Implementation Measurement Heavy Utilize Macrobending on Fiber optics Using Microcontroller Media

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Abstract— **Fiber optics is a light-utilizing signal transmission medium and can be used in a wide variety of sensing sensors. Optical fiber has multifunctional sensing capabilities, namely strain, pressure, temperature, and acoustic signals with a high level of sensitivity. In this study, optical fiber will be used as a mass sensor by utilizing the macro bending method with microcontroller media. The data analysis carried out was compares the graph when the fiber optic is given a certain load, by the number certain windings and when bending with a certain diameter will then be made formula for measuring mass with optical fiber. Load or load mass = 0 gr, 200 gr, 400 gr, up to 10 kg with 9 turns and ¼ inch, ½ inch, 5/8 inch, ¾ inch, and 1 inch diameter hose. In this study, the results of weight measurement using an equation obtained from measuring the power loss against the load used are formed in a graph which results in the linier equation that is entered converted into a formula for finding the load which is then inputted into the android code so that it can be processed properly. The value obtained after measurement is that when given a load of 100 grams - 1800 grams, the load results shown in the program result in a difference in the value of the load of 1545 grams. When given a load of 2000 grams - 5600 grams, the load results shown in the load show a difference in the load value display of 905 grams and the load display when given a load of 5800 grams - 10000 grams experience a load difference of 1670 grams.**

Keywords—**Fiber optic, Bending, Measurement**

I. INTRODUCTION

Fiber optic is a medium that utilizes light. Optical fiber is made of glass or plastic that can transmit light signals from one place to another. Fiber optics is also a technology base that can be used in various kinds of sensing sensors. Fiber optics have multifunctional sensing capabilities, namely strain, pressure, temperature, and acoustic signals. Optical fiber has a high level of sensitivity, so the sensor can directly or indirectly affect the power of the optical fiber. Power loss is caused by changes in the propagation of light in the optical fiber which results in changes in the intensity of light received by the detector.

The load sensor is an element in the measurement system that is used to sense changes in the force that hits a certain area. The load sensor is an elastic sensor, which means it will sense changes in dimensions due to changes in force. The load sensor in the load measurement system is a key component of the system device. There are three types of sensors that have been used in the load measurement system, namely piezoelectric sensors, bending plates, and load cells. Piezoelectric-based load sensors, bending plates, and load cells have quite large dimensions. The three sensors use an electrical signal as the basis for their measurement signal, thereby allowing electromagnetic interference to occur. In addition, if it is applied to an integrated measurement system network at several points, it requires a very complicated wiring system.

Currently, optical fiber-based sensors and transducers are developing rapidly. This technology is developing rapidly because fiber optics has several advantages, including not being affected by electromagnetic waves and not triggering an explosion due to the signal in the form of light. The advantages of optical fiber-based sensors compared to the three sensors above are that they are very sensitive, can be used at long distances and can be used in an integrated measurement system network at several points.

A. Previous Research

The method used in this study is to give a load to the optical fiber that has been formed with multi bending indentations after which the intensity of the output that passes through it will be measured before being given the mass of the fiber optic load to be passed on the paralon pipe with several different shapes of paralon diameter, namely 1.5 cm, 2 cm, and 2.5 cm. The mass of the load is determined from 0 g - 950 g in multiples of 50 g for each additional mass of the load. From the results of the research that has been done, it is shown that the mass of the load on the optical fiber causes curvature of the optical fiber which makes the fiber optic sensor experience increasing power losses and smaller voltages. The measurement results show that the sensitivity increases when the mass of the load on the optical fiber forms a sharper indentation [1],[2].

This study uses the principle of loading on fibers that have a number and specified diameter. Power loss was analyzed using an optical spectrum analyzer (OSA). The load variations used for power loss analysis in this study are 200, 400, 600, 800 and 1000 g. As for the variations in the number of turns of 1, 3 and 5 turns and the variations in diameter are 3, 4 and 5 cm. This research uses the loading method, namely the continuous method. Method this is fiber optic is loaded for every increment of 200g up to a maximum load of 1000g. The results of the research on power loss show that it has a maximum value of 17.308 W on optical fiber with a diameter of 3 cm and 1 winding for 1000 g loading[3],[4].

The LIPI Physics Research Center is developing an optical-based load sensor with the advantages of resistance to water, electromagnetic waves, temperature changes and low-cost, simple and light enough. This sensor consists of a 1310 nm LED light source, a microbending board with a 1.5 mm period, a multimode step index (MMSI) fiber optic type FG050LGA, and a reader system with LabVIEW software. In this study using a static test load of 10-150 kg with a difference of 10 kg for each test and repeated 10 times. From the experimental data which is then represented in a graph of the relationship between the load and the output voltage, it shows that the data has an accuracy value of 81.3%[5],[6].

The test used a laser source with a wavelength of 1310 nm, multi-variety optical fiber, rubber coating, load, stainless wire, modified sensor (made by the Center for Physics Research), photodetector, Data Translation DAQ, and Weight in Motion software made by the LIPI Physics Research Center. From the research, several results were obtained, namely the laser stability was met with statistical T test, the effect of microbending had a significant effect on the response of the load sensor with ANOVA at a significance level of 0.05, sensor hysteresis with an error < 5% and sensor validation with polynomial equations and sensor reliability were met with the T test. Statistics[7],[8].

B. Fiber optic

Optical fiber is a cylindrical transmission medium or light waveguide. Fiber optics was developed in the 1960s. Optical fiber is made of glass or very fine plastic, and is used as a transmission medium because it can transmit light signals from one location to another at high speed. Optical fiber has a very small size and is very fine with a diameter of only 125 micrometers[9].

Optical fiber is a component that is quite popular due to its very high access speed, so it is widely used as a medium for communication channels. In general, cables transmit data using electricity, but in optical fiber, data is transmitted using light. The light flow is converted from electricity so it is not easily disturbed by the presence of electromagnetic waves[10],[11],[12].

The core part of the optical fiber is made of a dielectric material (silica material (SiO_2), usually given doping with germanium oxide (GeO_2) or phosphor Penta oxide (P_2O_5) to increase its refractive index) which does not conduct electricity, is cylindrical with fingers of 8-200 micrometers and a refractive index n1 of about 1.5.

The blanket (Cladding) on the optical fiber is a protective part that protects the core so that the light pulses that will come out of the core are reflected into the core again so that the light pulses are not lost on the way. Cladding has a diameter that varies between 125 μm (for singlemode and multimode step index) and 250 μm (for multimode graded index).

The Jacket (Coating) section on optical fiber is made of elastic plastic material, serving as core protector and cladding from outside interference.

This part is a very important part because it becomes the main protector of a fiber optic cable. The strength member layer and outer jacket are the outermost parts of the optical fiber that protect the cable core from various physical disturbances directly.

The use of fiber optics as a communication transmission medium has several advantages, including, have a signal transmission over a long distance. It has a large bandwidth, a small diameter and a light size. Not disturbed by electromagnetic waves because it utilizes light waves. Has high security. In addition to the advantages, fiber optics also have several shortcomings, including, installation and maintenance costs tend to be more expensive. It requires a strong light source.

The working principle of fiber optics is the delivery of pulses of light through a cell from one place to another. Light in fiber optics travels through the core by bouncing off the skin (cladding), because the skin does not absorb light from the core at all, this is called the process of perfect reflecting. In the event of perfect reflection, no refracted light. If the difference in core bias index and skin is drastic, then it is called fiber optic Step Index, the difference between the skin bias index and the inti bias index[13]-[17].

II. METHOD

A. System Description

The design that will be made in this research will be shown in fig. 1 and block diagram of the system design will be shown in fig. 2.

Figure 1. The proposed system designs

The block diagram of the system design will explain the flow carried out during the research, including design of the application display that will be made in this study.

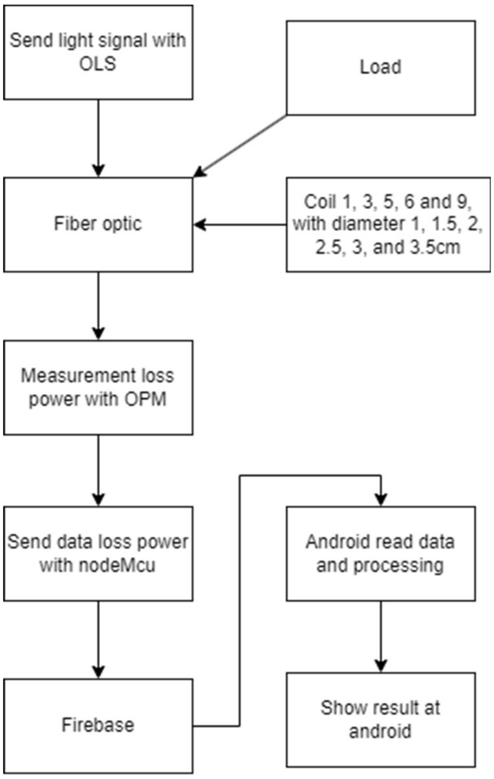

Figure 2. Block Diagram of the System

B. Research Procedures

Getting around all tools and materials and checking specifications of materials either fiber optic cables or elastic pipe types.

Measurements of the length of the cable wrapped in the elastic pipe are carried out on each variation of the type of elastic pipe with a diameter ¼ of inches,1/2 inches, 5/8 inches, ¾ inches, and 1 inch and 9 windings. Preparing the load, it is also ensured that the load is clearly measured and can be placed well on the aluminium cross section. Connecting fiber optic cables with light source and OPM is also ensured that the measurable power loss does not reach above -20 dBm. When above -20 dBm fiber optics should be replaced with better cables or performed tool inspection both OLS and OPM.

The process begins the laying of load mass over the cross section that has been given an elastic pipe with several variations that have been wrapped around fiber optics. The load is placed gradually according to the needs, namely from 0 - 10 kg which is added gradually by 0.2 kg. And any change in load weight should start from 0 or the initial state.

- Calculating and developing measuring data with actual mass.
- Get the calculation of equations from measuring results.
- Enter equation results into android.
- Comparing microcontroller reading results with actual mass.

C. Research Parameters

- Free variables: the load given and the amount of winding given to the fiber optic.
- Bound variable: the power loss value on the fiber optic at the time the fiber optic is loaded and bending.
- Controlled variables: Optical Light Source laser type, Fiber optic singlemode type.

D. Data Capture

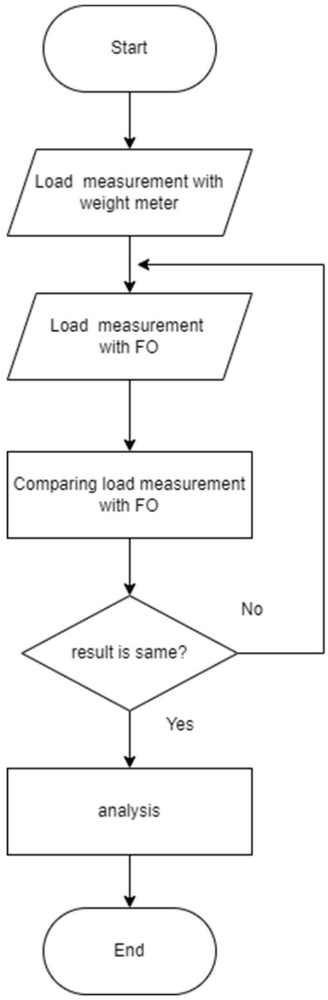

Figure 3. Data Retrieval Diagram

Planning data retrieval by measuring the attenuation of fiber optic output using Optical Power Meter which was previously fiber optics given input from optical light source lasers and loaded between 0 Kg - 10 Kg with a load difference of 200 grams and fixed with 9 windings in elastic pipe media with a diameter ¼ of inches,1/2 inches, 5/8 inches, ¾ inches, and 1 inches.

III. RESULTS AND DISCUSSION

The output power value obtained from the data collection process on the FC-to-FC single mode core patch cable which is bent with 9 turns on an elastic hose made of PVC with a diameter of ¼ inch, ½ inch, 5/8 inch, ¾ inch, and 1 inch before loading. The FC-to-FC single mode core patch cable used in this measurement is 2 meters long. In the measured results, the input power value is -7 dBm. The output power measurement value on the fiber optic cable is shown in Table I below:

TABLE I
POWER VALUE MEASUREMENT RESULTS WITHOUT LOADED

No.	Diameter (inch)	Number of Windings	Output power (dBm)
1	$\frac{1}{4}$	9	-27,88
2	$\frac{1}{2}$	9	-15,85
3	$\frac{5}{8}$	9	-11,83
4	$\frac{3}{4}$	9	-11,53
5	1	9	-11,40

The output power value obtained from the data retrieval results on an elastic hose with a diameter of 1/4 inch. In the measured output power value before being loaded at -27.88 dBm and the input power value of -7 dBm. The output power measurement value on the fiber optic cable is shown in Table II and the automatic equation search results by entering the average data into excel whose results are shown in the figure 5.

TABLE II
MEASUREMENT RESULTS OF POWER VALUE WITH 9 WIRING WITH 1/4 INCHI HOSE DIAMETER

Weight (gr)	Readable Attenuation (dBm)			
	Data 1	Data 2	Data 3	Average
100	-27,92	-27,94	-27,96	-27,93
200	-29,75	-29,94	-29,98	-29,85
400	-30,3	-30,98	-30,92	-30,64
600	-30,41	-30,99	-30,99	-30,70
800	-30,88	-30,96	-30,95	-30,92
1000	-33,11	-33,97	-33,99	-33,54
1200	-33,47	-33,93	-33,95	-33,70
1400	-33,63	-33,92	-33,97	-33,78
1600	-33,78	-33,96	-33,91	-33,87
1800	-33,83	-33,98	-33,98	-33,91
2000	-33,84	-33,94	-33,94	-33,89
2200	-33,97	-33,98	-33,99	-33,98
2400	-34	-33,95	-33,94	-33,98
2600	-34,53	-34,94	-34,99	-34,74
2800	-34,94	-34,96	-34,99	-34,95
3000	-36,04	-36,92	-36,97	-36,48
3200	-38,76	-38,92	-38,94	-38,84
3400	-40,31	-40,96	-40,93	-40,64
3600	-40,46	-40,91	-40,91	-40,69
3800	-41,07	-41,94	-41,99	-41,51
4000	-41,35	-41,91	-41,97	-41,63
4200	-42,65	-42,96	-42,96	-42,81
4400	-43,56	-43,94	-43,99	-43,75
4600	-43,74	-43,94	-43,96	-43,84
4800	-43,75	-43,97	-43,96	-43,86
5000	-45,25	-45,94	-45,96	-45,60
5200	-47,43	-47,94	-47,97	-47,69
5400	-48	-48,97	-48,99	-48,49
5600	-48,57	-48,92	-48,97	-48,75
5800	-50	-50	-50	-50,00
6000	-50	-50	-50	-50,00
6200	-50	-50	-50	-50,00
6400	-50	-50	-50	-50,00
6600	-50	-50	-50	-50,00
6800	-50	-50	-50	-50,00
7000	-50	-50	-50	-50,00
7200	-50	-50	-50	-50,00
7400	-50	-50	-50	-50,00
7600	-50	-50	-50	-50,00
7800	-50	-50	-50	-50,00
8000	-50	-50	-50	-50,00
8200	-50	-50	-50	-50,00
8400	-50	-50	-50	-50,00
8600	-50	-50	-50	-50,00
8800	-50	-50	-50	-50,00
9000	-50	-50	-50	-50,00
9200	-50	-50	-50	-50,00
9400	-50	-50	-50	-50,00
9600	-50	-50	-50	-50,00
9800	-50	-50	-50	-50,00
10000	-50	-50	-50	-50,00

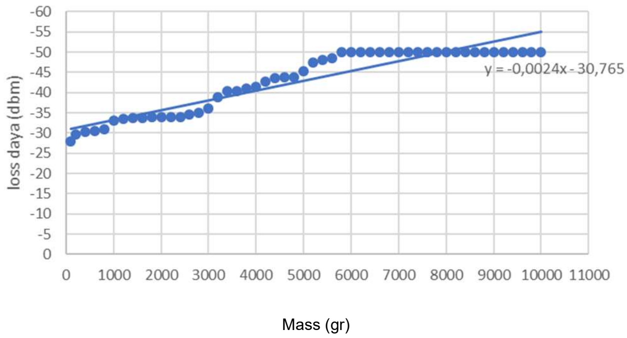

Figure 4. Graph of Power Loss to Mass Relationship at ¼ inch Diameter

The output power value obtained from the data retrieval results on the FC-to-FC single mode core patch cable wrapped around 3 times the winding on the elastic hose with a diameter of 1/2 inch with a load of 0.1 Kg- 10 Kg with a range of 200 grams. The FC to FC singlemode core patch cable used in this measurement is 2 meters long. In the measured result the output power value before being loaded by -15.85 dBm and the input power value of -7 dBm. The output power measurement value on the fiber optic cable is indicated in table III and the automatic equation search results by entering the average data into excel whose results are shown in Fig. 5.

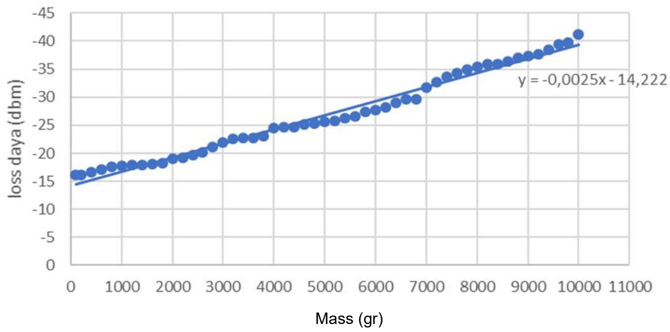

Figure 5 Graph of Power Loss Relationship with Mass at inch Diameter

Explains the results of the weight value from making a program which uses the formulation of the data that has been taken and processed using excel then the equation is entered in the programming tool to bring up the measured load value. Here, we only compare data between ¾ inch and 1 inch diameter because it has the most stable damping value from other diameters. Value for data ¾ inch it shows in table IV.

TABEL III
MEASUREMENT RESULTS OF POWER VALUE WITH 9 WIRING WITH ½ INCHI HOSE DIAMETER

Weight (gr)	Readable Attenuation (dBm)			
	Data 1	Data 2	Data 1	Average
100	-16,14	-16,98	-16,93	-16,56
200	-16,17	-16,95	-16,95	-16,56
400	-16,58	-16,92	-16,99	-16,75
600	-17,04	-17,93	-17,92	-17,49
800	-17,63	-17,93	-17,96	-17,78
1000	-17,76	-17,96	-17,93	-17,86
1200	-17,83	-17,94	-17,91	-17,89
1400	-17,97	-17,97	-17,96	-17,97
1600	-18,09	-18,91	-18,94	-18,50
1800	-18,21	-18,99	-18,94	-18,60
2000	-18,98	-18,92	-18,96	-18,95
2200	-19,26	-19,91	-19,93	-19,59
2400	-19,68	-19,92	-19,94	-19,80
2600	-20,11	-19,94	-19,95	-20,03
2800	-21,06	-21,94	-21,97	-21,50
3000	-21,89	-21,94	-21,97	-21,92
3200	-22,58	-21,94	-21,97	-22,26
3400	-22,69	-21,93	-21,97	-22,31
3600	-22,76	-21,96	-21,97	-22,36
3800	-23,03	-24,96	-24,96	-24,00
4000	-24,47	-24,92	-24,95	-24,70
4200	-24,57	-24,91	-24,91	-24,74
4400	-24,65	-24,96	-24,93	-24,81
4600	-25,07	-24,93	-24,92	-25,00
4800	-25,3	-24,94	-24,99	-25,12
5000	-25,57	-24,96	-24,95	-25,27
5200	-25,83	-24,99	-24,93	-25,41
5400	-26,25	-26,97	-26,95	-26,61
5600	-26,57	-26,93	-26,96	-26,75
5800	-27,44	-26,92	-26,98	-27,18
6000	-27,74	-26,98	-26,94	-27,36
6200	-28,21	-28,94	-28,97	-28,58
6400	-28,98	-28,93	-28,93	-28,96
6600	-29,7	-28,94	-28,91	-29,32
6800	-29,7	-28,96	-28,93	-29,33
7000	-31,76	-31,97	-31,93	-31,87
7200	-32,7	-31,92	-31,94	-32,31
7400	-33,59	-33,97	-33,95	-33,78
7600	-34,27	-34,96	-33,97	-34,62
7800	-34,85	-33,92	-35,91	-34,39
8000	-35,46	-35,92	-34,96	-35,69
8200	-35,88	-35,91	-35,95	-35,90
8400	-35,9	-34,96	-35,91	-35,43
8600	-36,31	-39,94	-36,95	-38,13
8800	-36,97	-38,93	-39,97	-37,95
9000	-37,27	-37,97	-37,93	-37,62
9200	-37,64	-38,96	-38,99	-38,30
9400	-38,41	-38,94	-38,98	-38,68
9600	-39,45	-39,97	-37,97	-39,71
9800	-39,68	-38,93	-37,97	-39,31
10000	-41,16	-40,92	-37,95	-41,04

Table IV shows the data that the result of the load value on the tool produces a difference in the value of the load of 20 - 95 grams to the actual load, where the smallest load value of 20 grams is obtained at the load value, namely 100, 200, 800, 1400, 2600, 2800, 3400, 3600, 3800 , 4000, 5000, 5800, 6400, 6600, 7200, 8600, 9400, 9600 and 9800 grams. The largest load value, which is the difference of 95 grams, is found in the load values of 3000, 3200, and 4400 grams.

TABLE IV
MEASUREMENT RESULTS USING EQUATIONS ON HOSE DIAMETER 3/4 INCH

No.	Weight (gr)	Loss power (dBm)	Weight load reading (gr)	Percentage error (%)
1	100	-11,75	145	45
2	200	-11,74	220	10
3	400	-11,74	470	17,5
4	600	-11,79	645	7,5
5	800	-11,77	820	2,5
6	1000	-11,80	1045	4,5
7	1200	-11,78	1270	5,83
8	1400	-11,81	1420	1,43
9	1600	-11,82	1670	4,38
10	1800	-11,82	1845	2,5
11	2000	-11,80	2045	2,25
12	2200	-11,81	2270	3,18
13	2400	-11,82	2470	2,92
14	2600	-11,86	2620	0,77
15	2800	-11,88	2820	0,71
16	3000	-11,87	3095	3,17
17	3200	-11,90	3295	2,97
18	3400	-11,98	3420	0,59
19	3600	-12,54	3620	0,56
20	3800	-12,53	3820	0,53
21	4000	-12,55	4020	0,5
22	4200	-12,64	4245	1,07
23	4400	-12,73	4495	2,16
24	4600	-12,79	4645	0,98
25	4800	-12,82	4845	0,94
26	5000	-12,85	5020	0,4
27	5200	-12,93	5270	1,35
28	5400	-12,96	5445	0,83
29	5600	-13,55	5645	0,8
30	5800	-13,62	5820	0,34
31	6000	-13,66	6045	0,75
32	6200	-13,69	6245	0,73
33	6400	-13,78	6420	0,31
34	6600	-13,81	6620	0,3
35	6800	-13,83	6845	0,66
36	7000	-13,93	7070	1
37	7200	-13,95	7220	0,28
38	7400	-14,49	7470	0,95
39	7600	-14,58	7670	0,92
40	7800	-14,58	7845	0,58
41	8000	-14,68	8045	0,56
42	8200	-14,73	8270	0,85
43	8400	-14,76	8445	0,54
44	8600	-14,80	8620	0,23
45	8800	-14,83	8870	0,8
46	9000	-14,90	9045	0,5
47	9200	-14,94	9245	0,49
48	9400	-15,53	9420	0,21
49	9600	-15,64	9620	0,21
50	9800	-15,68	9820	0,2
51	10000	-15,75	10045	0,45

The percentage error obtained from the comparison of the actual load with the load on weight is 0.2% - 45% where the percentage of the load is less than 10% at the use of a load of 600-10000 grams while at a load of 100-400 grams the percentage is above 10%, the largest percentage is at the load is 100 grams and the lowest is when the load is 9800 grams. The percentage of 0.2% - 7.5% in the measurement of 600 - 10000 grams indicates the tool has high accuracy due to the small percentage of error.

TABLE V
MEASUREMENT RESULTS USING EQUATIONS ON HOSE DIAMETER 1 INCH

No.	Weight (gr)	Loss power(dBm)	Weight load reading (gr)	Percentage error (%)
1	100	-11,69	57	43,00
2	200	-11,68	157	21,50
3	400	-11,69	323	19,25
4	600	-11,67	557	7,17
5	800	-11,68	723	9,63
6	1000	-11,69	923	7,70
7	1200	-11,67	1257	4,75
8	1400	-11,71	1423	1,64
9	1600	-11,72	1657	3,56
10	1800	-11,71	1723	4,28
11	2000	-11,72	2023	1,15
12	2200	-11,70	2257	2,59
13	2400	-11,73	2457	2,38
14	2600	-11,75	2557	1,65
15	2800	-11,75	2723	2,75
16	3000	-11,83	3023	0,77
17	3200	-11,82	3257	1,78
18	3400	-11,84	3323	2,26
19	3600	-11,84	3623	0,64
20	3800	-11,85	3757	1,13
21	4000	-11,87	4057	1,43
22	4200	-11,86	4157	1,02
23	4400	-11,86	4323	1,75
24	4600	-11,86	4623	0,50
25	4800	-11,89	4857	1,19
26	5000	-12,54	4957	0,86
27	5200	-12,61	5123	1,48
28	5400	-12,66	5423	0,43
29	5600	-12,69	5623	0,41
30	5800	-12,73	5723	1,33
31	6000	-12,74	6023	0,38
32	6200	-12,75	6257	0,92
33	6400	-12,74	6423	0,36
34	6600	-12,73	6557	0,65
35	6800	-12,86	6723	1,13
36	7000	-12,96	6957	0,61
37	7200	-13,59	7257	0,79
38	7400	-13,67	7423	0,31
39	7600	-13,72	7657	0,75
40	7800	-13,78	7823	0,29
41	8000	-13,80	7957	0,54
42	8200	-13,82	8123	0,94
43	8400	-13,87	8423	0,27
44	8600	-13,90	8623	0,27
45	8800	-13,94	8857	0,65
46	9000	-14,48	8957	0,48
47	9200	-14,60	9123	0,84
48	9400	-14,65	9423	0,24
49	9600	-14,72	9623	0,24
50	9800	-14,80	9757	0,44
51	10000	-14,89	10023	0,23

Explains the results of the weight value from making a program which uses the formulation of the data that has been taken and processed using excel then the equation is entered in the programming tool to bring up the measured load value. Here, we only compare data between ¾ inch and 1 inch diameter because it has the most stable damping value from other diameters. Value for data 1 inch it shows in table V.

Shows the data that the results of the load value on the tool produce a difference in the value of the load of 23 - 123 grams to the actual load, where the smallest load value of 23gram is obtained at the load value, namely 1400, 2000, 3000, 3600, 4600, 5400, 5600, 6000, 6400, 7400, 7800, 8400, 8600, 9400, 9600, 10000 grams. The largest load value, namely the difference of 123 grams, is found in the load values of 1000, 2400, 3400, 4000 and 6800 grams.

The percentage error obtained from the comparison of the actual load with the load on weight is 0.23% - 43% where the percentage of the load is less than 10% at the use of a load of 600-10000 grams while at a load of 100-400 grams the percentage is above 10%, the largest percentage is at the load is 100 grams and the lowest is when the load is 10000 grams. The percentage of 0.23% - 9.63% in the measurement of 600 - 10000 grams indicate the tool has high accuracy due to the small percentage of error.

IV. CONCLUSION

The discussion in the closing is an explanation of the conclusions and suggestions from the results of the research Implementation of Weight Measurement Utilizing Macrobending on Optical Fiber Using Microcontroller Media. the provision of macrobending on fiber optics with an error percentage of 0.2% to 7.5% in the -inch interval and 0.23% to 9.63% in the 1-inch interval with a load measurement of 600 – 10000 grams. The effect of the load given on optical fiber inversely proportional to the power loss. Where if the load given is more than the load weighing 100-10000 grams, then the resulting power loss will decrease. The percentage error obtained from the comparison of the actual load with the load on weight is 0, 23% - 9.63% in the measurement of 600 - 10000 grams indicates the tool has high accuracy due to a small percentage of error.

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