



Thermal Calculation of the Reduction Gear 2XAB/StCu110So as Part of Hybrid Locomotive's LHy-M Mechanical Transmission

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The purpose of this work is to present the reduction gear's efficiency, reduction gear that is load part of hybrid locomotive's mechanical transmission. The purpose of the calculation is to determine the overall efficiency of the reduction gear to determine its operating temperature.

Keywords: *efficiency, power losses, coverage percent, thermal*

1. Introduction.

The reduction gear type 2AB/StCu110So, of the mechanical transmission component of the hybrid locomotive, is the basic aggregate that transforms and adapts the power developed to the traction electric motor axels to the convenient parameters to ensure the traction effort of the locomotive to the values necessary to meet the requirements of the applications for which it was built.

2. Calculation of the total efficiency of the reduction gear

Due to the frictions occurring during the gearing of the reduction gear bearings, the power output at the P_{II} reduction gear is less than the input power to the reduction gear P_I [2].

As follow:

$$P_I - P_{II} = P_p \quad (1)$$

in which: P_p – power losses.

But:

$$P_p = P_a + P_I + P_u \quad (2)$$

where:

P_a – power losses through gearing;

P_I – power losses in bearings;

P_u – power losses through oil shuffle.
 Reduction Gear total Efficiency 2xAB50/StCU110So is:

$$\eta = \frac{P_I}{P_{II}} = \eta_{T0} \eta_{TV1} \eta_{TV2} \eta_{TV3} \eta_L^7 \eta_u \quad (3)$$

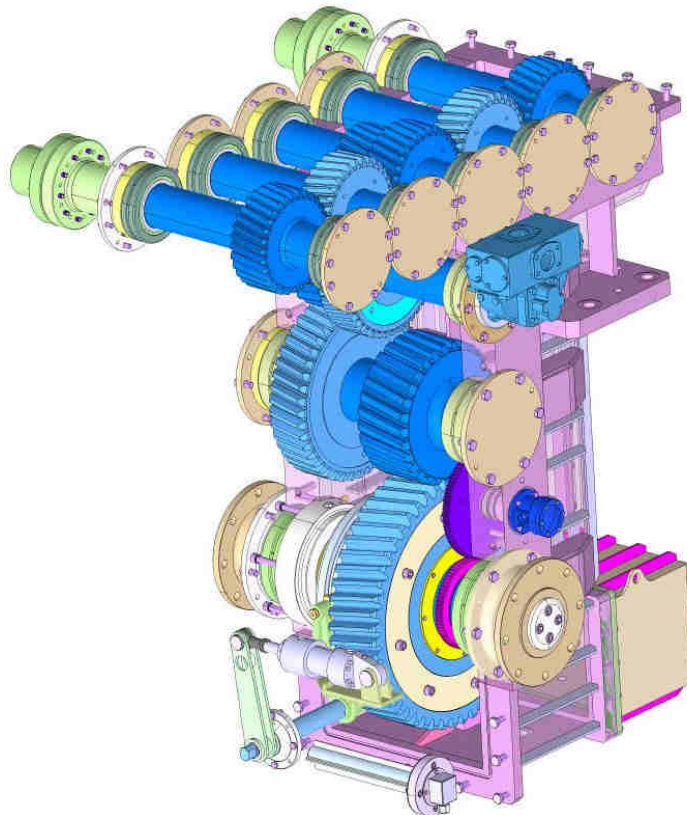


Figure 1. Reduction Gear 2xAB50/StCU110So

where:

- η_{T0} – horizontal rung total efficiency;
- η_{TV1} – Vertical rung 1 efficiency;
- η_{TV2} – Vertical rung 2 efficiency;
- η_{TV3} – Vertical rung 3 efficiency;
- η_L – One bearings pair efficiency
- η_u – Efficiency due barbotage loss.

In drawings (2) and (3) is presented reduction gear overall drawings.

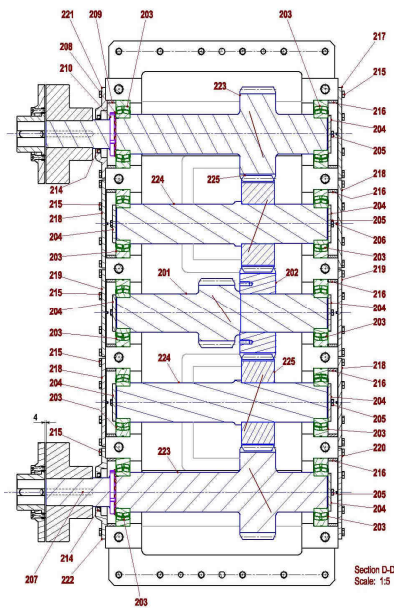


Figure 2. Horizontal plan section

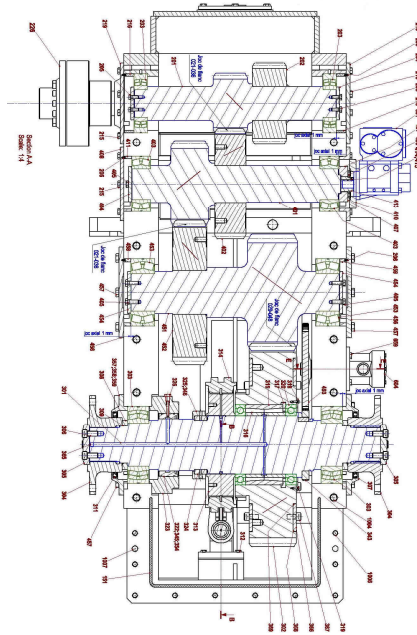


Figure 3. Vertically plan section

2.1 . Determination of gear yields

Calculation relation of cylindrical yields efficiency is

$$\eta_a = 1 - \frac{\pi \mu \epsilon_\alpha}{f \cos \beta} \left(\frac{1}{Z_1} + \frac{1}{Z_2} \right) \quad (4)$$

where:

ϵ_α – degree of coverage; the tilting angle of the teeth;

β - the tilting angle of the teeth;

f - coefficient values f is set according to the type of the gear toothing.

In this reduction gear case, gears efficiency determination was made by Kiss software and has indicators from the table 1.

Table 1. Gears efficiency

Power (kW)	[P]	2x115
Maximum rotation (rpm)	[n]	3600
Factor of service	[K]	1

In table 2 the reduction gear working efficiency are presented.

Table 2. Working efficiency

No.	Engagement level	Power Loss [kW]	Efficiency
1	Horizontal	2,34	0,992
2	Vertical 1	1,92	0,993
3	Vertical 2	1,49	0,995
4	Vertical 3	1,19	0,996

Result: $\eta_a = 0.9762$ (5)

2.2. Bearings efficiency determination which are reduction gear components

Since the reduction gear bearings are self-aligning ball bearings type, the yield for a pair of bearings according to [2] shall be considered:

$$\eta_a = 0.99 \quad (6)$$

2.3. Performances due to barbotage losses

Reduction gear lubricating is made with pressurized oil. In this case:

$$\eta_u = 1 \quad (7)$$

From (5), (6) and (7) result:

$$\eta_u = 0.9672 \times 0.99 = 0.90 \quad (8)$$

3. Working temperature calculation of the reduction gear

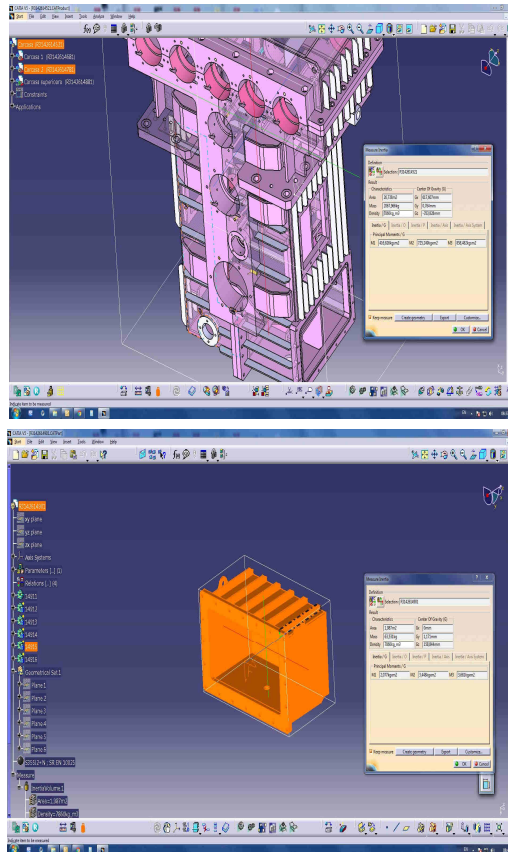


Figure 4. Determination of the cooling surface of the reduction gear –
Result: $t=111^{\circ}\text{C}$

Equation of thermal balance of the reduction gear according to [2] is:

$$P_p = P_c \quad (9)$$

where:

P_p - power losses;

P_c - the power output through the reduction gear housing.

Replacing in relation (9) follow:

$$P_{II} = \frac{(1-\eta)}{\eta} = KS(t-t_0) \quad (10)$$

where:

P_{II} - output power from reduction gear;

H - reduction gear total efficiency;
K - the global heat exchange coefficient between the reduction gear housing and ambiently environment;
S=19.035 m² - air cooling of reduction gear housing cooling surface, figure 4;
t - reduction gear working temperature;
t₀ – ambiental temperature.

4. Conclusion

The calculation of the total gear ratio and the calculation of the operating temperature indicate that the operating temperature is t=111°C.

The normal operating temperature must not exceed 80-90°C in which case the oil viscosity drops, thus changing the clearance in the bearings and gears.

Considering that in this case it is not possible to increase the area of the housing, and this has already been ripped, the technical solution to be adopted will be to use an oil cooler.

6. Acknowledgments

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References

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- [2] Musat M. Stoica G. *Transmisii mecanice cu reductoare intr-o treapta*, 2004., www.omtr.pub.ro/didactic/indrumare/indrumar_gstoica.pdf
- [3] ***** ISO 6336/1996 *Calculation of load capacity of spur and helical gears*, part 1-5,
- [4] ***** KISSsoft - *Calculation software for machine design*.

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