Development Microcontroller Base Draught Force Instrumental on Tillage Operation

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Abstract- The paper is on development of device for the measurement of draught force during tillage operation that data can be used for analysis and explains some of soil dynamic. The draught force device consists of "S" load cell, load cell amplifier and 24 bit serial output analog-to-digital converter, microcontroller, microSD card, and liquid crystal display (LCD). The load cell was attached to form link between the tractor and plough tool carriage. As plough is lowered and move it drag or pull the carrying plough and dynamic change in force of pulling is detected by load cell corresponding quantified value is measured by 24 bit load cell amplifier, HX711. The microcontroller process the e result store data and display the information on LCD. The instrument has the maximum capacity of 100 kN of draught force that can measure. The resolution for draught force is 0.001 N. Errors estimated for each parameter is ±0.04 N.

Indexed Terms- Draught force, tillage, microcontroller, load cell, soil dynamic

I. INTRODUCTION

Agricultural implement place a major role in agricultural cultivation practice that is in soil tillage activities. Much work has been carryout in soil tillage activities using imported implement but majority of work done has no accurate record of draught force and soil dynamic behaviour locally and effect on the tillage tools. Also, the performance of the tillage operation tools has not been properly examined with accurate data for analyses did accurate examination draught force in USA and other soil dynamic behavior, and in the work accurate data was used in their analyses. Actually, the investigation of soil dynamic parameters is very importance, it is also difficult to generalize the dynamic mechanical behaviour of the soil directly as constituent of the soil is complex and dynamic mechanical behavioural changing of disturbed soil is unstable. Today,very few researchers in Nigeria using current electronic technology to measure data on real-time bases. Therefore the work was on development of draught instrument that can be used in soil tillage operation is a great importance to the agricultural engineers be able to carry out accurate analysis of the soil dynamic in Nigeria at lower cost.

II. MATERIAL AND METHOD

2.1 Basic Block Diagram

The draught force instrument consists of both button and "S" type load cell (depends on which one of interest), load cell amplifier, arduino mega 2560, SD card shield and liquid crystal display(LCD) were connected together to form the completed draught instrument as shown Figure 1.

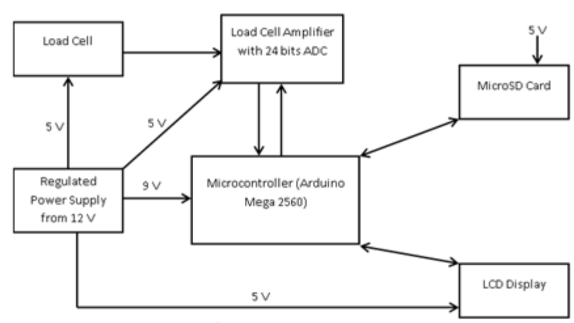

Figure 1: Block Diagram of Draught Force Instrument

2.2 Load Cell

A load cell is a device that converts a force or load into a measureable output. Load cells can come in multiple styles including hydraulic, pneumatic, strain gage, piezoelectric, and capacitance, but in the scope of this work strain gage load cells was used. Strain gage load cells are the most common and are defined as a device that converts a force or load into an equivalent electrical signal or digitized load value.

The force applied is translated into a voltage by the resistance change in the strain gages, which are intimately bonded to the transducer structure. The amount of change in resistance correlates to the deformation in the transducer structure and hence the load applied (See Figure 2).

General purpose load cells are suitable for a wide range of routine static force measurement applications, including weighing, structural testing and material testing machines. Fatigue-rated versions are designed for fatigue testing machines and applications where high cyclic loads are present. A high-quality fatigue-rated load cell should be compensated to minimize the effects of temperature and barometric pressure changes as well as applied extraneous loads. It consists of wheatstone bridge.

2.3 Wheatstone Bridge

The load cells use strain gages in a four-arm Wheatstone bridge configuration, which acts as an adding and subtracting electrical network. The Wheatstone bridge allows for compensation of temperature effects, as well as cancellation of signals caused by extraneous forces. These circuits consist of a full four-arm bridge of at least one precision strain gage per arm.

A regulated 5 to 20 volt DC or AC rms excitation is required to power the bridge.. The Wheatstone bridge is shown in Figure 2. The strain gages used in the Wheatstone bridge all have the same resistance value creating a balanced bridge when no load is applied. When a load is applied to the load cell, the strain gages deform, which changes their resistance, creating a bridge that is unbalanced, causing an output voltage that is proportional to the applied load. The load applied to the load cell in Figure 2 causes the tension gages (T1 and T2) to stretch and the compression gages (C1 and C2) to compress. An output voltage will then be sent through the signal lead wires (+S and –S) to a load cell amplifier to transform the output voltage into a force value (Lb, N, kg, etc.).

2.4 Load Cell Amplifier with 24 bits Analog-to-digital Conversion

Based on Avia Semiconductor's patented technology (www.sparkfun.com), HX711 is a precision 24-bit analog-to-digital converter (ADC) designed for weigh scales and industrial control applications to interface directly with a bridge sensor. The input multiplexer selects either Channel A or B differential input to the low-noise programmable gain amplifier (PGA). Channel A can be programmed with a gain of 128 or 64, corresponding to a full-scale differential input voltage of ±20mV or ±40mV respectively, when a 5V supply is connected to AVDD analog power supply pin.

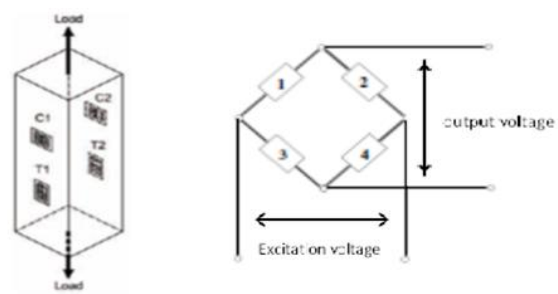

Figure 2: Strain Gauge Bounded Point and Wheatstone bridge

Channel B has a fixed gain of 32. On chip power supply regulator eliminates the need for an external supply regulator to provide analog power for the ADC and the sensor. Clock input is flexible. It can be from an external clock source, a crystal, or the on-chip oscillator that does not require any external component. On-chip power on-reset circuitry simplifies digital interface initialization. There is no programming needed for the internal registers. All controls to the HX711 are through the pins. The loads cell amplifier is link to microcontroller via DOUT of pin 12 HX711 to pin 3 on arduino and PD_SCK of pin 11 of HX711 to pin 2 of arduino. The circuit diagram of HX711 is shown on Figure 3.

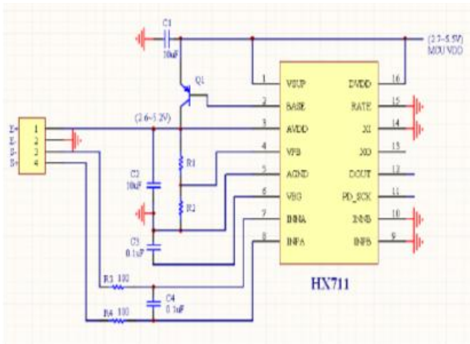

Figure 3: Circuit Diagram of Strain Gauge Amplifier (HX711)

III. MICROCONTROLLER UNIT WITH LOGGING AND DISPLAY UNIT

Microcontroller is small size computer on a single IC containing processor core, memory and programmable input-output peripheral. Microcontrollers are designed for the use of embedded applications, in contrast with microprocessor which are used for personal computers and other general purpose applications. Atmega2560 is a low power, high performance; CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. Atmega2560 provides 256 Kbytes with 8 Kbyte RAM of in-system self-programmable memory with read while write capability and 2 Kbyte EPROM. The microcontroller coordinates all the activities of the instrument from accepting data from load cell amplifier to the processing of data to the storing and displaying information.

MicroSD card shield module was interfaced with microcontroller using Serial Peripheral interface (SPI) protocol standard. The module is designed for dual voltage power supply. The interface module can be used with two logic level i.e. CMOS 3.3V or TTL 5V.

The Liquid Crystal Display (LCD) is used to display the draught force during tillage operation for visual information. A Dig chip make 20 character × 4 lines JHD162A liquid crystal display was used in the instrument developed. The display is a 16 pin which works with maximum power supply of 5.0 V and the data can be sent in either 4 bit, 2 operations or 8-bit, 1 operation so that it can be interfaced to 8-bit Microcontroller. Here we used 4 bits, 2 operation system.

IV. TESTING AND CALIBRATION DRAUGHT INSTRUMENT

The load place on the table and load was place on it and value was display on the LCD in accordance to load. Likewise when the loads remove on it there is a reduction in the load value. The draught instrument was calibrated by changing the calibration factor constant in C programming of the arduino platform until the value display on the LCD is equal to value place on it. Later, the instrument was now checked for the correctness when various loads were added (See Table 1).

Table 1: Shows Correctness of the Force Measurement

Standard Load (N)	Display Load(N)
5	5.021
10	10.060
15	14.971
20	20.016
40	40.054
60	60.031
Correlation	0.99

V. USING DRAUGHT INSTRUMENT ON SOIL BIN

The draught load cell was attached between tractor and tractor implement, the tractor moves at a steady speed. The power unit was an MF 415 tractor with the following specifications: power, 31.6 kW; 2WD; Diesel engine; water cool; oil bath air cleaner with PTO drive shaft and 3-point linkage; a good range of forward speeds (2.59 – 34.21 km/h); a slow and fast reverse speeds of 3.5 and 14.2 km/h, respectively. The data was collected during cross examination of developed draught instrument at step-B site outdoor and FUTA-indoor soil bins was shown on Figure 4 and 5 respectively. The sample data was shown on Table 2 and graph of sample was plot on Figure 6 to describe dynamic variation of draught force during tine plough operation.

VI. CONCLUSION

A Microcontroller Base Draught Instrument on Tillage Operation was designed, assembled, tested and found suitable for evaluation of draught of tillage tools in both indoor and outdoor soil bin conditions. Results showed that draught force dynamically changes as tractor is performing the tillage operation which will depends on soil type and soil moisture content. This draught provides a cheap cost solution to the imported assembly adapted draught force instrument by more 87% reduction price.

Figure 4: Outdoor Soil Bin

Figure 5: Indoor Soil Bin

Table 2: Sample Data of Draught Force Instrument

time (1 s Interval) (s)	Draught Force (N)
1	307.7360
2	421.1710
3	769.6230
4	1558.9380
5	1572.0330
6	1598.6190
7	1632.1680
8	1659.6720
9	1680.2130
10	1703.7320
11	1718.0100
12	1740.4350
13	1759.7930
14	1717.5280
15	1758.7850
16	1760.0560
17	1787.8660
18	1800.0420
19	1829.4740
20	1861.7970
21	1757.1210
22	1125.5210
23	1834.8170
24	1983.9030
25	2009.7000
26	2039.5260
27	2834.0970
28	2779.3950
29	2675.9450
30	2598.4240
31	2508.2890
32	2498.4790
33	2447.8490
34	2409.2190
35	2532.2900
36	2490.5080
37	2510.9170
38	2521.9970
39	2548.6700
40	2549.2390
41	2552.3060

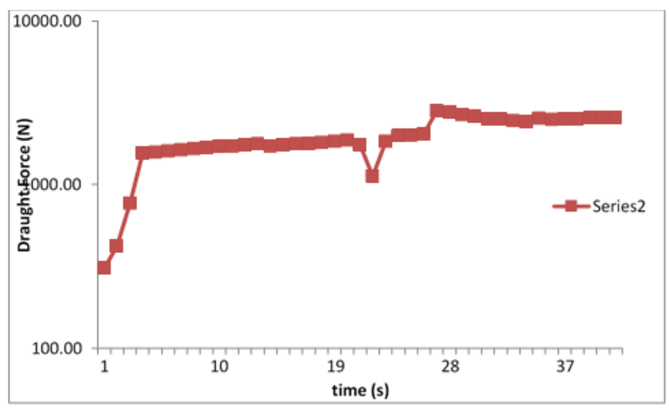

Figure 6: Sample of Draught Force during Tine Plough Operation

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