proportion of regenerative braking will also decrease being adapted to the battery characteristics.

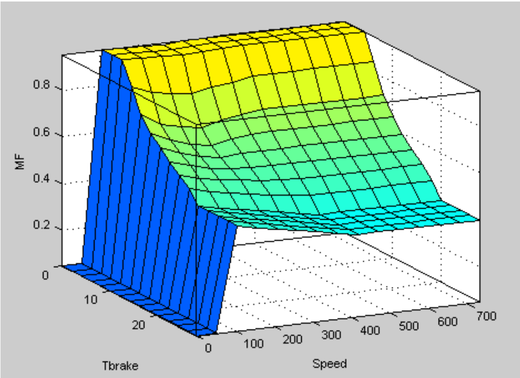

Fig.11. The torque proportion as a function of T_{brake} and speed

Fig. 11 displays a three-dimensional representation of the output variable (the regenerative braking torque proportion MF) as a function of the pedal braking torque T_{brake} and the speed, as the input variables. For the increasing speed, the proportion of the electric braking will decrease in accordance with the braking-current generated by the converter. For the speed below 100 rpm the sharing of the electric braking is 0%.

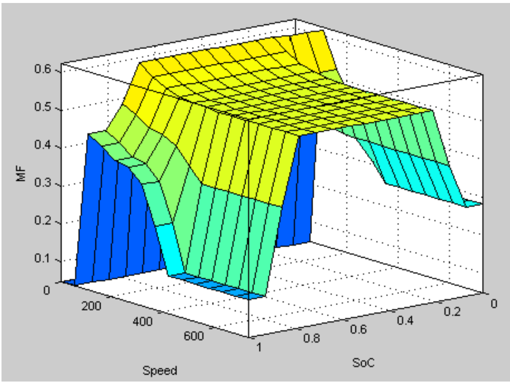

Fig.12 The torque proportion as a function of SoC and speed

Fig. 12 illustrates a three-dimensional representation of the output variable (the regenerative braking torque proportion MF) as a function of the state-of-charge SoC of the battery and the vehicle speed, as the input variables. It indicates that while being in the state of Middle SoC, the sharing proportion of the regenerative braking has a high value in order to maximize the battery charging for the vehicle speed above 100 rpm.

The results of laboratory testings done also indicate that the converter could be functioning in its working region and that the battery charging process was in accordance with its characteristics.

IV. Conclusion

Some conclusions are drawn based on the analysis of the system being considered in this paper.

The results of simulation show that the proposed method was able to maintain the battery charging characteristics as it should be. When the state-of-charge SoC of the battery was less than 10%, the charging current could not be more than 2 A, when the SoC was in the range between 10% and 90%, the charging current could not exceed 15 A, whereas when the SoC was higher than 90%, the charging current could not be more than 1 A.

The results of experiment indicated that for the speeds below 100 rpm, the electric braking was not favorable anymore because the regenerative power was smaller than the power system losses. Consequently, the proportion of the electric braking should be zero for the speed less than 100 rpm. The simulation results showed that the proportion of the electric braking for the speeds below 100 rpm was 0.05. It was also shown that within the speed range of 100-400 rpm the achieved maximum braking current was not more than 20 A, while beyond the speed of 400 rpm it was not more than 15 A. It means that the desired sharing proportions between the braking modes were achieved.

TABLE V
Results Of Experiment On Torques Distribution Using Fuzzy-Logic Control

TB	SoC (%)	N (rpm)	p	T_e	T_m	I_a	I_o
5.0	10	100	0.05	0.23	4.77	0.28	0.03
5.0	10	101	0.95	4.77	0.24	5.76	0.61
5.0	10	400	0.50	2.50	2.50	3.02	1.26
5.0	50	100	0.05	0.23	4.77	0.28	0.03
5.0	50	101	0.95	4.77	0.24	5.76	0.61
5.0	50	400	0.95	4.77	0.24	5.76	2.40
5.0	90	100	0.05	0.23	4.77	0.28	0.03
5.0	90	101	0.80	4.00	1.00	4.84	0.51
5.0	90	400	0.20	1.00	4.00	1.21	0.50
12.5	10	100	0.05	0.58	11.92	0.71	0.07
12.5	10	101	0.65	8,15	4.35	9.85	1.04
12.5	10	400	0.31	3.88	8.63	4.69	1.95
12.5	50	100	0.05	0.58	11.92	0.71	0.07
12.5	50	101	0.65	8.15	4.35	9.85	1.04
12.5	50	400	0.59	7.34	5.16	8.87	3.70
12.5	90	100	0.05	0.58	11.92	0.71	0.07
12.5	90	101	0.50	6.25	6.25	7.56	0.80
12.5	90	400	0.16	1.95	10.55	2.36	0.98
28.0	10	100	0.05	1.31	26.69	1.58	0.16
28.0	10	101	0.50	14.00	14.00	16.93	1.78
28.0	10	400	0.11	2.97	25.03	3.59	1.50
28.0	50	100	0.05	1.31	26.69	1.58	0.16
28.0	50	101	0.50	14.00	14.00	16.93	1.78
28.0	50	400	0.40	11.20	16.80	13.54	5.64
28.0	90	100	0.05	1.31	26.69	1.58	0.16
28.0	90	101	0.20	5.60	22.40	6.77	0.71
28.0	90	400	0.05	1.31	26.69	1.58	0.66

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