Two Reaction Theory of Salient pole Synchronous Alternator.

REGULATION OF SALIENT POLE SYNCHRONOUS MACHINE-BLONDEL’S TWO REACTION THEORY:

In case of salient pole machines the air gap is not uniform in length around the inner periphery of the armature.

It is minimum along the polar axis and maximum along the inter polar axis.

It is not correct to combine the actual field AT of the distributed armature winding.

They can be combined vectorially only when they act upon the same magnetic circuit.

Consequently the methods for finding out the regulation of cylindrical rotor machines when applied to salient pole machines give results which are not correct.

In case of salient pole machines regulation is found out by applying Blondel’s two reaction theory.

According to this theory two axes are recognized in the machine namely an axis along the polar axis called the direct axis or d-axis and an axis along the interpolar axis called the quadrature axis or q-axis which is 90° e displaced from the direct axis.

The armature mmf contains a quadrature (cross magnetizing) and a direct (demagnetizing or magnetizing) component which produce effects of different kinds.

The direct component exerts demagnetizing effect if \( \phi \) (angle between E0 & I) is an angle of lag and magnetizing effect if \( \phi \) is an angle of lead.

Two reactances are introduced namely Xd called the direct axis synchronous reactance and xq called the quadrature axis synchronous reactance.

Current can also be split up into components along these axes.

The component of the armature current I cos\( \phi \) is in phase with E0 and I sin\( \phi \) is the component of armature current in quadrature with it.
Both these components of armature reaction rotate at synchronous speed with respect to the armature winding.

The voltage vector diagram based on the two reaction theory is shown in the following figure. Referring to the phasor diagram,

\[ V = \text{terminal voltage} \]
\[ I = \text{load current, lagging behind } V \text{ by an angle} \]
\[ I_d = \text{component of } I \text{ along d-axis} \]
\[ I_q = \text{component of } I \text{ along q-axis} \]
\[ I_r = \text{armature resistance drop} \]
\[ I_{dx} = \text{direct axis synchronous reactance drop} \]
\[ I_{qx} = \text{quadrature axis synchronous reactance drop} \]
\[ E_0 = \text{induced emf} \]
\[ E_0 = V + I_r + I_{dx} + I_{qx} \]

DIRECT AND QUADRATURE AXIS SYNCHRONOUS REACTANCES:

Direct and quadrature axis synchronous reactances arise from fluxes which have widely different paths. The direct component of the armature mmf acts on the main magnetic circuit of the machine.

The quadrature component has a magnetic circuit largely through the air gaps and inter polar space. Hence, the quadrature axis synchronous reactance is smaller than the direct component and is less affected by saturation.

In the non-salient pole pole machine, \( X_d \) is nearly equal to \( X_q \).
Analysis of phasor diagram:

In the phasor diagram $Y = (f + d)$ is not known for a given $V,I$ and $f$. Since the location of $E_0$ is unknown $I_d$ and $I_q$ cannot be found which are needed to draw the phasor diagram.

This difficulty is overcome by establishing certain geometric relationships for the phasor diagram.

From the above figure, AC is drawn at $90^\circ$ to the current vector $I$, and CB is drawn at $90^\circ$ to $E_0$.

The currents drawn by the armature setup an mmf wave rotating at synchronous speed as shown in the figure.

Since the motor is being run at a speed close to synchronous, the stator mmf slowly past the field poles at slip speed $(N_s - N)$. The two sets of poles will be alternately in line and in space quadrature.

When they are in line the armature mmf acts through the main magnetic circuit and at that instant the impressed armature voltage, divided by the corresponding armature current will be equal to $X_d$, the direct axis synchronous reactance.

When two sets of poles are in space quadrature the ratio of armature voltage to armature current will be $X_q$, the quadrature axis synchronous reactance.

If the slip is sufficiently small, the pointer of the indicating meters will swing slowly from a maximum to a minimum. The C.R.O. records of the armature voltage and current are shown in figure.

The voltage induced in the open field winding is the result of the varying flux linked with it as the field poles slip through the rotating armature field.

Then,

$$X_d = \frac{\text{Maximum armature voltage}}{\text{minimum armature current}}.$$ This occurs when the induced field voltage is a minimum.
Xq = Minimum armature voltage / maximum armature current. This occurs when
the induced field voltage is a maximum.

Source: http://mediatoget.blogspot.in/2011/04/two-reaction-theory-of-salient-pole.html