E L E C T R O M E C H A N I C A L   A N A L Y S I S   L A B
E M E T   3 4 2 4 _ 7 0
T U E S D A Y ,   M A R C H   1 3 ,   2 0 0 1
8 : 0 0   –   9 : 5 0 A M ,   S E T   3 6 3

LAB#7

SCOTCH YOKE MEASUREMENTS

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LAB OBJECTIVE

The objective of this laboratory experiment is to gain experience and practice working with electrical devices. We will look at how a scotch yoke mechanism converts circular motion into linear motion. There are many ways to measure velocity. We will look at three, tachometer, oscilloscope, and velocity transducer.

The equipment used in this lab is listed but limited to this list.

- Tachometer
- Linear Velocity Transducer (LVT), manufacture sensitivity: 500 mV/in/s
- Tektronix TDS 310 Two Channel Oscilloscope, S/N: B040281, Instr. TDS310, Voltage Range: 90 – 132 V, Frequency Range: 47 – 440 Hz
- Hewlett Packard 34401A Multimeter, S/N 3146A29090

SCOTCH YOKE MEASUREMENTS

THEORY

Scotch yoke takes a revolution per minute and converts it to a linear velocity.

FIGURE 1: BLOCK DIAGRAM SCOTCH YOKE

The displacement motion of the scotch yoke is at a maximum velocity is zero. When velocity is a t a maximum, displacement is zero. Velocity max is equal to output voltage divided by sensitivity of the linear velocity transducer (LVT).

FIGURE 2: VELOCITY PEAK EQUATION

$$V_{peak} := \frac{\text{Volts}}{\text{Sensitvity}}$$

With the use of an oscilloscope, we can convert time in to angler acceleration.

FIGURE 3: BLOCK DIAGRAM FOR OSCILLIOSCOPE

We divided two pi by time, times a thousand for unit conversion to get angler acceleration.

FIGURE 4: VELOCITY PEAK EQUATION FOR OSCILLIOSCOPE

$$\omega := \frac{2 \cdot \pi}{\text{Time} \cdot 1000}$$

With the use of a Tachometer, we can convert time in to linear velocity.

FIGURE 5: BLOCK DIAGRAM FOR TACHOMETER

We divided two pi by time, times a thousand for unit conversion to get angler acceleration.

FIGURE 6: VELOCITY PEAK EQUATION

$$\omega := \frac{2\cdot\pi}{Time\cdot 1000}$$

FIGURE 7: SLOPE EQUATION

$$ScaleFactor := \frac{CalibratedResult}{RawData}$$

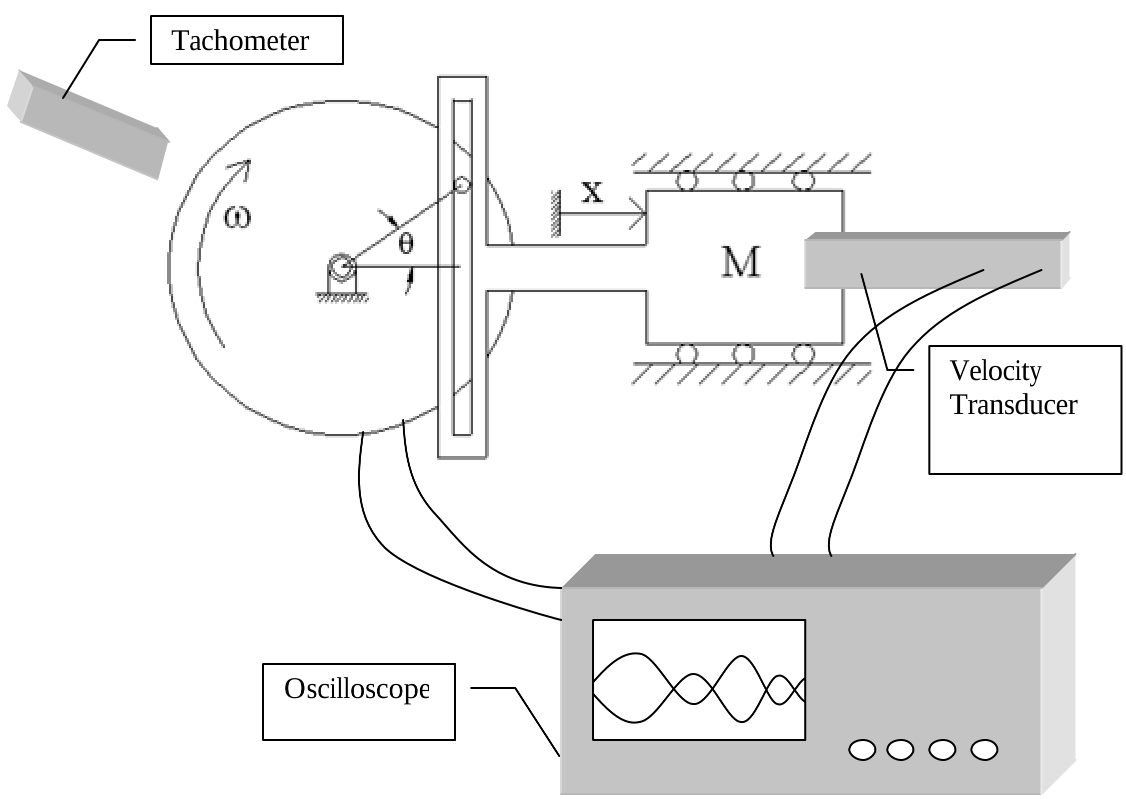
We find the percent error by finding the difference of calibrated result and true value divided by full-scale value.

FIGURE 9: PERCENT ERROR EQUATION

$$\%Error := \frac{CalibratedResult - TrueValue}{FullScaleValue}\cdot 100$$

SCHEMATIC

FIGURE 6: MECHANICAL SETUP



PROCEDURE / DATA COLLECTION

To calibrate the system we first connect a potentiometer on the output of the velocity transducer. We set the motor to 150 RPM. We then adjusted the pot such that the output voltage peak was 150mV. We then speed up the motor up to 500 RPM. This will give us an output voltage reading of 500 mV.

We can calibrate the system to linear velocity by adjusting the pot to the time on the oscilloscope.

CALCULATIONS

Tachometer

$RPM := 298$

$\omega := \frac{2 \cdot \pi \cdot RPM}{60}$

$\omega = 31.206$

$S_o := .108173$

$V_{scope} := S_o \cdot \omega$

$V_{scope} = 3.376$

Oscilloscope

$Time := 200$

$\omega := \frac{2 \cdot \pi}{\frac{Time}{1000}}$

$\omega = 31.416$

$S_o := .108173$

$V_{scope} := S_o \cdot \omega$

$V_{scope} = 3.398$

Transducer

$Volts := 1.7$

$Sensitvity := .500$

$V_{peak} := \frac{Volts}{Sensitvity}$

$V_{peak} = 3.4$

RESULTS SUMMARY

TABLE 1: ANGULAR DISPLACEMENT MEASURMENTS

Tachometer			Oscilloscope			Velocity Transducer		% Error
RPM	ω_{Tech} (rad/s)	V_{Tech} (in/sec)	T (s)	ω_{scope} (rad/s)	V_{scope} (in/sec)	V_{pp}	$V_{Transducer}$ (in/sec)	
152.7	16.04	1.74	395	15.91	1.72	1.76	1.76	0.44%
199.7	20.98	2.27	300	20.94	2.27	2.28	2.28	0.19%
249.1	26.17	2.83	240	26.18	2.83	2.84	2.84	0.16%
298.0	31.31	3.39	200	31.42	3.40	3.40	3.40	0.24%
350.7	36.84	3.99	171	36.74	3.97	3.92	3.92	-1.15%
400.0	42.02	4.55	150	41.89	4.53	4.52	4.52	-0.45%
449.9	47.26	5.11	132	47.60	5.15	5.12	5.12	0.13%
498.3	52.35	5.66	121	52.14	5.64	5.68	5.68	0.31%

FIGURE 11: SCOTCH YOKE MEASURMENTS GRAPH

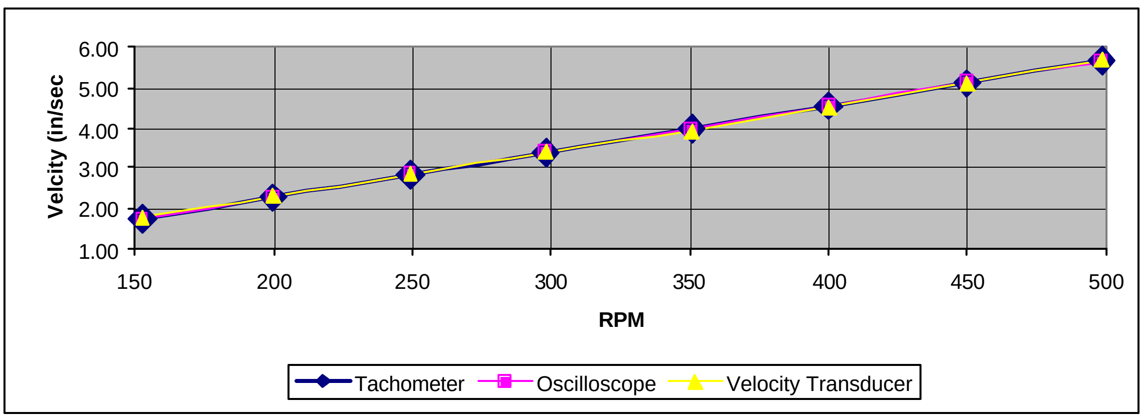
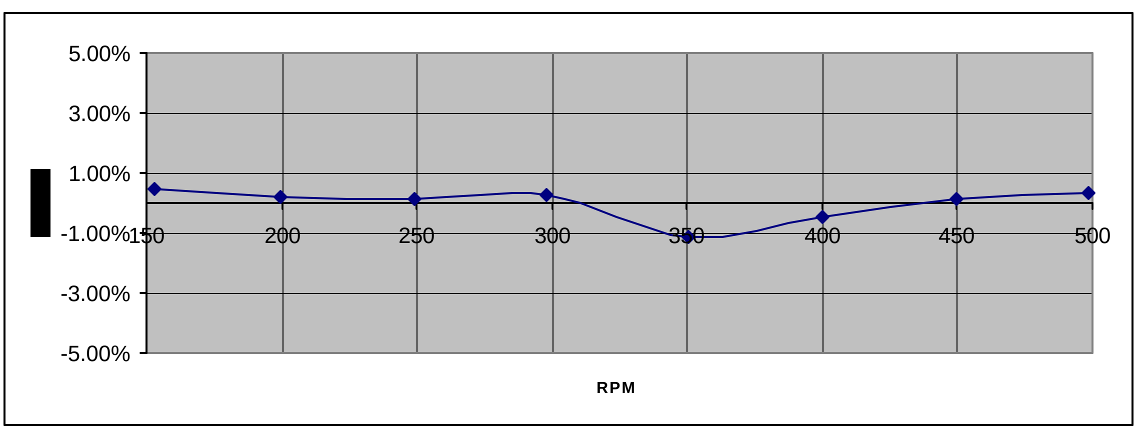


FIGURE 12: % ERROR GRAPH



DISCUSSION

We can see that all configurations used to find the linear velocity are very accurate. However there are some drawbacks. The biggest is human error. When this lab was first conducted, the So, total travel of the stock yoke was incorrectly reported. As a result, all data that included this figure we off. Once the mistake was corrected, we were able to see the true results. In all configurations, it comes down to what equipment is available. In addition, from our percent error we can see that there is no significant difference of reads due to speed.

LAB SHEET

NOTES

ORGINAL DATA