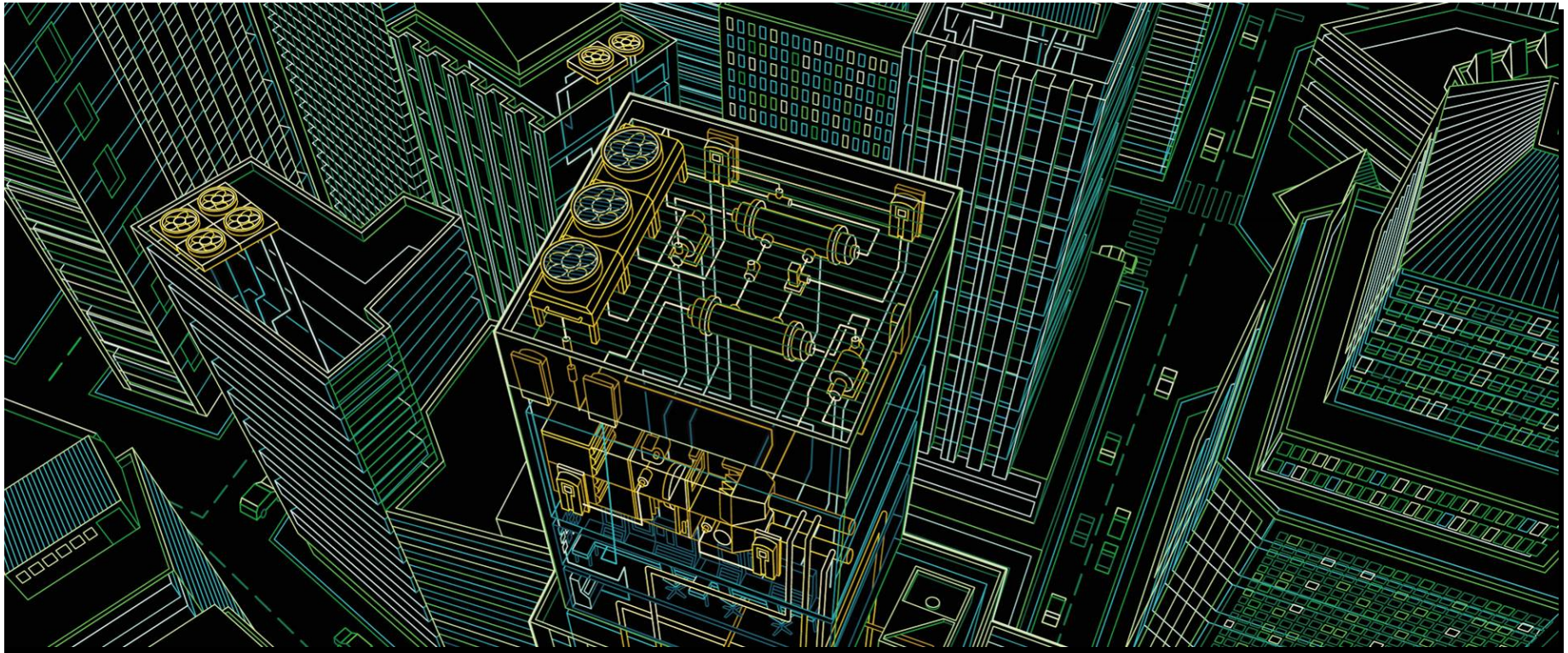


Drives and Motor Sizing Made Easy

Drive and motor sizing made easy

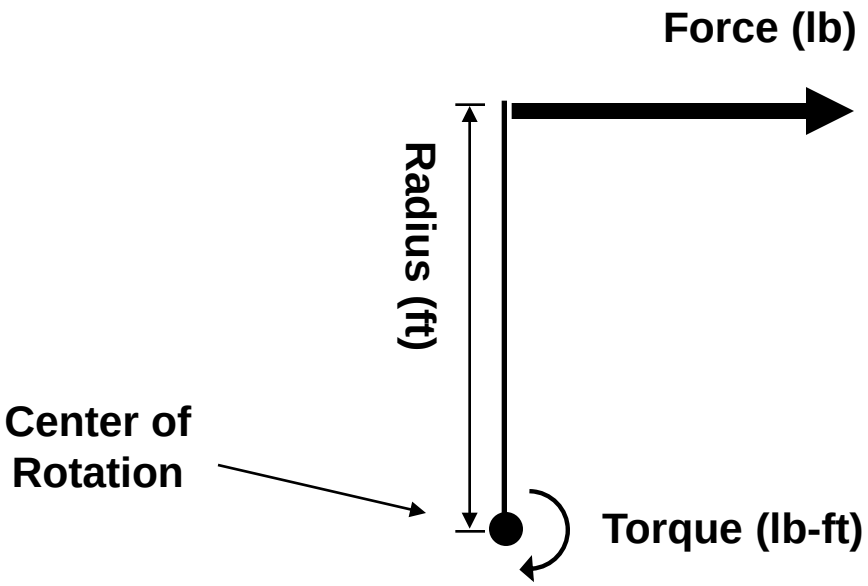
- Size your drive and motor in three easy steps
  - Determine the application requirements
  - Size the motor to meet the application
  - Size the drive to meet the motor and the application

Determine the application requirements

- What are the torque requirements?
  - Motor torque (not power) is usually the decisive factor
    - Torque requirement establishes current requirement
  - Continuous torque requirements
    - Variable torque vs. Constant torque
  - Intermittent (peak) torque requirements
    - Starting torque
    - Acceleration torque
- What is the speed requirement?
  - Maximum speed
  - Minimum speed

Torque, what is it?

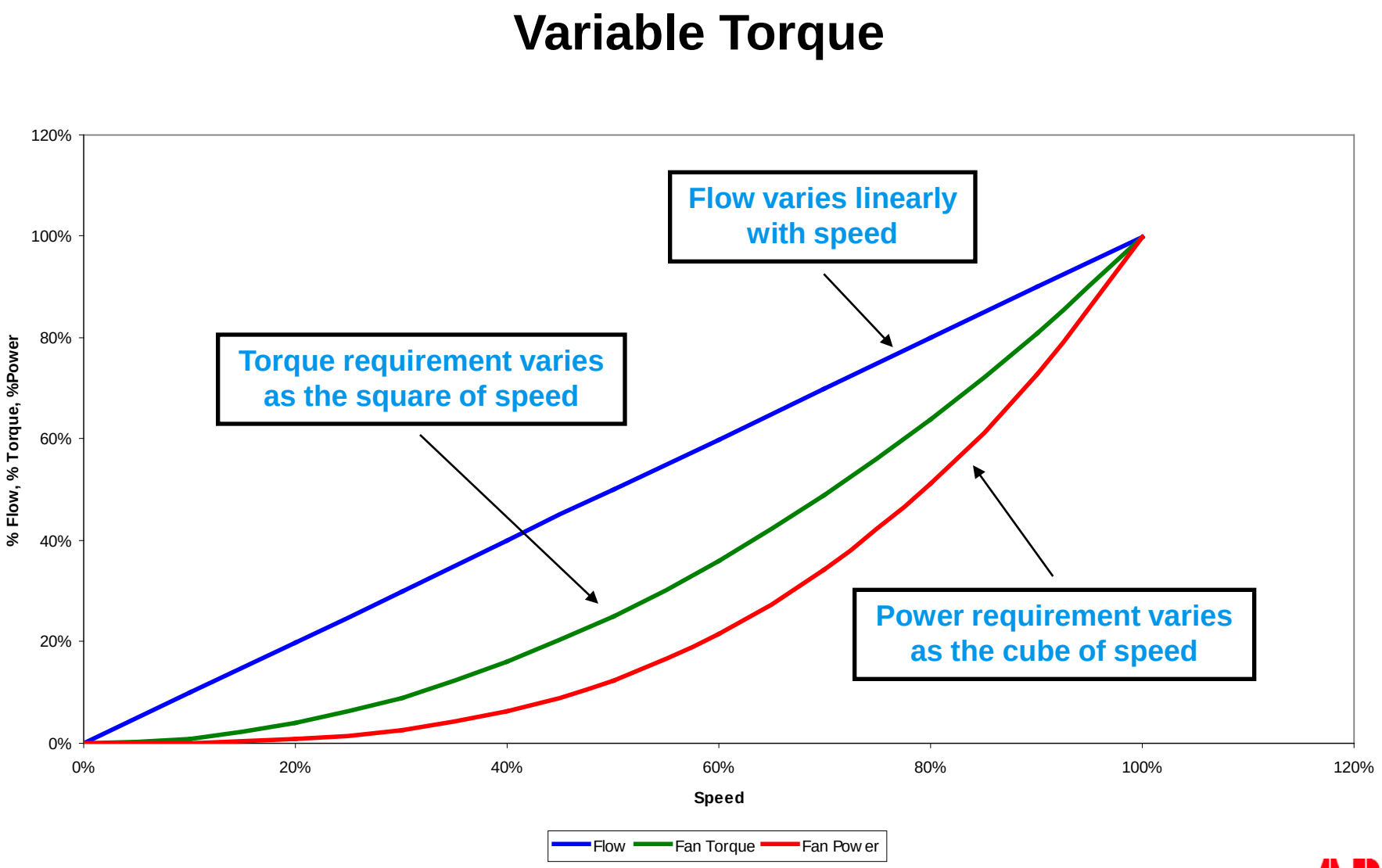
- A measure of the effect of a force applied at a distance to an axis
  - Torque is a force that tends to rotate or turn things
  - Torque(lb-ft) = Force (lb) x Radius (ft)



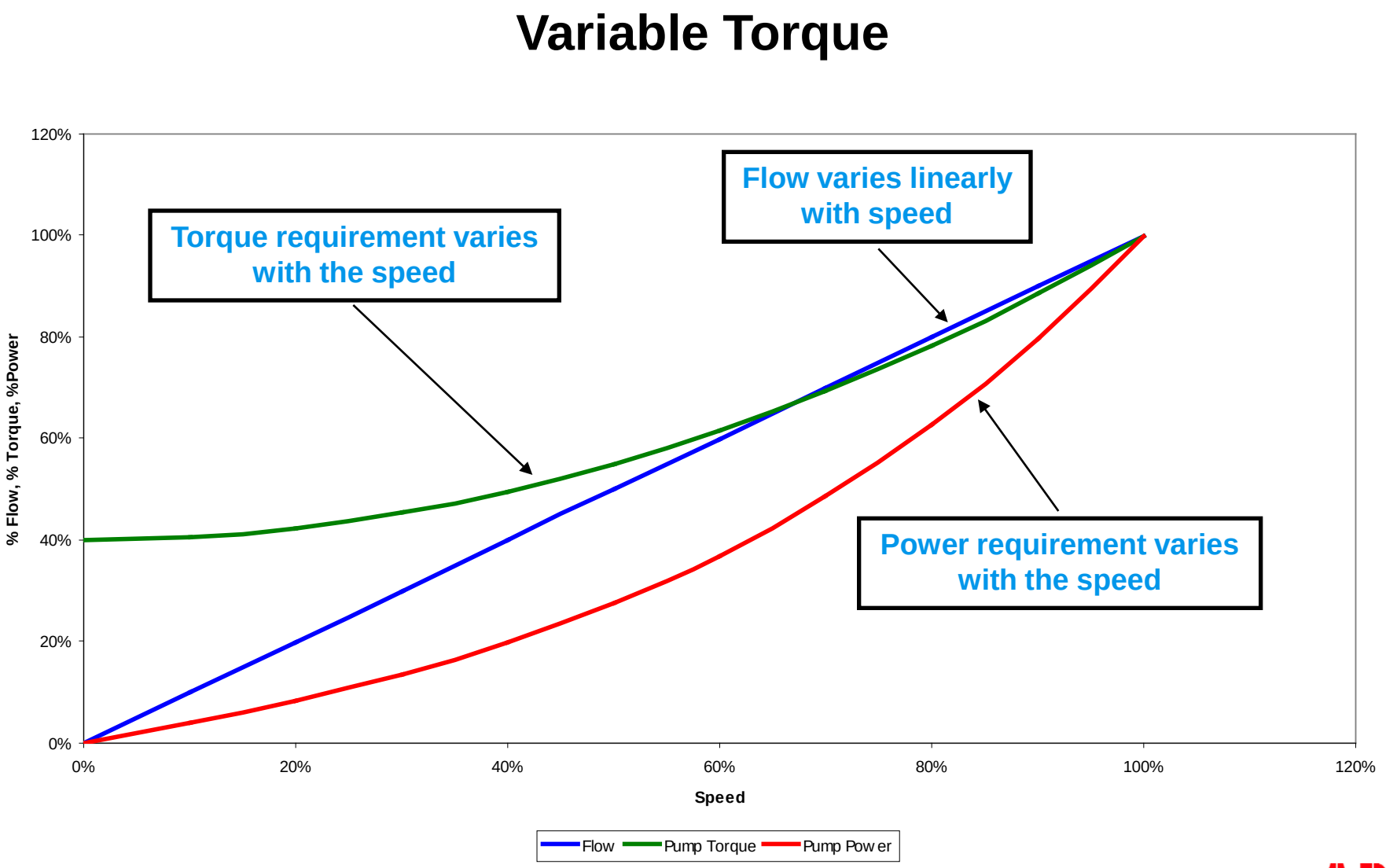
Variable Torque

- Variable torque changes as the operating speed changes
  - Fans
  - Centrifugal Pumps
  - Centrifugal Blowers
  - Mixers (material dependent)

Variable Torque (fan with no static head)



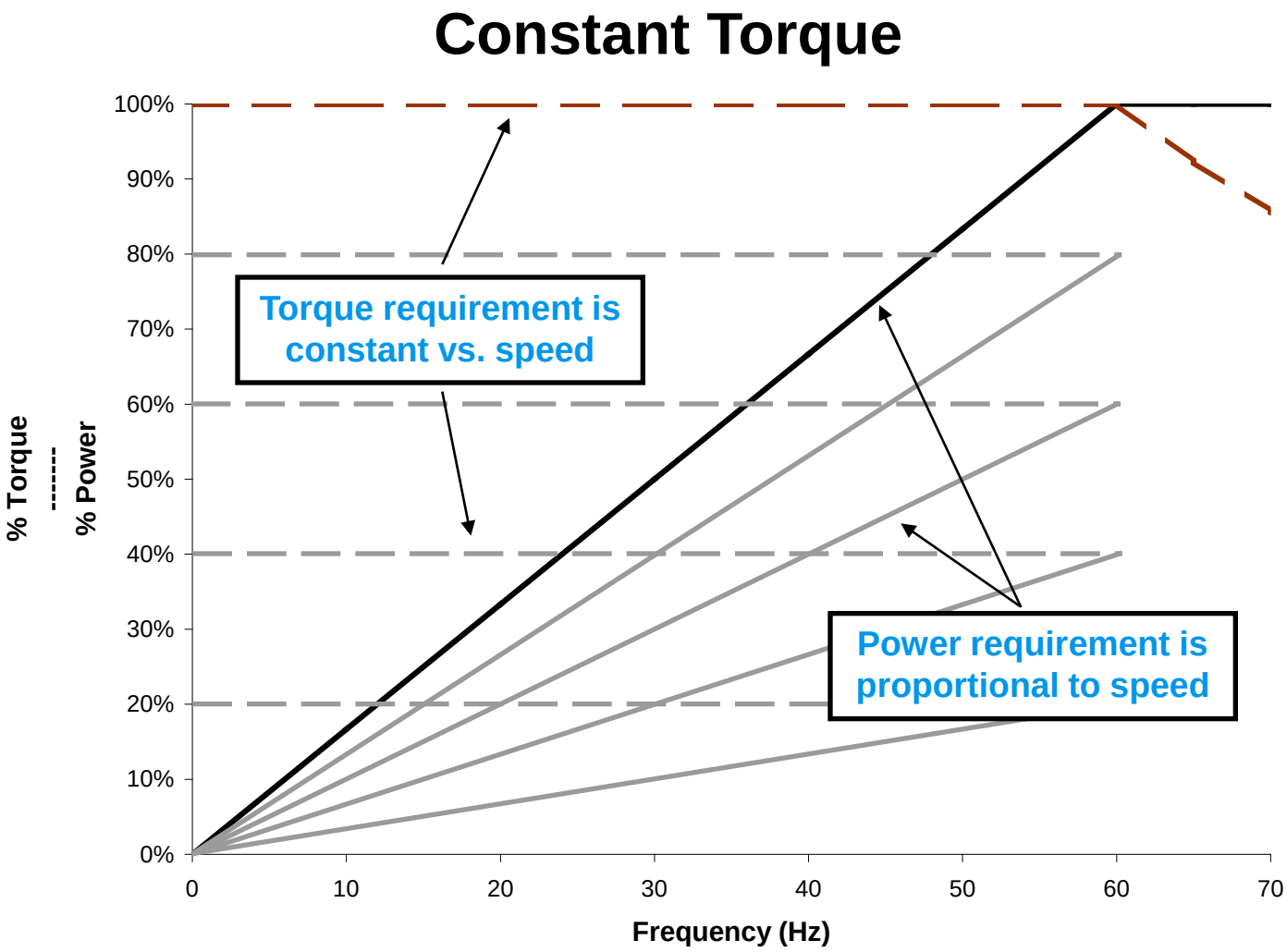
Variable Torque (pump with static head)



Constant Torque

- Constant torque remains the same as the speed changes
  - Conveyers
  - Positive Displacement Pumps
  - Extruders
  - Crushers
  - Mixers (material dependent)
  - Rotary Kilns
  - Hoists
  - Elevators

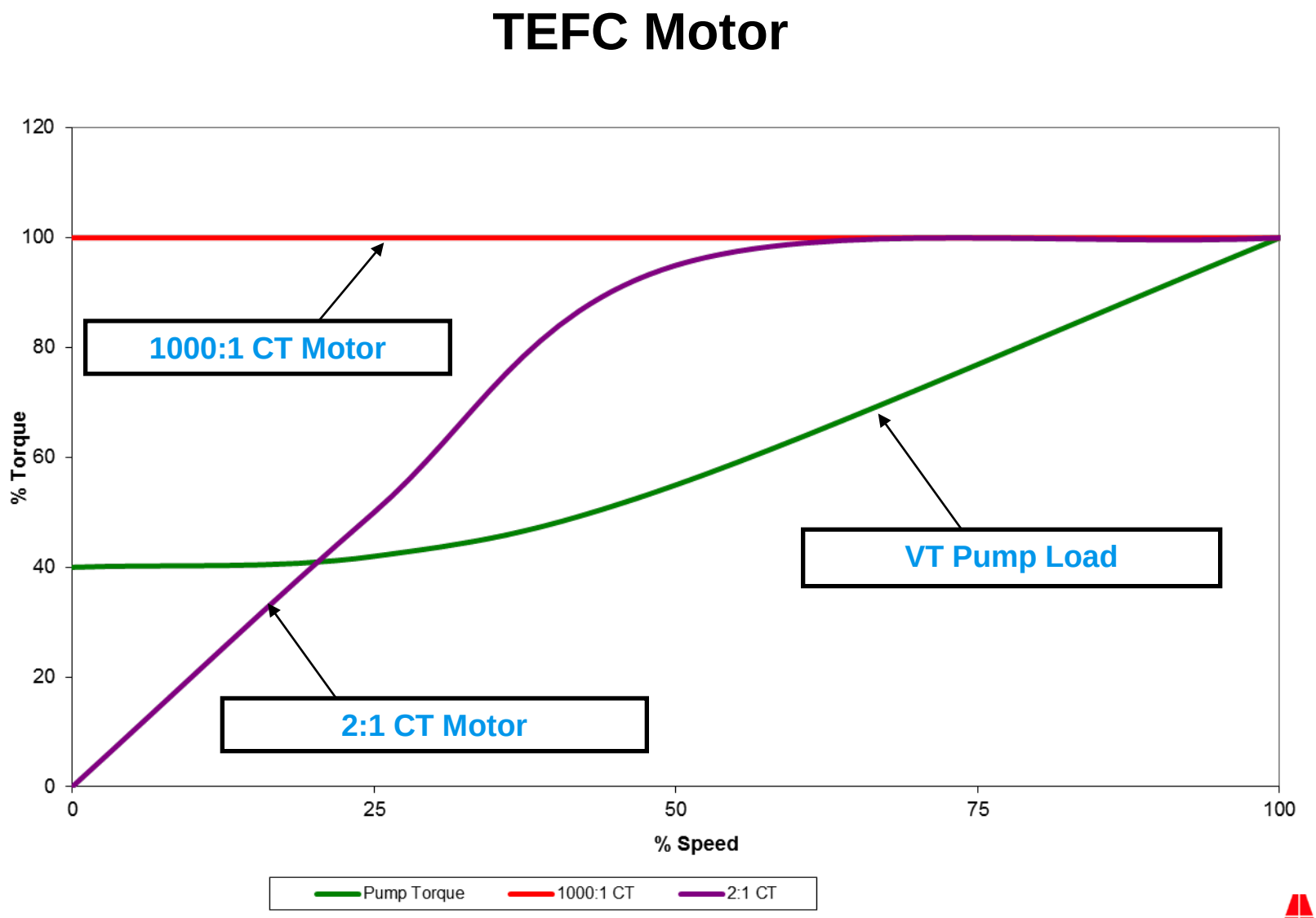
Constant Torque



Constant Vs. Variable Torque

- Why should I care?
- Isn't all torque the same?
- Yes. But ….
  - Motor current is proportional to torque
  - Motor heating is proportional to current
  - In the case of a TEFC motor, cooling is proportional to speed
- Result --- **a TEFC motor's ability to thermally handle torque varies with speed**
- A **constant torque load often requires a larger TEFC motor** than that required for an equivalent variable torque load

TEFC Motor Torque

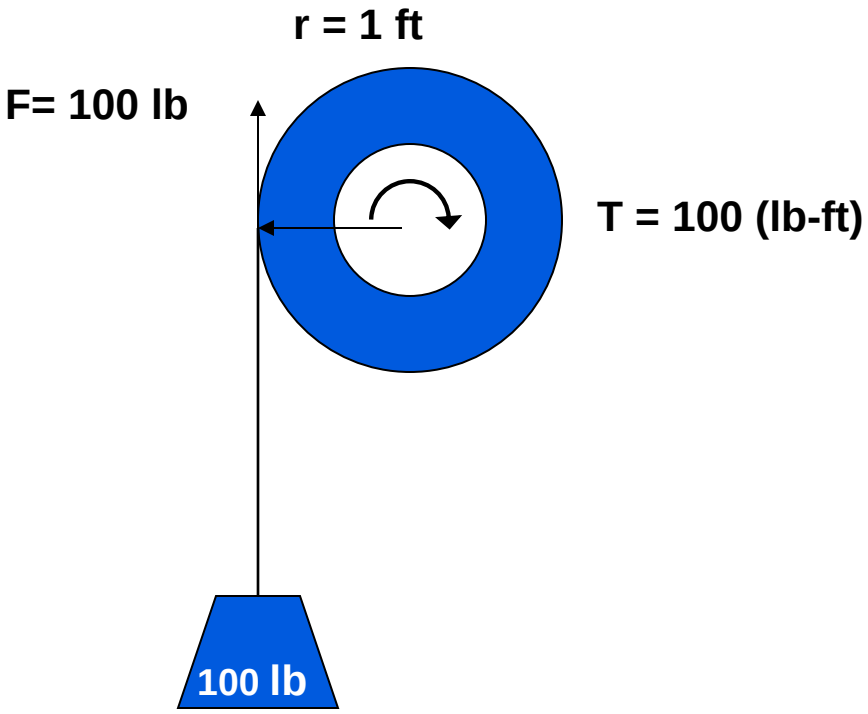


Intermittent torque

- Intermittent torque is torque that is required for a relatively short period of time. Examples:
  - Torque to breakaway the load and start motion
    - Friction
  - Torque to accelerate the load
    - Inertia

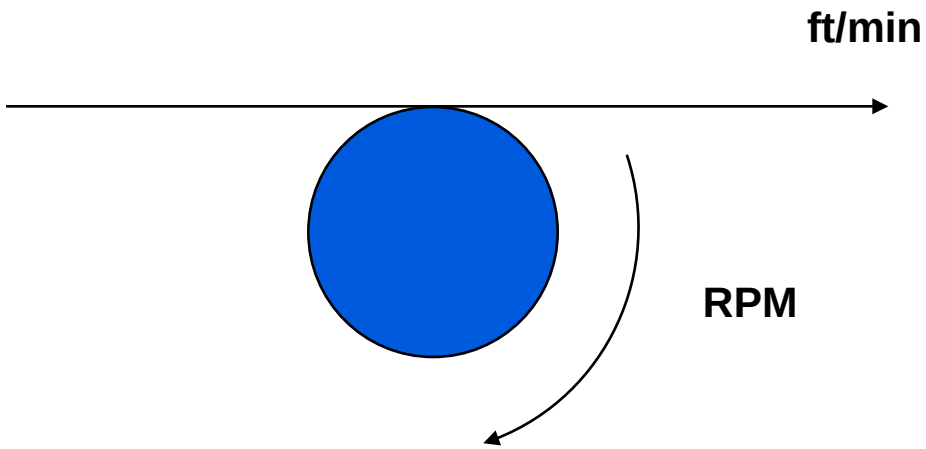
Torque Example

- Torque (lb-ft) = F (lb) x r (ft)



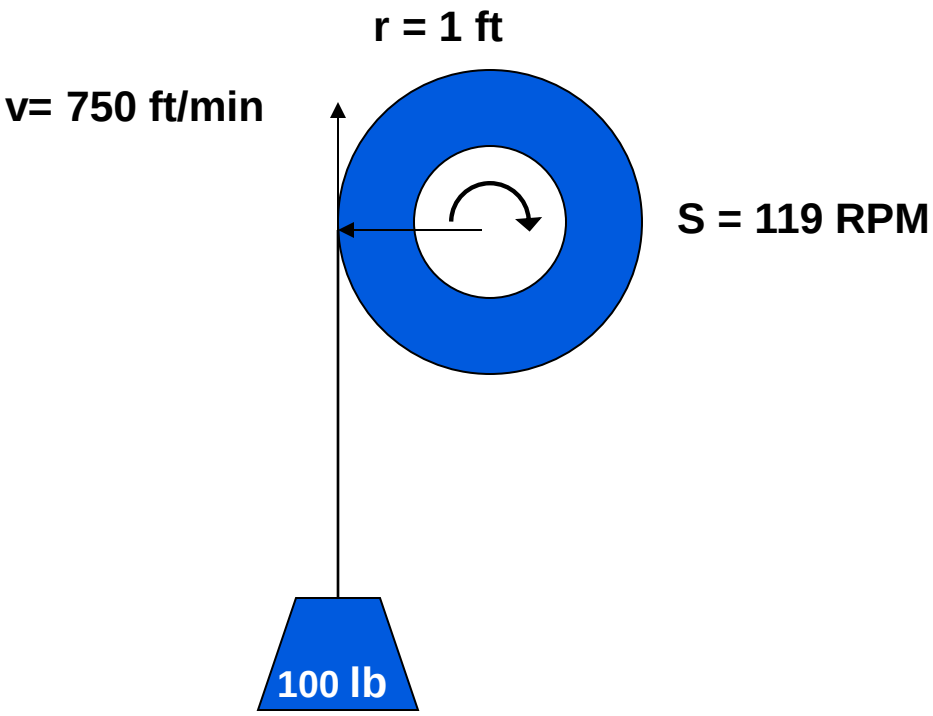
Speed

- With direct mechanical drive, motor speed is determined by mechanical speed and physical dimensions
- Speed (RPM) = v (ft/min) / (r (ft) x 2 x pi)



Speed Example

- Speed (RPM) = v(ft/min) / (r(ft) x 2 x pi)
- Speed (RPM) = 750(ft/min) / (1 (ft) x 2 x pi) = 119 (RPM)



Power

- Power is the product of torque times speed
  - Power (HP) = Torque (lb-ft) x Speed (RPM) / 5252
  - For our example:
    - Torque = 100 lb-ft
    - Speed = 119 RPM
    - Power = 100 (lb-ft) x 119 (RPM) / 5252 = 2.3 HP

Motor Sizing

- In our example
  - Torque = 100 lb-ft
  - Speed = 119 RPM
  - Power = 100 x 119 / 5252 = 2.3 HP
- What size motor do we pick?

A motor only develops its nameplate power at its nameplate speed. At a reduced speed it develops a proportionately reduced power.

HP	Base Speed	Rated Torque
3	1790	9
5	1790	15
7.5	1790	22
10	1790	29
15	1790	44
30	1790	88
40	1790	117

Motor Sizing

HP	Base Speed	Rated Torque
3	1790	9
5	1790	15
7.5	1790	22
10	1790	29
15	1790	44
30	1790	88
40	1790	117

- What if we add a gear box?
  - Torque at motor = torque / gear ratio
  - Speed at motor = speed x gear ratio
- Now what motor do we pick?

Gear Ratio	1	2	5	10	15
Torque at motor (lb-ft)	100	50	20	10	6.7
Speed at motor (RPM)	119	239	597	1194	1790

Intermittent torque

- Torque for Acceleration
  - Torque = Inertia x Acceleration Rate
  - If you know:
    - Inertia (WK^2) in $lb\text{-}ft^2$
    - Acceleration Time in sec.
    - Change in motor speed in RPM
  - Then:
    - Torque = WK^2 ($lb\text{-}ft^2$) x Speed(RPM) / (Accel Time(sec.) x 307.6)

Intermittent torque

- Torque for Acceleration
  - Assume for our example:
    - Total WK^2 = 1.2 lb-ft^2
      - Includes 100 lb load, drum, 15:1 gear box and motor
    - Change in speed is 1790 RPM
    - If accel time is 10 seconds
      - Accel Torque = 1.2(lb-ft^2) x 1790(RPM) / (10(sec.) x 307.6)
      - Accel Torque = 0.7(lb-ft)
      - Total torque = 6.7 + 0.7 = 7.4 lb-ft; less than rated motor torque
    - If accel time = 1 second
      - Accel Torque = 1.2(lb-ft^2) x 1790(RPM) / (1(sec.) x 307.6)
      - Accel Torque = 7.0 (lb-ft)
      - Total torque = 6.7 + 7.0 = 13.7 lb-ft, 150% of rated motor torque

Pick a drive

- Assume for our example:
  - Motor is 3 HP, 1790 rpm, 4.2 FLA, 9 lb-ft
  - Torque to lift load and accel in 10 s is 7.4 lb-ft
    - Max Current is less than 4.2 amps
    - Use 3 HP normal duty drive, 4.9 amps, with 110% O.L. (5.4 amps peak)
  - Torque to lift load and accel in 1 s is 13.7 lb-ft
    - Max current is about 6.4 amps
    - Use 3 HP heavy duty drive, 5.6 amps, with 150% O.L. (8.4 amps peak)

Sample Rating Table

ACS800-U1 size	I_{max}	Normal use		Heavy-duty use		Frame size	Air flow	Heat dissipation
		I_{2N}	P_N	I_{2hd}	P_{hd}			
	A	A	HP	A	HP		ft^3/min	BTU/Hr
Three-phase supply voltage 208 V, 220 V, **230 V** or 240 V								
-0002-2	8.2	6.6	1.5	4.6	1	R2	21	350
-0003-2	10.8	8.1	2	6.6	1.5	R2	21	350
-0004-2	13.8	11	3	7.5	2	R2	21	410
-0006-2	24	21	5	13	3	R3	41	550
-0009-2	32	27	7.5	17	5	R3	41	680
-0011-2	46	34	10	25	7.5	R3	41	850
-0016-2	62	42	15	31	10	R4	61	1150
-0020-2	72	54	20 *	42	15 **	R4	61	1490
-0025-2	86	69	25	54	20 **	R5	147	1790
-0030-2	112	80	30	68	25 **	R5	147	2090
-0040-2	138	104	40 *	80	30 **	R5	147	2770
-0050-2	164	132	50	104	40	R6	238	3370
-0060-2	202	157	60	130	50 **	R6	238	4050
-0070-2	282	192	75	154	60 **	R6	238	4910
Three-phase supply voltage 380 V, 400 V, 415 V, 440 V, **460** V or 480 V								
-0004-5	6.5	4.9	3	3.4	2	R2	21	410
-0005-5	8.2	6.2	3	4.2	2	R2	21	480
-0006-5	10.8	8.1	5	5.6	3	R2	21	550
-0009-5	13.8	11	7.5	8.1	5	R2	21	690
-0011-5	17.6	14	10	11	7.5	R2	21	860
-0016-5	24	21	15	15	10	R3	41	1150
-0020-5	32	27	20	21	15	R3	41	1490
-0025-5	46	34	25	27	20	R3	41	1790

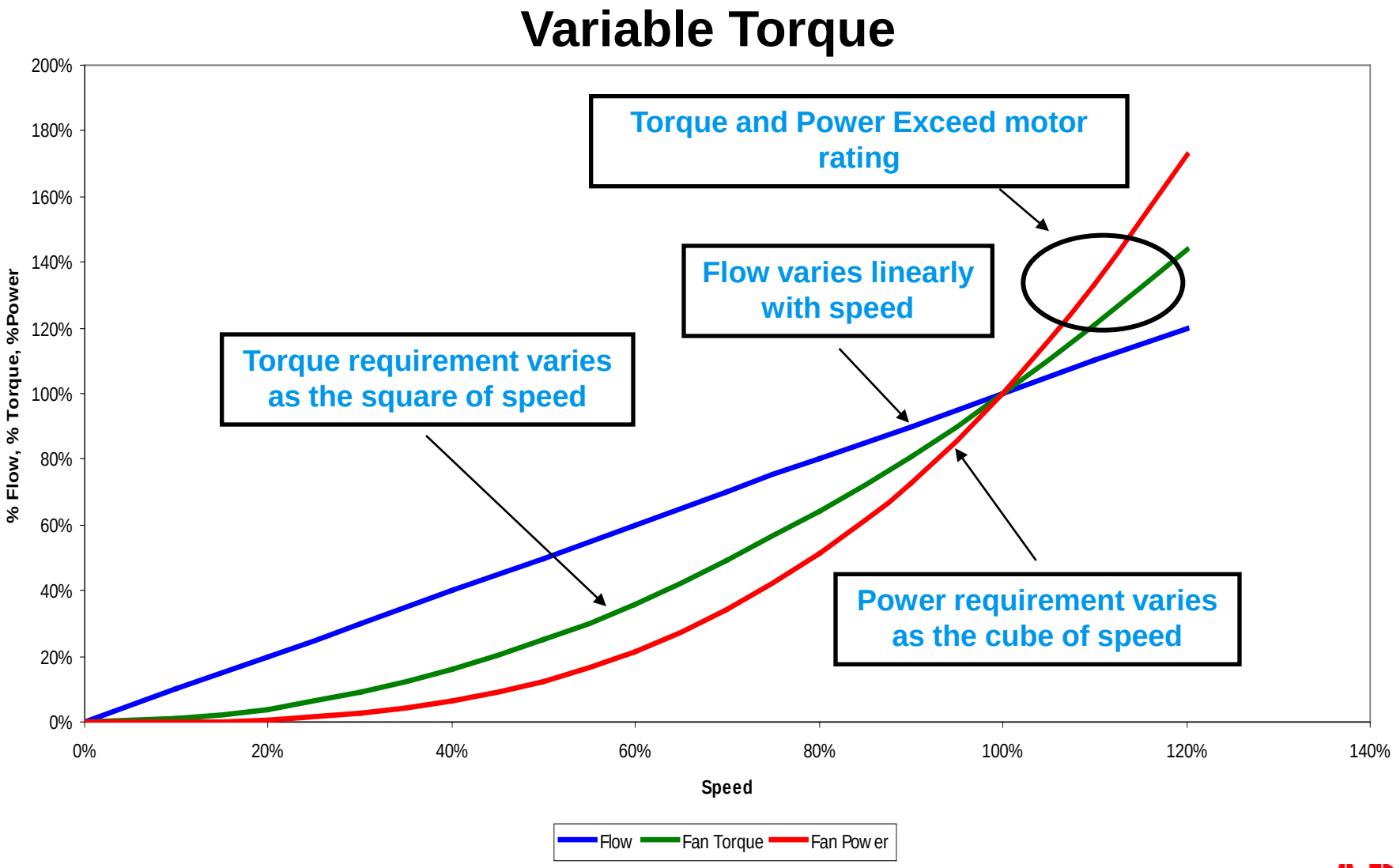
Special cases

- Intermittent torque is required for a relatively long time
  - Large inertias
    - Results in long accel time, several minutes
    - Drive and motor sized for acceleration torque
    - Examples
      - Centrifuges
      - Kilns
  - Long periods of breakaway torque
    - Mixer starting with product

Watch the limits

- Limits that can come in to play
  - Torque
    - AC Motors have max torque limits, about 200% (Drive limits motor to about 70% of motor's rated breakdown torque)
  - Speed
    - Limited by maximum safe mechanical speed
    - Limited by maximum drive frequency
    - Limited by reduced maximum torque above base speed (Constant HP operation)
  - Current
    - Limited by inverter
    - Full speed motor current rises when line voltage is low
  - Regenerative (Braking) Torque
    - If less than 10% Flux braking may be good enough
    - If more than 10% but intermittent, such has stopping only, use brake chopper and resistor
    - If more than 10% and continuous, consider a regenerative drive

Variable Torque Above Base Speed



Conclusion

- Drive sizing made easy
  - Determine the application’s requirements
    - Torque
      - Continuous
      - Intermittent
    - Speed
  - Pick the motor
    - Try to gear in to run at base speed
    - Size on torque not power!
  - Pick the Inverter
    - Continuous current
    - Overload current

Now, that’s easy!

Power and productivity
for a better world™