

VFDs & their Side Effects on Pumpsets : Motor Cooling

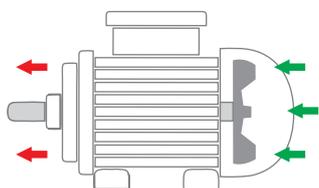
The use of VFDs for pumping applications is a promising possibility (*subject to the precondition of Frictional head being a substantial portion of Total System head*) to save Energy & regulate Flow - a typical water supply (*distribution*) pumping system with VFD can result into such a scenario wherein there are substantial energy savings.

Typical benefit of VFD on Pump-Motor set							
Frequency		Hz	50	45	40	35	30
		%	100%	90%	80%	70%	60%
Pump	Sync Speed	rpm	1500	1350	1200	1050	900
	Head	m	35.0	28.4	22.4	17.2	12.6
	Flow	m ³ /hr	1000	900	800	700	600
	bkW	kW	112.1	86.9	61.0	50.3	34.3
Motor	kVAi	kVA	147	118	87	74	54
	V	V	415	374	332	291	249
		%	100%	90%	80%	70%	60%
	A	Amp	204	182	152	147	124

Hence this paper is published to raise awareness about some Side Effects (*of VFDs onto pumps & motors*) & methods to mitigate them.



However, satisfactory operation of any Motor depends upon its (*Stator Insulation*) Temperature which in turn relies upon the rate of Heat Dissipation always being more than that of Heat Generation

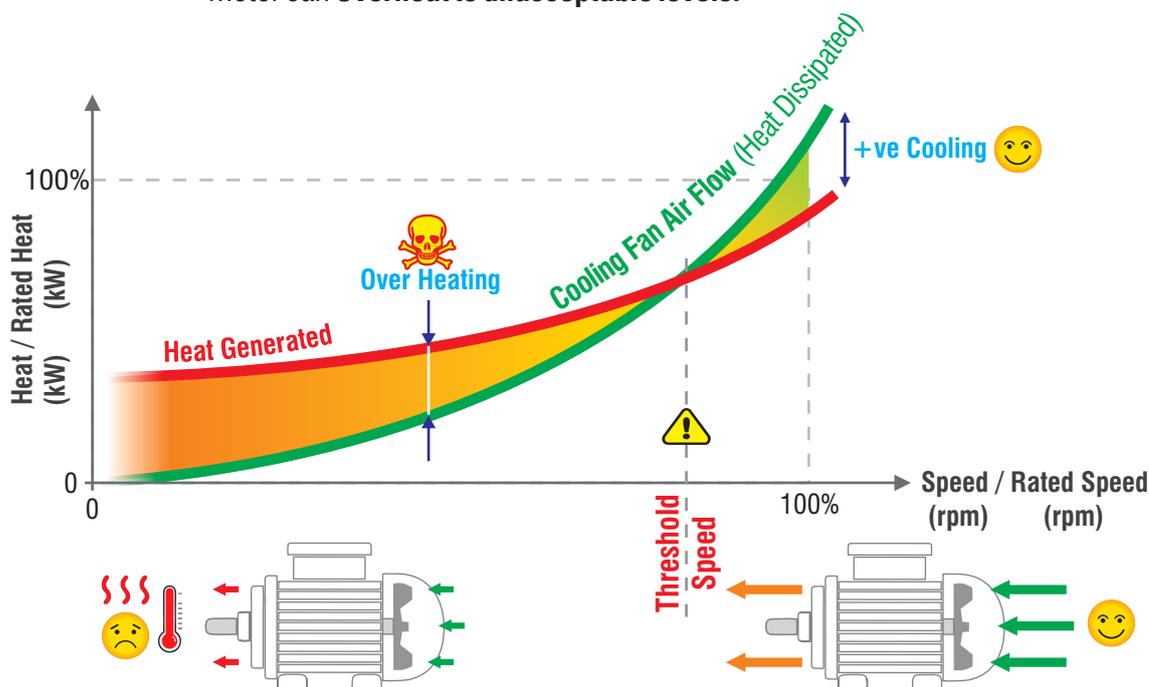


Totally Enclosed
Air Fan Cooled (TEFC)
(Squirrel Cage Induction) motor
(Shaft Mounted Fan - IC4A1A1)

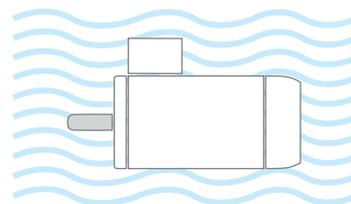
In case of typical Air Cooled (TEFC) motors, Heat Dissipation (Cooling) is by mode of Forced Air blown by a (*centrifugal axial*) Fan mounted on the motor shaft itself.

As per the basic law of centrifugal machines, the Fan's Output (*heat dissipation*) is proportional to the **cube** of it's speed.

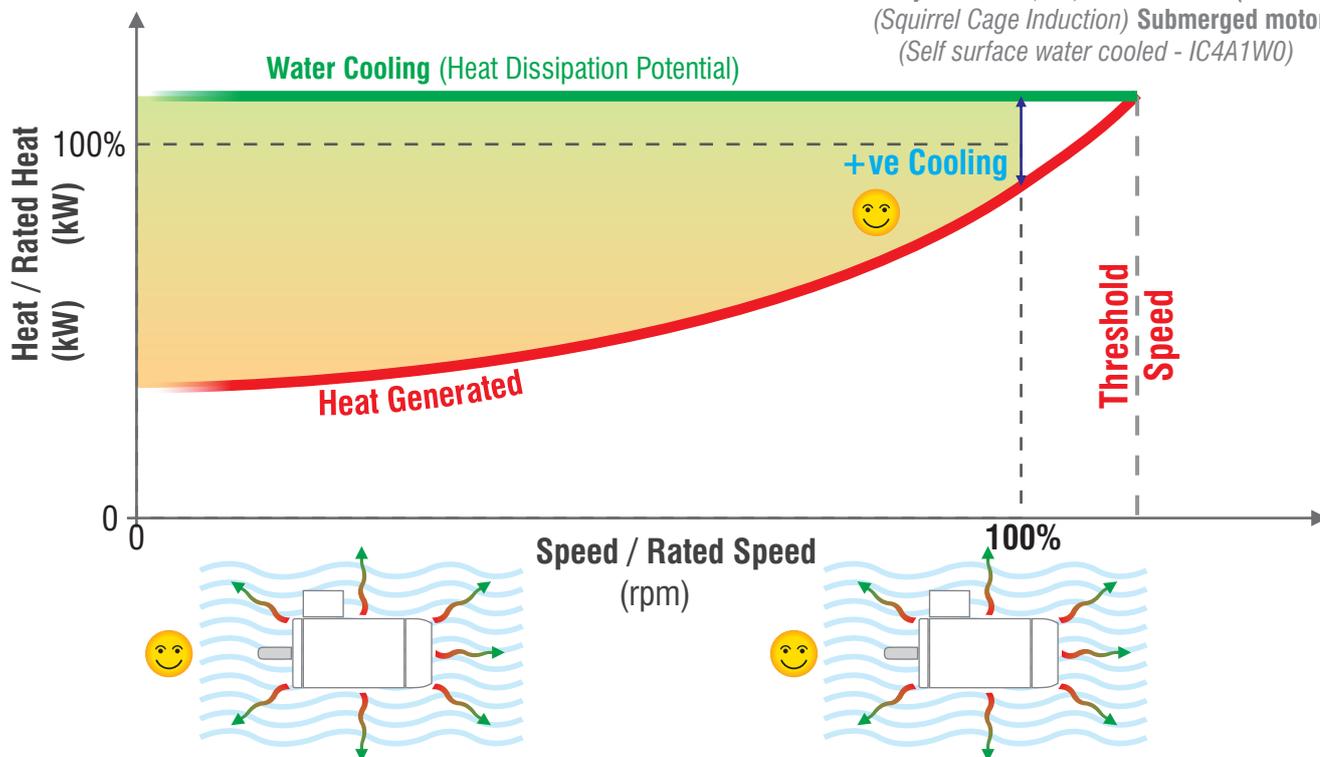
Hence when such motor's speed is slowed down by VFDs, the Cooling Fan (*being mounted on the motor's shaft*) **also slows down** & subsequently the motor's **Cooling Air Flow** (*heat dissipation*) **reduces drastically** - so much so that below a **threshold** speed; the motor can **Overheat to unacceptable levels**.



Totally Enclosed (IP68) **Water Cooled (TESWC)** (Squirrel Cage Induction) **Submerged** motors are cooled (quenched) by **Surrounding Water** - hence **it's cooling effectiveness is not dependent on the speed (or VFD).**



Totally Enclosed (IP68) **Water Cooled (TESWC)** (Squirrel Cage Induction) **Submerged motor** (Self surface water cooled - IC4A1W0)



Typical effects of VFD on Various Types of Pump-Motor sets (rated parameters 125kW, 1500rpm (sync) 4P; 35m x 1000m³/hr @ 50Hz)

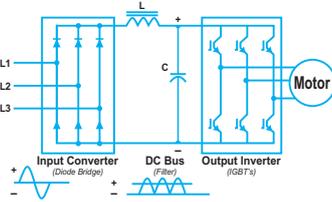
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Pump	Speed (sync)	rpm	1500	1350	1200	1050	900
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Motor	kVAi	kVA	147	118	87	74	54
	V	v	415	374	332	291	249
		%	100%	90%	80%	70%	60%
	A	Amp	204	182	152	147	124
	Heat Generated Iron Losses	kW	1.63	1.20	1.05	0.86	0.74
	Heat Generated Copper Losses	kW	7.80	6.20	4.85	3.55	2.36
	Heat Generated Stray Losses	kW	1.96	1.20	0.80	0.55	0.38
Total Heat Generated	kWh	11.39	8.60	6.70	4.98	3.48	
TEFC Air Cooled motor	Cooling Fan Flow (Heat Dissipated)	cfm (kWh)	11.75	8.57	6.70	4.97	3.48
	Heat Dissipated / Heat Generated	%	103%	100%	90%	81%	73%
		Condition	Cool	Cool	⚠ Heats up	☠ Heats up	☠ Heats up
Submerged Water Cooled motor	Water Cooling (Heat Dissipation Potential)	kWh	11.75	11.75	11.75	11.75	11.75
	Heat Dissipated / Heat Generated	%	103%	137%	175%	236%	337%
		Condition	Cool	Cool	Cool	Cool	Cool



Thanks to Unchanged cooling effect of Surrounding Water; Submerged motors can be blindly used with VFDs while still being always effectively cooled at any Speed.

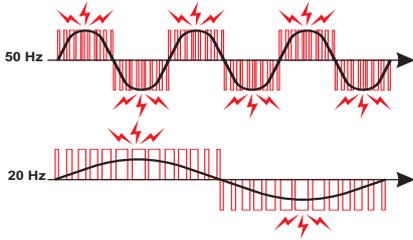
VFDs & their Impact on Motors : Stress on Motor Insulation

The use of VFDs in water pumping is increasing day by day & hence this paper is published to raise awareness about some side effects (& methods to mitigate them) of VFDs on motors.



Side Effects of **Speed Control** of Pumpsets via **VFD's** :

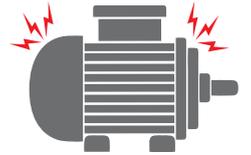
- 1) Generate PWM Output with **High Harmonic Distortion** which causes **severe Di-Electric stress** (on Motor's Stator's Winding Insulation),
- 2) Excite Motor Stator - Rotor **Bearing Circulating Currents** (which flow through **NDE bearings**),
- 3) May cause **Shaft Vibrations & even Structural Resonance** (if the **Critical Speed of the Shaft lies below the maximum speed**).



Harmonic Distortion due to VFD causes severe stress on Di-Electric on Motor's Stator's Winding Insulation Leading to its accelerated aging & even failures...!



Thanks to Additional **Mica** (Over & Above Glass Fibre Aramid), + **Dual Vacuum Pressure Resin Impregnation (VPI)**; Aqua's Motor's **Insulation** has **Extremely High Stator Winding Di-Electric Strength** enabling it to work satisfactorily even when fed by **VFD**.



World's Best, Premium **Motor Insulation**



VFDs & their Impact on Motors : Bearing Current & Static Charges

Larger & HT motors are always offered with **Current Insulated NDE Bearing Housings**, reducing the risk of bearing failures arising from internal Rotor-Stator-Bearing Circulating Currents excited by VFD's.



Superb Bearing Life

thanks to **Heavy Duty Designs** (upto **Quadruplex** arrangements are offered)



All **Thrusts** are absorbed by **Grease Lubricated, Anti Friction Bearings** located deep inside the motor & inherently **isolated from the pumped media** - this makes the **bearings Fail Proof** even in case of increased Silt/ Abrasive levels in Pumped Liquid.



Anti Drip, Fully Synthetic: Super Premium Synthetic Grease ensures a minimum Regreasing Interval (710%) of 75,000h (for Pumpsets rated upto 650kW) & 45,000h (for larger kW)

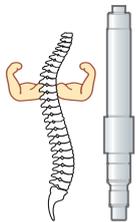
VFDs & their Impact on Pumpsets : Shaft & Structural Resonance

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No Resonance or No Excessive Vibration in
Rigid, Single Shaft Pumpsets
when used with VFD

<p>Multiple, Jointed; Long Slender Shafts (Vertical Turbine Pumpset (VT))</p>	<p>Rigid, Single; Robust Shaft (Submerged Tubular Column Pumpset (ATBx))</p>
<p><i>As the Critical Speed of Submerged Tubular Column Pumpsets lies Safely ABOVE its Maximum Speed, there is No Risk of Resonance or Vibration (when speed is varied with VFD)</i></p>	

A Strong, Mono Shaft for Fail Safe Operation



Single, Robust & oversized Shaft is Common between the motor & pump made from Stainless Steel & designed without any Sleeves (below the Mechanical Seals) thereby reducing maintenance problems & eliminating need of Costly Spare Parts.

