1. HOIST DC Motors Mathematical Model (Ref. HDK)

1.1 Motor Data:

Motor Type : CD Kinamatic shunt wound DC Motor
Frame CD6063
Mechanical Power : 375 HP - 280 kW
Efficiency : 91 %
Voltage : 225 V armature 120 V field
Current : 1360 A arm. 30/12.6 A field
Speed : 850/2070 rpm

Resistances (@ 25°C: Cold windings)
Armature = 0.0037 ohm
Comm (&Comp.) Fld. = 0.0016 ohm
=> Ra = 0.0053 ohm (arm. & Comm field coils in series)
Shunt Field = 11.1 ohm (two circuits in series) => 5.55 ohm (each circuit)
=> Rf = 2.775 ohm (field coils in parallel)
Resistances (@ 128°C: Hot windings) = Resistances (@ 25°C) x [1 + 4.3x10-3/°C x (128°C - 25°C)]
Armature = 0.0053 ohm
Comm (&Comp.) Fld. = 0.0023 ohm
=> Ra = 0.0076 ohm (arm. & Comm field coils in series)
Shunt Field = 16 ohm (two circuits in series) => 8 ohm (each circuit)
=> Rf = 4 ohm (field coils in parallel)
Inductances (Unsaturated)
Armature Circuit Total = 0.3494 mH
=> La = 0.3494 mH
Shunt Field = 19.1 H (two circuits in series) => 9.55 H (each circuit)
=> Lf = 4.775 H (field coils in parallel)

Torque Constant, estimated linearized value (calculated at nominal conditions)
Tmnom=Pmnom/Wmnom = 279.75x10^3 W/ 89.0118 rad/s = 3142.842 N.m
Kt = Kv = Tmnom/(Ifnom x Ianom) = 3142.842 N.m / (30 A x 1360 A) = 0.07703 N.m/A2
=> Kt = Kv = 0.07703 N.m/A2
Inertias
Jm = 250 lb.ft2 = 10.54 kg.m2 (WK2) (motor)
Jb = 112.5 lb.ft2 = 4.741 kg.m2 (brake)

Jmec = 142 lb.ft2 = 5.984 kg.m2 (drum, gearbox, etc.)
Jl = 8.2504 kg.m2 (rated load (40LT) + spreader & headblock)
Je = 2.132 kg.m2 (empty spreader & headblock)

1.2 Model Parameters:

2 DC Motors - Series Connected
Armature parameters:
La = 2 x 0.3494x10-3 H => La = 0.6988x10-3 H
Cold: Ra = 2 x (0.0037 + 0.0016) ohm => Ra = 0.0106 ohm Arm. Time Constant τa = La/Ra = 65.92 ms
Hot: Ra = 2 x (0.0053 + 0.0023) ohm => Ra = 0.0152 ohm Arm. Time Constant τa = La/Ra = 45.97 ms
Field parameters:
Lf = 2 x 4.775 H => Lf = 9.55 H

Cold: Rf = 2 x 2.775 ohm => Rf = 5.55 ohm Field Time Constant τf = Lf/Rf = 1.72 s
Hot: Rf = 2 x 4 ohm => Rf = 8.00 ohm Field Time Constant τf = Lf/Rf = 1.19 s
Torque constant:
Kt = 2 x 0.07703 N.m/A2 => Kt = 0.15406 N.m/A2
Total Hoist Drive Inertia reflected to motor shaft :
@ Empty Spreader Jtote=2 x (Jm + Jb)+ Jmec + Je => Jtote = 38.678 kg.m2
@ Rated load (40 LT) under Spreader Jtotl=2 x (Jm + Jb) + Jmec + Jl => Jtotl = 44.7964 kg.m2
Reducer Gearbox ratio (motor shaft to drum shaft):
r = 24.45 : 1 => r = 24.45 : 1
Load Gravitational Torque reflected to drum shaft:
Ml = 40 LT = 40642 kg, Ms = 10.715 LT = 10886.976 kg, Mh = 3.219 LT = 3270.665 kg
Empty Spreader Mtot=Mh+Ms Mtote = 14161 kg
Rated load (40 LT) under Spreader Mtot=Mh+Ms+Ml Mtotl = 54801 kg
Empty Spreader : Tle = (Mtote.g)/2 x Dd/2 => Tle = 41661.59 N.m
Rated load (40LT) under Spreader : Tll = (Mtotl.g)/2 x Dd/2 => Tll = 161224.27 **N.m**
Friction coefficient reflected to motor shaft: neglected => fm = 0 N.m/rad/s

1.3 Motor Block diagram: