AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
MECHATRONICS ENGINEERING DEPARTMENT
Mechatronics Engineering Program

Spring, 2022

MCT 333: Mechatronic Systems Design

Sheet 3: Industrial Motor Selections

1) Consider the machine shown in Figure 2.12. If both axes are moving at the speed of 101 mm/s using trapezoidal velocity profile with t_a = 0.2 s, how long will it take each axis to complete its move?

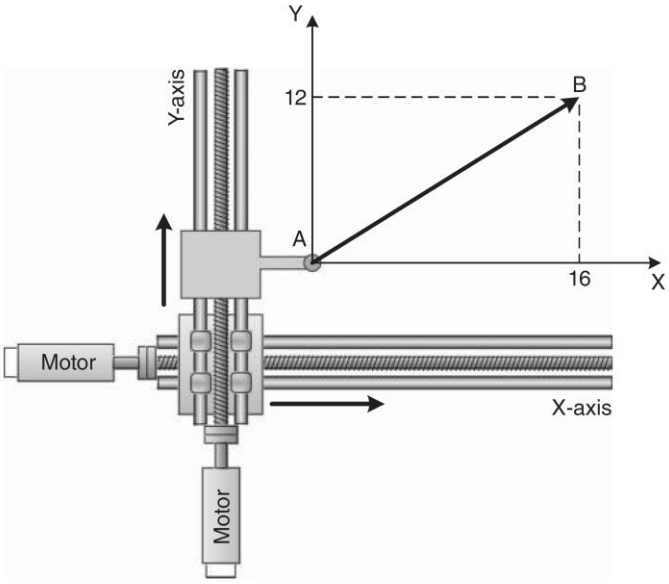
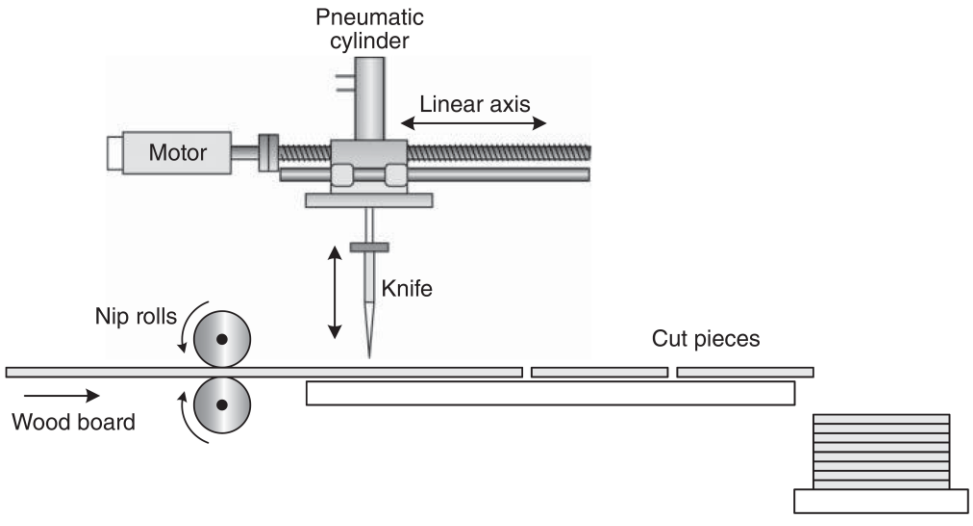
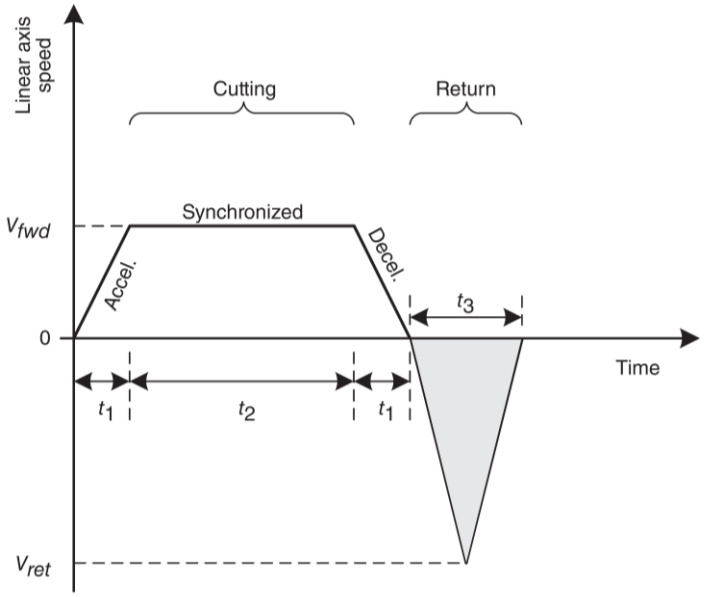


Figure 1: Multiaxis machine

2) In the motion control application shown in Figure 2, the nip rolls feed long wood boards which are cut to equal length pieces. Figure 1b shows the velocity profile for one cycle of the linear axis that carries the shear. The shear waits at a hover position over the conveyor. When it gets a signal from the controller, it accelerates and matches the speed of the conveyor (constant velocity segment). During this time, the shear is lowered and retracted to make the cut. After that, the axis slows down to zero speed and returns to the hover position. Find the return velocity V_{ret} to be programmed into the controller.



(a)



(b)

Figure 2: (a) Flying shear machine to cut continuous material into fixed lengths. (b) Velocity profile for the shear

3) Motion controllers use counts (cts) to track position. The motor in Figure 3 has an encoder that produces 8000 cts/rev. The ball-screw advances 10 mm/rev. A motion application requires the carriage of the linear axis to travel 406 mm at 101 mm/s with an acceleration of 254 mm⁄s^2. Calculate the following parameters for the carriage in the units shown: speed (cts/ms), distance (cts), acceleration (cts⁄ms^2), and move time (constant velocity time) in ms.

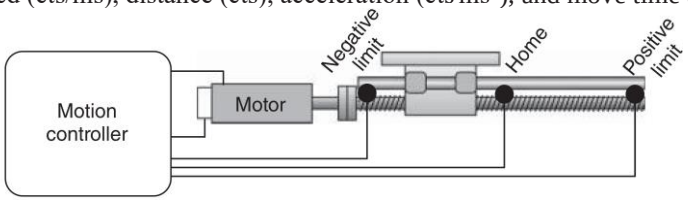


Figure 3

4) The gantry machine in Figure 4 carries a 20 kg load. The X-axis of the machine uses two 404XE-T13-VL linear tracks in parallel. The Y-axis and Z-axis use 403XE-T04 and 402XE-T04 linear tracks by the same manufacturer. The X- and Y-axis tracks have 10mm screw leads. The Z-axis has 5mm screw lead. Each axis is equipped with a BE230D motor. Each motor is connected to its axis using a cylindrical aluminum coupler with 28mm outer diameter and 38mm length. Referring to the data sheets, calculate the acceleration and continuous torque required to move each linear track of the X-axis at 250 cts⁄ms speed for 1s. Acceleration time is t_a = 50 ms.

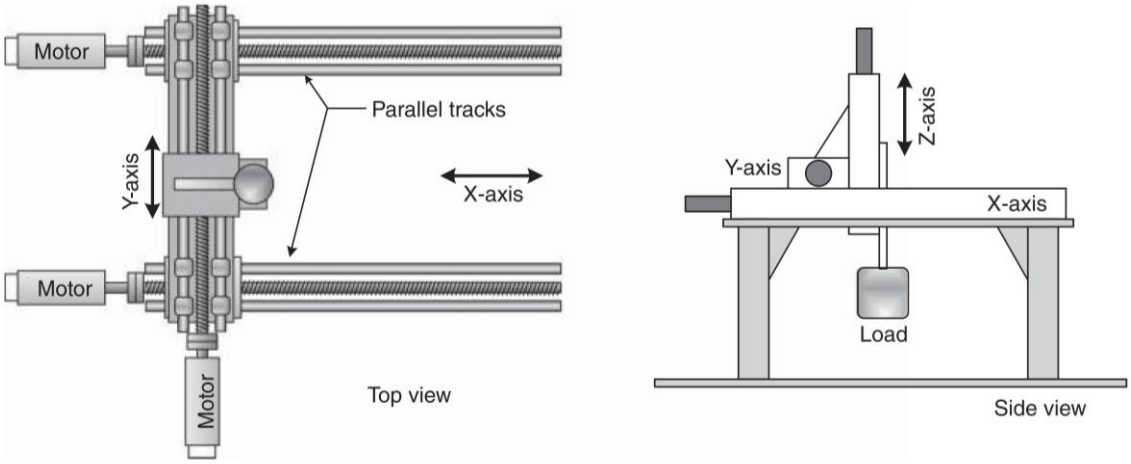


Figure 4: Gantry machine with two parallel linear tracks for *X*-axis

5) A 5 HP Black Max® vector-duty motor with 460 VAC supply voltage at 60 Hz base frequency has 1765 rpm Full Load (F.L.) speed, 7A F.L. current, 14.9 lb.ft F.L. torque and 70 lb.ft breakdown (B.D.) torque. Sketch the torque–speed curves for this drive and motor combination if the motor is connected to a drive with 5A continuous and 10A peak current.

6) The flying shear machine shown in Figure 2a will be redesigned to use a belt-drive actuator instead of the lead screw. The designer plans to use an ERV5 rodless actuator (belt drive) to replace the lead screw actuator. The cutting tool assembly weighs 35 lb. The axis has a travel length of 48 in. The cutter needs to travel at V_{fwd} = 16 in⁄s speed in synchronization with the wood board while cutting the material. The trapezoidal motion profile in Figure 2b has t_1 = 500 ms and t_2 = 2.5 s. The return motion is completed in t_3 = 2 s. Select an AC servomotor for the axis from the BE Series servo motor catalog by Parker Hannifin Corp.

7) A small converting machine shown in Figure 5 is used to process sheet aluminum. The load inertia on the rewind axis is $J_{load} = 2 \times 10^{-2}$ kg-m^2 and the axis has 7Nm load torque due to friction and tension. The motion uses trapezoidal velocity profile with ω_{load} = 150 rpm. Change in the size of the rewind roll can be ignored. Select a NEMA 23 size servomotor and a gearhead to drive the rewind axis if the cycle consists of (a) $t_a = t_d$ = 30 ms, t_c = 3 s, t_{dw} = 4 s, or (b) $t_a = t_d$ = 30 ms, t_c = 5 s, t_{dw} = 1 s.

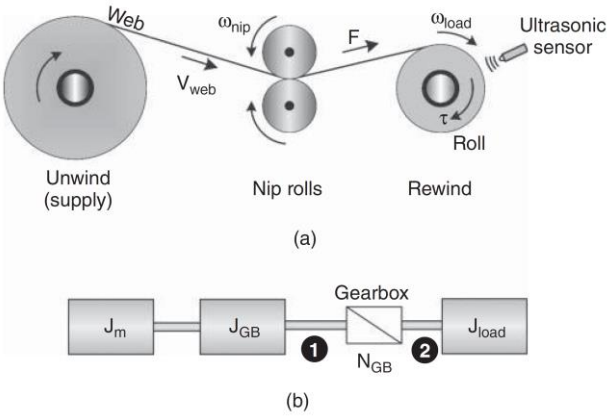


Figure 5: Motor and gearbox selection for a converting machine. (a) Sheet aluminum converting machine. (b) Rewind axis schematic

8) The machine shown in Figure 6 retrieves a plastic cap from a magazine and inserts it into the end of the core of a roll. The turret has vacuum chucks and pneumatic pistons at both ends to hold and insert the caps. First, the turret retrieves a cap from the magazine. Then, it rotates 180° and stops to position the cap in front of the core. Next, the piston inserts the cap into the core and the vacuum chuck releases the cap. Finally, the turret makes another 180° rotation back to the magazine. The turret inertia is 40 lb-ft^2. It follows a triangular velocity profile to make each 180° move in 0.8 s. The friction torque is 0.23 lb-ft. Select a vector-duty AC induction motor and gearbox for the turret axis assuming no limitations imposed by the drive current capacity.

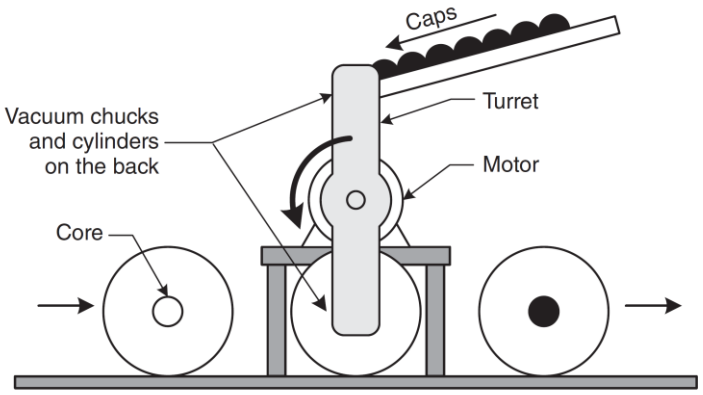


Figure 6: Core capping machine

9) A machine needs to be designed to apply glue to a product which is 60 in long. The glue head must travel over the product at constant speed while applying the glue. Due to the structural design of the machine, there are only additional 4 in of space at each end of the 60 in linear travel to be used to accelerate and decelerate the glue head. The glue must be applied in 0.8 s. The glue head is 7 in wide and weighs 28 lb. Select components from the following product families: MKR-Series linear belt drive by Bosch Rexroth AG, AKM™ servomotor by Kollmorgen and EPL-H gearhead by GAM.

10) A pallet dispenser shown in Figure 7 is used to dispense one pallet at a time to a conveyor from a stack of pallets. The machine has two axes, one for lifting the stack of pallets and the other for moving the forks in or out of the pallet stack. Initially, a stack of pallets is placed into the machine.

The machine operates as follows: (1) The forks are moved into the pallet above the bottom pallet in the stack, (2) The machine lifts the stack leaving the bottom pallet on the conveyor, (3) The conveyor is started to dispense that pallet out of the machine, (4) The conveyor is stopped, the stack is lowered and placed on the conveyor, and (5) The forks are pulled out and raised to the level of the second pallet from the bottom. The cycle is repeated from step 1. The lift axis needs to move 24 inches in 5 s ($t_a = t_d = 1$ s). It then dwells for 3 s. The machine can handle a stack of 10 pallets. The total weight of the pallets and the carriage is 1500 lb. The chain weighs 11 lb and uses two 3 in sprockets with $J_{sp} = 9.69 \times 10^{-4}$ lb-in-s^2 inertia each. The chain drive efficiency is 95%. Select a three-phase AC induction vector motor and a gearbox for the lift axis from manufacturer catalogs (search online).

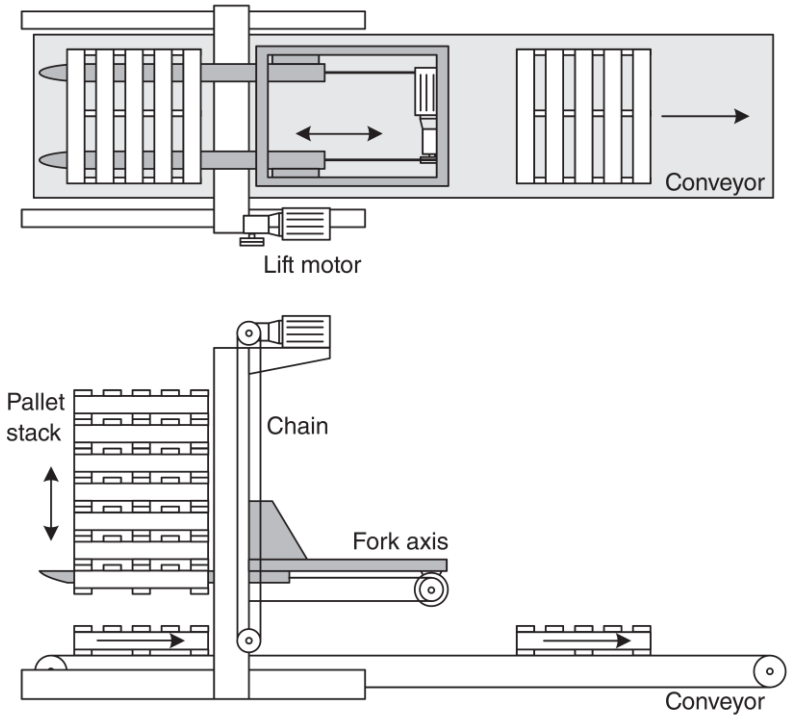


Figure 7: Pallet dispenser