Synopsis of CONTROL METHOD FOR VARIABLE SPEED STALL CONTROLLED WIND TURBINES

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Innovation and relevance: Up to now, large variable speed turbines are mostly provided with pitch-control. This control method is expensive and requires maintenance. This is the reason why attention is drawn to the so far neglected combination of stall-control and variable speed in this paper.

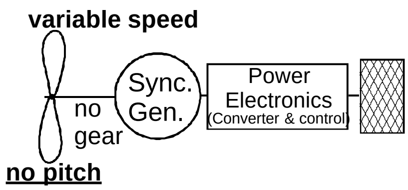

Fig. 1: Overviev

Purpose of the work: Generator systems of variable speed receive ever increasing interest in Wind energy applications. Possible power peaks due to wind gusts are compensated by an. increase of rotor speed, leading to a decrease of mechanical loads of the drive train together with a more constant power injection. Another advantage of the speed variability is the possibility of maximum power tracking of the turbine: maximum aerodynamic efficiency and a decrease-of aerodynamic rotor noise in partial load operation are achieved.

Principally, stall- controlled turbines with variable speed are able to supply any desired power output by simply adjusting the rotor speed until the required output value is achieved. However, then the Generator system must be capable to bears short time overload. This is the reason for combining variable speed turbines with pitch-control in order to prevent the expensive power converter from overload. The aim of this work is to investigate stall-controlled Wind turbines with variable speed. The benefits and penalties of replacing the pitch-control system by a combination of variable speed and stall-control will be worked out.

Approach: The point of main interest is the necessary rating of the power converter, since this considerably influences the overall costs. The necessary rating of the power converter is found by simulating the complete system under worst case conditions. At first a dynamic model of the 720 kW wind turbine is designed. It consists of the power characteristics of the rotor, drive train inertia and simplified models of the Generator and power converter. The Generator system is assumed to be a direct-drive concept. Special attention has to be payed to the control systen, where a fast and reliable control at full load is necessary.
For wind speed greater than the rated one ($v_w > v_{w,rated}$) rated power (P_{rated}) has to be injected into the ac-network in steady state. Under transient conditions however, especially

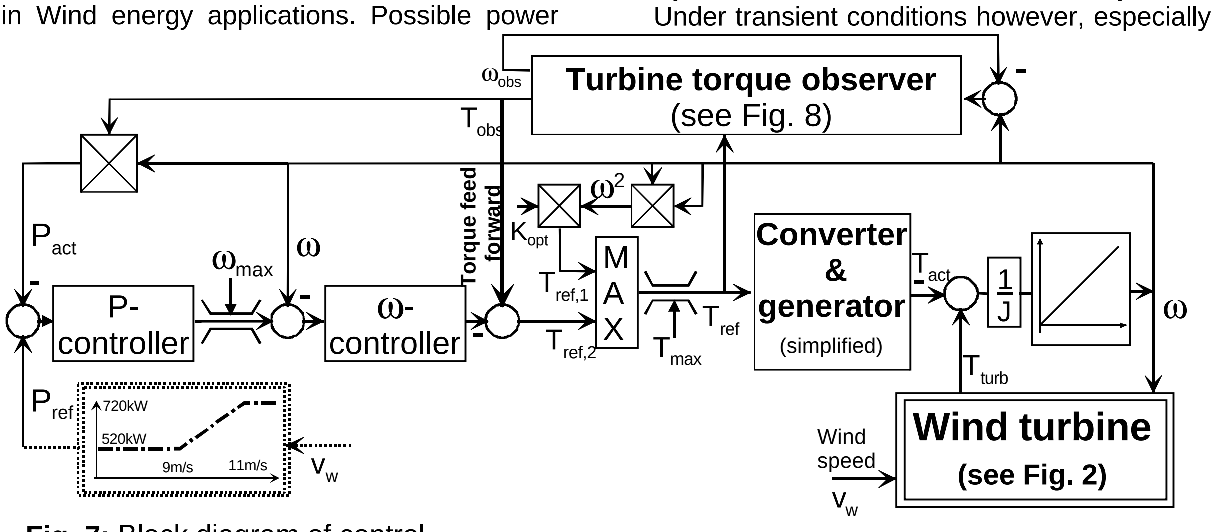

Fig. 7: Block diagram of control .

while a gust of wind, the electrical power has to be adapted to the mechanical power of the turbine very fast, in order to achieve save operation. To do this, stall must be enforced by slowing down the wind turbine. Slowing down the turbine needs an additional torque from the generator. If this additional torque is produced too late, then the turbine's speed increases and the mechanical power generated by the turbine will increase even more. When the limit of the converter's capacity is reached, then the mechanical brake has to be activated to slow down the turbine. This situation has to be avoided strictly. Thus, special attention has to be paid to the dynamic behaviour when operating at full load.

The deciding measure to prevent the situation mentioned above is to carefully design the profile of the blades. Reasonable good results are obtained with the profile Gö 758. The turbine is optimized according to the design method of Betz-Schmitz .

The block diagram of the simulated system is shown in Fig. 7.

Results from simulation:

For the considered plant, a series of simulations show that the worst case concerning the torque of the generator (-and the torque producing current of the converter-) is characterised by an increase of wind speed from $v_{w=}$10m/s to 15m/s with an acceleration of 5m/s^2. With this gust of wind in Fig. 9 the turbine's torque rises to 450kNm, the maximum torque of the generator / converter unit is limited to 455kNm in this simulation. The electrical power of the generator / converter unit rises to 1.2MW, i.e. P_{max}= 1.66·P_{rated}. These results are valid for a control system without a wind speed measurement.

It should be noted, that gusts of wind with higher or with lower wind speed are less critical with respect to torque, since both of them generate lower turbine torque.

A tremendous reduction of necessary torque and power converter ratings is possible, if information about wind speed is available to the control system, as shown in the full paper.

Conclusions

Wind turbine design with variable speed and stall regulation is an option for the future. The dynamic performance for both partial load and full load operation is competitive to existing variable speed concepts with pitch regulation. The work indicates a clear link between aerodynamic rotor characteristics, control strategy and demands on electrical components.

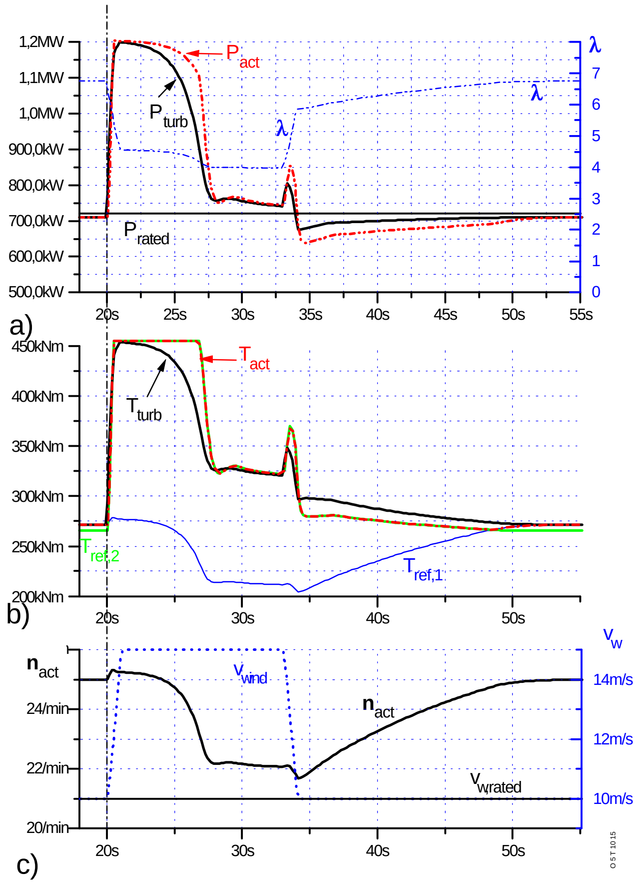

Fig. 9: Worst case torque without wind speed measurment