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THE STUDY ON THE TRANSTION IN ELECTRIC GENERATOR REGIME OF TRACTION MOTOR FOR 060 DA LOCOMOTIVES

Ing. Daniel APOSTOL[1]
[1]Depot Iasi

Abstract - *This piece of work aims at dealing both with the passage to a generating set-like conditions of the driving electric motor for the 060DA Diesel railway engine and the influence of this passage upon the electric outfit. There is also a short presentation of the 060DA Diesel railway engine and its main power parts.*
Keywords *– diesel-electric locomotive, traction motor, DC generator.*

1.INTRODUCTION

Traction motors used on locomotives are designed to transform the received electricity, into mechanical energy that can drive the locomotive axles. The locomotives are used in general for these types of traction motors:
- DC motors with series excitation;
- Electric motors asynchronous three-phase AC.
- The locomotives manufactured in Romania are used electric motors DC excitation series type:
- GDTM 533 F on diesel-electric locomotive type 040 DF, 060 DA;
- GDTM 533 H on diesel-electric locomotive type 060 EGM;
- MCT 542x320/6 on diesel-electric locomotive type 060 DC si 060 DD;
- LJE 108/1 (2) on diesel-electric locomotive type 060 EA.

Traction motor of continuous current excitation winding number is provided with compensation (the auxiliary police) and the compensation windings. Generally for less than 300 kW power engine is equipped only with winding commutation.

Today started in Romania use as a traction motor three-phase AC induction motor, namely:
- GDTM 533 F a.c. motor 475 KVA / 2300 rot/min / 1400 V / 48 Hz on diesel-electric locomotive type Carpathia 2300 DE-M, modernization to la SC REMARUL Cluj;
- MTA2 de 1000 Kw / 1089 rot/min / 1200 V / 55 Hz on electric locomotive 060 EA Trans Montana, modernization to SC SOFTRONIC SRL Craiova.

Operating conditions of an electric motor used as traction motor locomotives are very heavy. He must be able to support current and voltage variables, within very large.

Electric traction motor must have a solid construction to withstand high temperature variations, as both the ambient and operating. You also need to be able to can transform mechanical energy into electrical energy to be recovered.

2. BRIEF INTRODUCTION OF DIESEL-ELECTRIC LOCOMOTIVE OF 2100 HP 060 DA

From 1960 to Electroputere plants in collaboration with UCM Resita and axles and bogies Caransebes Enterprise, begins manufacturing diesel-electric locomotive 060 - DA, and is produced under license companies: Sulzer, SLM and Brown Boveri, so:
- Diesel engine – "Sulzer Freeres Winterthut";
- mechanical and pneumatic equipement – "Swiss Locomotive&Machine";
- electrical equipement – "Brown Boveri&C Baden".

Diesel-electric locomotives of 2100 HP was built with a self-supporting box with two driving cabins heads are used to maneuver, towing passenger trains and freight trains on the railway main, secondary and industrial.

Fig. 1 Diesel-electric locomotive type 060 DA

Technical specifications:

Destination	Hauling passenger trains, freight, industrial
Gauge	1435 mm
Minimum curve radius	100 m
Formula axles	Co-Co
Wheel diameter	1100 mm
Overall length	17.000 mm
Width	3000 mm
Height	4435 mm
Transmision	Electrical
Diesel engine	Type 12 LDA 28
Traction performance	
- output power (UIC)	2300 CP
- output power	2100 CP
- maximum force to start	320 kN
- continues force	200 kN
- maxim speed	120 km/h
- continues speed	21,5 km/h
Weight	117 t
Axle weight	19,5 t
Brake	direct
	automation
	handy
Installation of speed control	Type INDUSI I60
Installation of safety and vigilance	Type WACMA, DSV
Speed measuring equipment	Type Hasler, IVMS

Diesel-electric locomotives DA 060 has a power transmission DC – DC. It is made up of electric machines interspersed between motor shaft and axles Sulzer type heat engines. These transmission torque is transmitted between diesel engines and axles through the electromagnetic field. Diesel engine driven electric machine operates in generator mode and train machines axles in motor mode.

The main elements of the electric transmission for locomotive 060 DA

Main electric generator

Main electric generator is a continuous current electric machine, ten poles and ten main pole auxiliary, with mixed excitation. The main poles are provided with compensation winding for improving commutation.
They are made of sheets and their excitation by three windings:

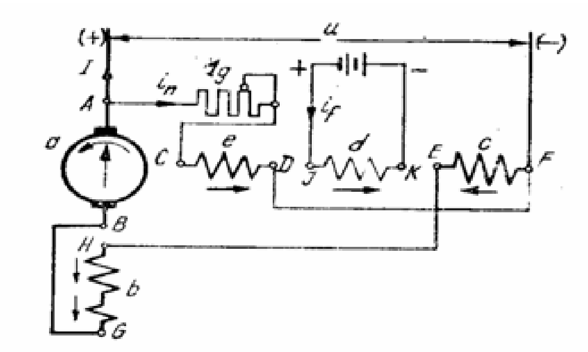
- separate excitation winding, which is powered by an auxiliary generator;
- excitation winding bends, which is connected in parallel with the armature circuit;
- anticompound excitation winding, which is crossed by the current in the armature circuit.

Excitation winding and the shunt anticompound consist of reading a coil and separate excitation winding consists of two main coils for each pole.

Technical specifications:

Generator type GCE 1 100/10
Duration regime:

- for maxim voltage	890 V	1520 A	1080 rot/min
- for minim voltage	550 V	2460 A	1080 rot/min
Uniorar regime:	500 V	2700 A	1080 rot/min
Maximum values:	990 V	3900 A	1080 rot/min



where: a - rotor b - pole auxiliary winding and compensation; c - winding anticompound d - separate excitation winding e - excitation winding bends, g - excitation current control resistance

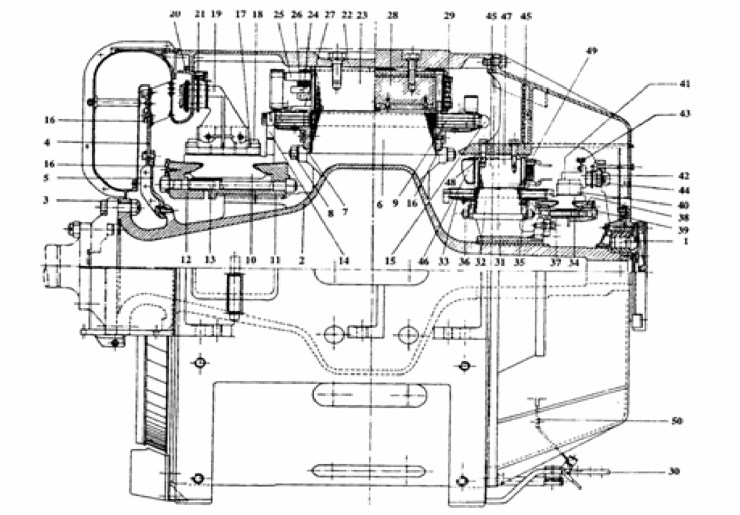


Fig. 2 General Assembly main / auxiliary

where: 1 - bearing, 2 - rotor shaft, 3 - coupling flange, 4 - fan, 5 - fan support, 6 - magnetic core, 7 - string rings, 8 - screw, 9 - winding rotor, 10 - slides copper, 11 - bush, 12 - contains a string, 13 - Screw, 14 - flags, 15 - deck brush, 16 - balancing weights, 17 - brush, 18 - carbon brushes, 19 - support brush, 20 - deck brush , 21 - rings, 22 - housing, 23 - the main poles, 24 - winding excited

In figure 3 is shown the external feature of the main generator .

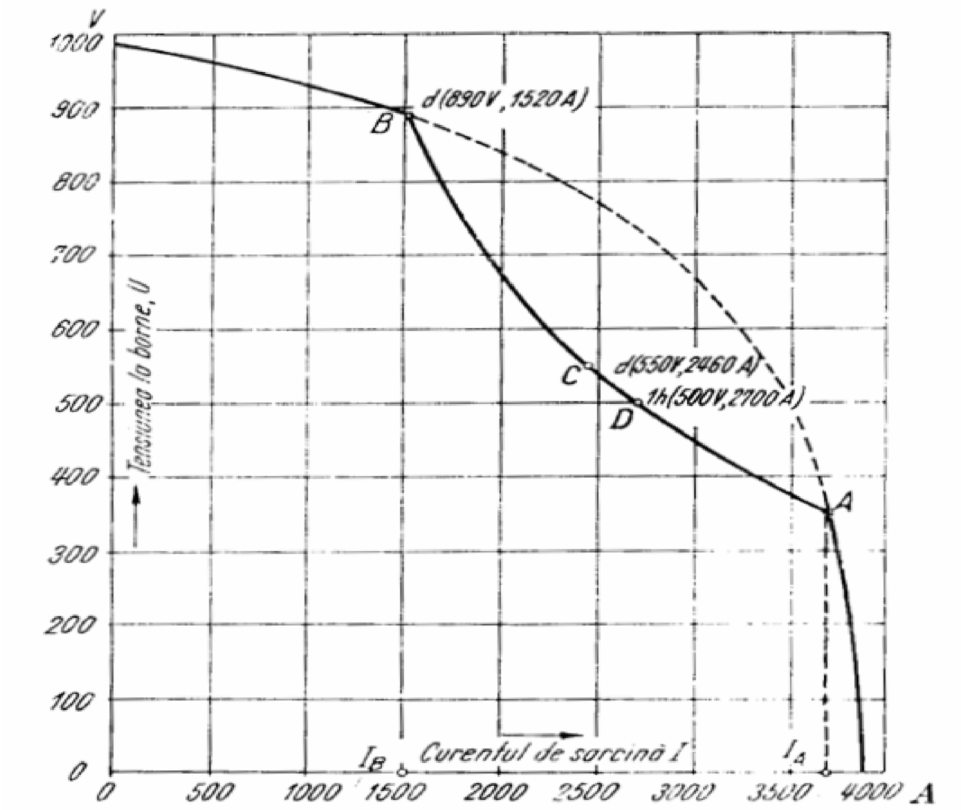


Fig. 3 External feature of the main generator

Auxiliary generator

Auxiliary generator is a DC machine with eight poles and eight main pole auxiliary, with excitation in the bends.

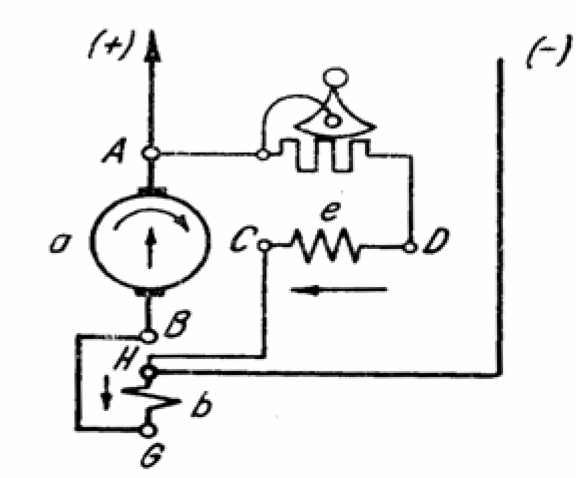
Technical specifications:

Electrical power 75 Kw

Voltage 170 V

Current 440 A

Speed 530…1080 rot/min



where: a - rotor b - pole auxiliary winding e - excitation winding bends.

The electric motor traction

Traction motors used on locomotives are electric motors 060 DA DC, with excitation range, and forced ventilated suspension "on nose". Motor housing is cast steel and features magnetic inlet air cooling and rectangular openings closed with a lid for access to brushes and collector.

Winding rotor is a regular six-way loop current in parallel. Under the rotor winding end, the collector is placed on a winding equipotential.

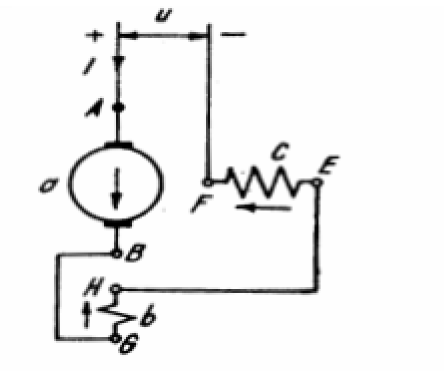
Main and auxiliary poles are six in number and are secured by motor housing screws.

Technical specifications for motor type GDTM 503F:

- in continous regime: P=200 kw / 275 V / 820 A / 495 rot/min;
- in uniorar regime: P=194 kw / 250 V / 900 A / 425 rot/min;
- in short-term regime: P=x / 460 V / 1300 A / 2300 rot/min;
- Weight 2500 kg;
- Maximum weight-loss field I_{cimp}/I_{indus}= 0,40;
- Air flow cooling 100 m3 / min – 160 mm col. H2O;
- Maximum altitude 1200 m;
- Average ambient temperature max 40 C;
- Insulation class F.

Allowable heating:

- Stator winding 140 C;
- Rotor winding 155 C;
- collector 120 C.



where: a - rotor b - pole auxiliary winding e - excitation winding number.

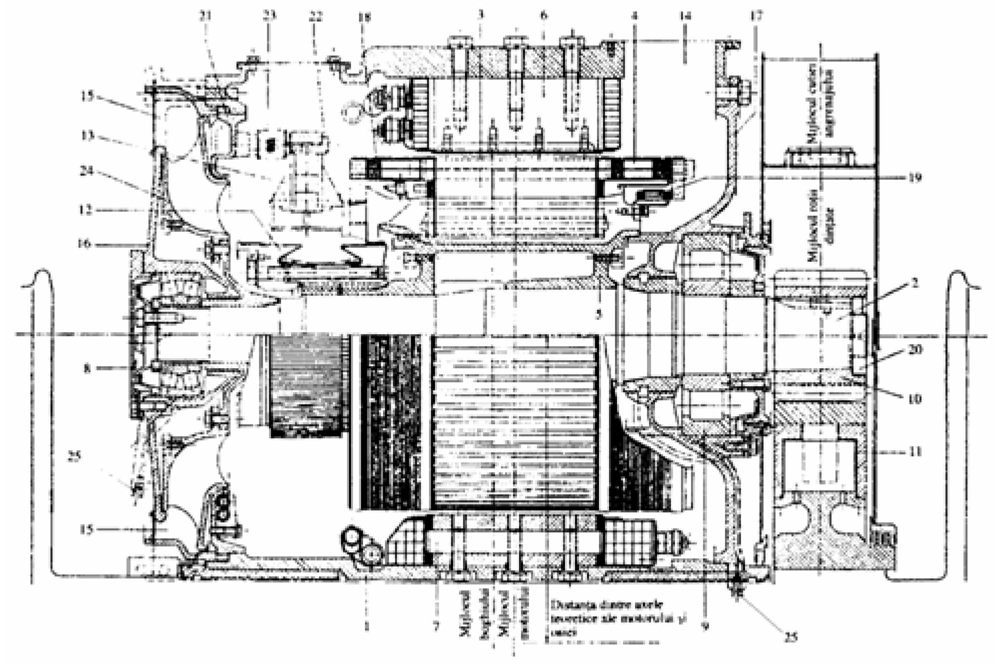


Fig. 4 Traction motor

where: 1 - engine casing, 2 - the motor shaft, 3 - magnetic core, 4 - copper winding of the armature, 5 - rotor hub, 6 - main poles, 7 - auxiliary poles, 8, 9 - bearings, 10 - pinion, 11 - a gear axle, 12 - collector, 13 - portperie, 14 - channel ventilation, 15 - openings for ventilation, 16, 17 - shield 18 - bandage, 19 - equipotential bonding, 20 - nut, 21 - bridge brush, 22 - bolts, 23 - insulators, 24 - valve, 25 - nipples

In figure 5 is shown the external feature of the traction motor.

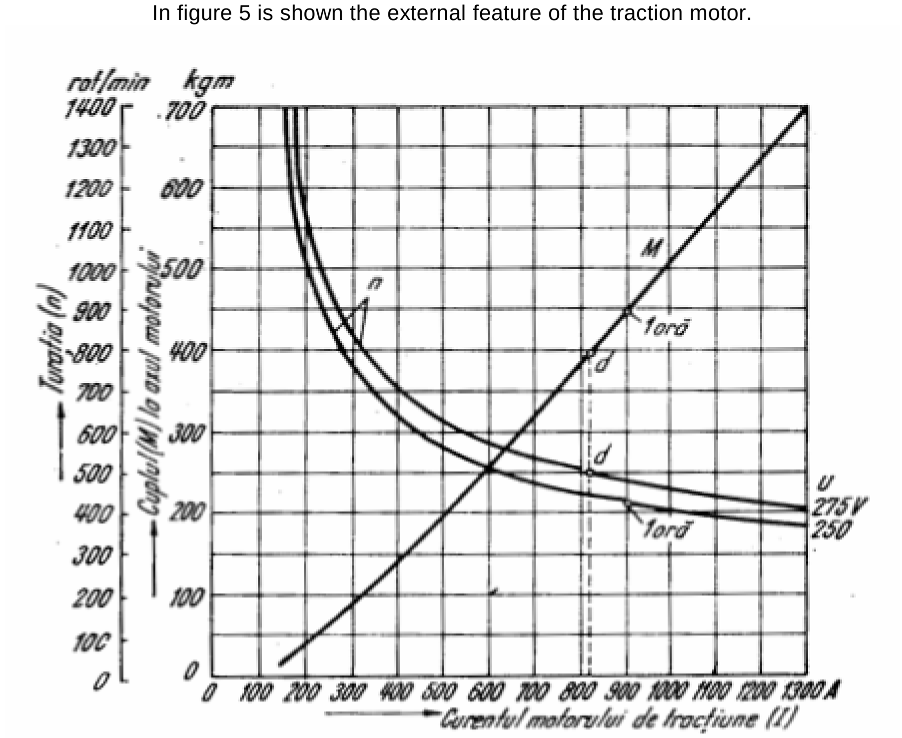


Fig. 5 The external feature of the traction motor

3. GENERATOR REGIME OF LOCOMOTIVE TRACTION ENGINE

Normally the locomotive diesel-electric traction electric machine is only used in engine mode, engine braking is not equipped with circuit rheostat. Figure no. 6 is shown the motor drive circuit as used on the locomotive 060 DA.

Note that there are two traction motors are in series and connected in parallel cite two, mounted on axles so the engine on the axle 1 is numbered with the axle 4 engine, the engine 2 is in series with the motor axle on axle 5 axle and engine 3 is in series with the engine on axle 6.

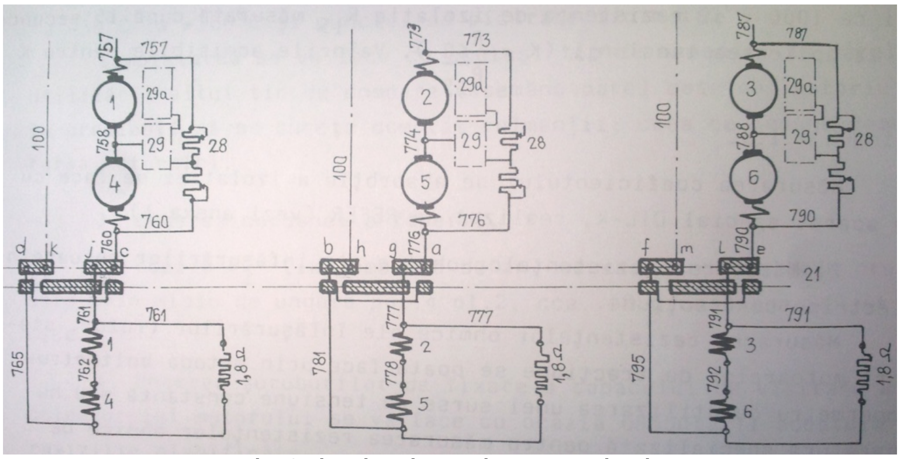


Fig. 6 The electric traction motor circuit

where: 1, 2, 3, 4, 5, 6 - dc electric motors with series excitation, 21 - inverter so; 28 - antilock resistance (1500Ω), 29 - antilock relay.

In figure 6 is shown how the windings rotor excitation windings are separated by an inverter so. Also excitation windings are in series resistance of 1.8 Ω bends and rotor windings resistance of 1500Ω.

To switch to generator mode, the electric car drive (electric motor), the locomotive must be engaged from outside, ie mechanical energy to take the axle. In this case, if there is a load resistance connected across the machine (generator) then due to residual magnetic field there will be a DC voltage proportional to the terminals of the drive rotor speed and load current I_S = Ie = 0 (where Ie is the excitation current). In case when the terminal machine (generator) is coupled load resistance will occur when load current IS = Ie > 0. This current has the same value as the excitation current as the car is a DC generator excitation series. In figure 7 is shown feature-load on the generator with series excitation, E = f (Ie) and Volt-ammeters feature EIR = f (Ie). In the sationary regim we can write:

$$U = E - (IR + \Delta U_p), \qquad (1)$$

where: U - the voltage across the generator, IR - voltage drop due to winding resistance, ΔUp - the voltage drop due to brush.
but,

$$E = K\, n\, \Phi \qquad (2)$$

where: K - constant of machine, n - speed shaft (rotor), Φ - magnetic flux.

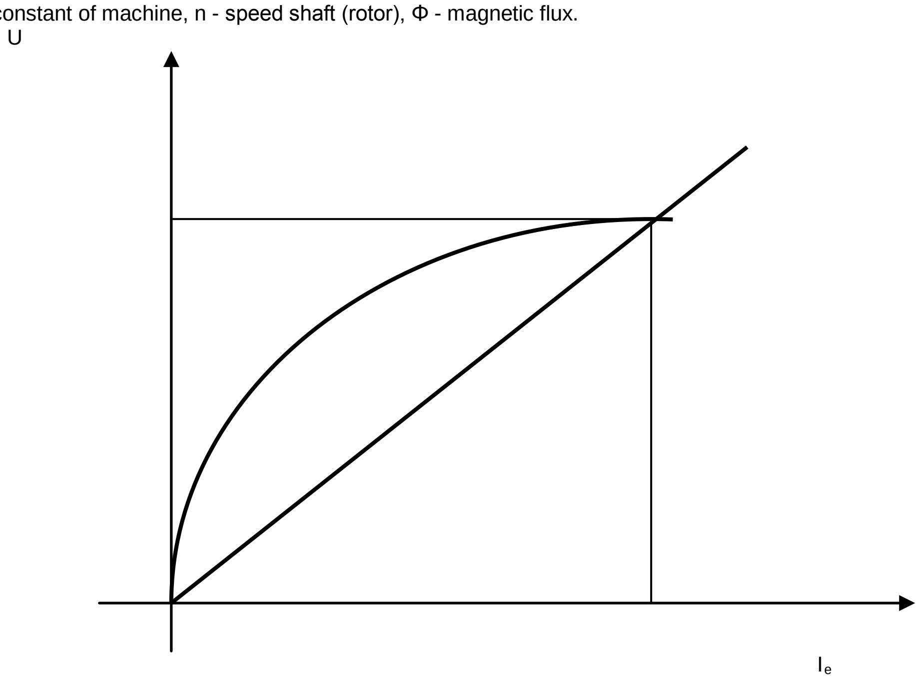


Fig. 7 The Feature-load and Volt-ammeters

Because the diesel-electric locomotive type DA 060 electric cars are in series there were two traction when operating in generator mode, the voltage at the terminals will be given by:

$$U_{1\text{-}4} = U_1 + U_4 = E_1 + E_4 - (IR_1 + IR_4 + \Delta U_{p1} + \Delta U_{p4})$$

$$U_{2\text{-}5} = U_2 + U_5 = E_2 + E_5 - (IR_2 + IR_5 + \Delta U_{p2} + \Delta U_{p5}) \qquad (3)$$

$U_{3\text{-}6} = U_3 + U_6 = E_3 + E_6 - (IR_3 + IR_6 + \Delta U_{p3} + \Delta U_{p6})$

but: $E = K\, n\, \Phi$ si $n = n_1 = n_2 = n_3 = n_4 = n_5 = n_6$, we can write:

$$U_{1\text{-}4} = U_1 + U_4 = n(K_1 \Phi_1 + K_4 \Phi_4) - (IR_1 + IR_4 + \Delta U_{p1} + \Delta U_{p4})$$

$$U_{2\text{-}5} = U_2 + U_5 = n(K_2 \Phi_2 + K_5 \Phi_5) - (IR_2 + IR_5 + \Delta U_{p2} + \Delta U_{p5}) \qquad (4)$$

$$U_{3\text{-}6} = U_3 + U_6 = n(K_3 \Phi_3 + K_6 \Phi_6) - (IR_3 + IR_6 + \Delta U_{p3} + \Delta U_{p6})$$

In case when the windings of the machine rotor circuit is numbered at the excitation windings, ie the load current and the excitation is zero, the voltage at the terminals will be given only remaining field and we can write:

$$U_{1\text{-}4} = U_1 + U_4 = n(K_1 \Phi_1 + K_4 \Phi_4) - (\Delta U_{p1} + \Delta U_{p4})$$

$$U_{2\text{-}5} = U_2 + U_5 = n(K_2 \Phi_2 + K_5 \Phi_5) - (\Delta U_{p2} + \Delta U_{p5}) \qquad (5)$$

$$U_{3\text{-}6} = U_3 + U_6 = n(K_3 \Phi_3 + K_6 \Phi_6) - (\Delta U_{p3} + \Delta U_{p6})$$

When diesel-electric locomotive will always have a load current to be zero. This is because of this resistance in the rotor circuit for antiskid (position 28 in Figure 6) of 1500 Ω each. Thus, the residual magnetic field will be either increased or decreased depending on the machine of meaning rotation and the terminal voltage will have a value higher than the case when $I_S = Ie = 0$ and will be lower or even zero.

In case when the machine rotor windings traction circuit is in series with the windings of the excitation, ie the load current and the excitation are equal, the voltage at the terminals will be given by the formulas (4). Thus, the generator will produce a DC voltage whose value is not controlled.

4. CONCLUSIONS

Generator regime of electric traction motor on diesel-electric locomotive is used to provide locomotive advantage, namely braking rheostat.

Regime causes a voltage generator that can be dangerous for locomotive equipment. Limitation of this tension can be easily avoided if the current passes through the excitation range of the car, the car becomes a generator excitation due to residual magnetic flux. This means, if the locomotive in reverse isolation of the excitation number sense.

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