybrid

Hybrid (P3)

\[ TP_1 = R_1 + R_2 = R_1 + \text{REESS power} \times K_1 \]

R1+R2 concept can be applied to series hybrid also.
Case 1 Series Hybrid

Series hybrid

TP1 = R1 + REESS power × K1
= R1 + R2

From this formula
R2 = REESS power × K1

Fig.1 Series Hybrid

Fig.2 Series Hybrid

Issues and solutions

R1 is ICE originated power and R2 is REESS originated power. Double-counting issue does not occur even if summing up R1 and R2. (Fig1)

R2 is defined as the battery originated power, it is sufficient to measure the battery power.

GEN/INV2 is downstream of R1. Measurement of GEN/INV2 power is not necessary for TP1. And losses of GEN/INV2 does not include for TP1. (Fig1)
Case 1 Series Hybrid

For series or mixed (power split) hybrids, TP1 will always give a higher result than TP2 because TP1 does not account for electrical conversion losses in the series portion.

Losses in the electrical conversion path (G + Inv2) would not be accounted for.

\[ TP1 = R_1 + R_2 \]

\[ TP2 = \text{Drive shaft power} / K_2 \]

TP1 > TP2 is occurred

TP1 does not show a higher value than TP2.

Proposal from JAPAN

R2 is part of motor output, which REESS originated power only.
Double-count of engine power does not occur, because R2 does not include engine originated power.

\[ TP1 = R_1 + R_2 = R_1 + \text{REESS power} \times K_1 \]
Case 2: Power split Hybrid (THS)

**ECVT**

**Power split hybrid**

![Diagram](image)

**Additional power for hybridization**

![Diagram](image)

**Fig.1**

**Fig.2**

**Fig.3**

**Fig.4**

**TP1 for power split hybrid is as same as other hybrids**

\[ TP1 = R1 + (\text{REESS power} \times K1) \]

\[ R2 = \text{REESS power} \times K1 \]

\[ TP1 = R1 + R2 \]
Three issues and result

- Double counting of engine power R1 in series hybrid.

- Multiple inverters in a series hybrid, necessity of measurement power for each inverter individually.

- Definition of R1 and R2 in power split hybrid.

R1 is ICE originated power and R2 is REESS originated power. Double count does not occur even if R1 and R2 are summed.

There is no need to measure GEN/INV2 power for TP1. Because GEN/INV2 is downstream of R1.

Same as other hybrids.
The hybrid is composed of ICE origin power and REESS origin additional power.

1. Every type of hybrids, TP1 can be expressed as 
   \[ TP1 = R1 + R2. \]
   (Includes series hybrid and power split hybrid)

2. R2 is motor output from REESS originated power only, should not include the engine originated power.

**Conclusion**