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Performance Improvement of Reed Type Frequency Meter

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***Abstract*- This paper focuses on selecting a suitable material for the reed of reed type frequency meter in order to enhance performance and to increase the production rate of the meter. While selecting the best suitable material the aim is to satisfy all the design and functional requirements thoroughly such as accuracy class, higher amplitude of vibration, clear visibility etc. Selecting a suitable material from the plenty of options is important as the material should posses certain properties like stiffness, fatigue strength, corrosion resistance etc. This paper also focuses on chemical composition of selected material to verify the properties held by the material are satisfactory or not. By selecting the proper material for reed the performance and life reed frequency meters will be drastically improved and in future it is possible to produce the meters without calibration which is one of the time consuming but essential process in traditional way of manufacturing the reed type frequency meter.**

I. INTRODUCTION

Vibrating reed type frequency meter is widely used instrument for frequency measurement because of its robust and simple construction. Other frequency measuring instruments like digital, ferrodyanmic type frequency meter, electrodynamometer type frequency meter are also available in the market but reed type frequency meter is mostly used. It works on the phenomenon of resonance hence it is also called as mechanical resonance type frequency meter [1]. This instrument can work on single or dual voltage, the specified voltage inputs are 110,220,380,440 [2,3,4]. The duel voltage meters are of type 110-220,220-380,380-440,220-440,110-440 this can be achieved by simply rearranging the resistor location. Various accuracy class available for this kind of instrument are 0.5, 1, 1.5 [5,6,7]. To manufacture instrument below 0.5 accuracy class every process should be precise and reed, base plate & support plate should be dimensionally accurate. The reed of this instrument is heart of the meter. There are certain properties like fatigue strength, corrosion resistance, temperature stability, stiffness, Homogeneousness, manufacturing ability etc that a reed should posses to improve the performance and life of instrument. Hence selecting a suitable material for reed is very important task and also the study on effect of elements of the material on its properties helps a lot to select best suitable material. A survey made during this paper shows that currently the some of the manufactures are using high carbon steel (carbon percentage 0.45%-0.75%) and some of them are using spring steel with low carbon content (about 0.81%) [8] with annealing because of which material looses all of its important properties like corrosion resistance, stiffness etc, all this material selection and annealing process is involved in order to make sure perfect 90^0 bending of reed. The selection of material also depends on its availability, cost, and thermal stability.

II. WORKING

An important electrical quantity with no equivalent in DC circuits is frequency. Frequency measurement is very important in many applications of alternating current, especially in AC power systems designed to run efficiently at one frequency and one frequency only. If the AC is being generated by an electromechanical alternator, the frequency will be directly proportional to the shaft speed of the machine, and frequency could be measured simply by measuring the speed of the shaft. If frequency needs to be measured at some distance from the alternator, though, other means of measurement will be necessary [9].

One simple but crude method of frequency measurement in power systems utilizes the principle of mechanical resonance. Every physical object possessing the property of elasticity (springiness) has an inherent frequency at which it will prefer to vibrate.

Frequency Meter is connected across the supply whose frequency is to be measured the coil of electromagnet carries a current i, which alternates at the supply frequency. This introduces the force of attraction between reeds and top plate. The force of attraction between the reeds and the electromagnet is proportional to square of the current i^2 and therefore this force varies twice at the frequency supply frequency. Thus, the force exerted on the reeds varies every half cycle. All the reeds tend to vibrate, but because of phenomenon of resonance the reed whose natural frequency is equal to twice the frequency of supply tends to vibrate the most. Vibration of other reeds is unobservable like in the figure 1[1,10].

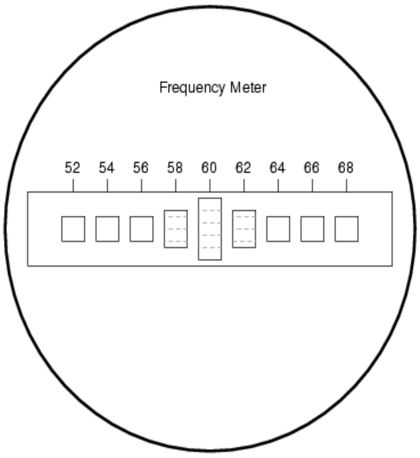

Figure 1: Frequency reading in the meter.

For a frequency exactly midway between that of the reeds, both will vibrate with amplitudes of equal magnitude. Shown in the figure 2 [9,11].

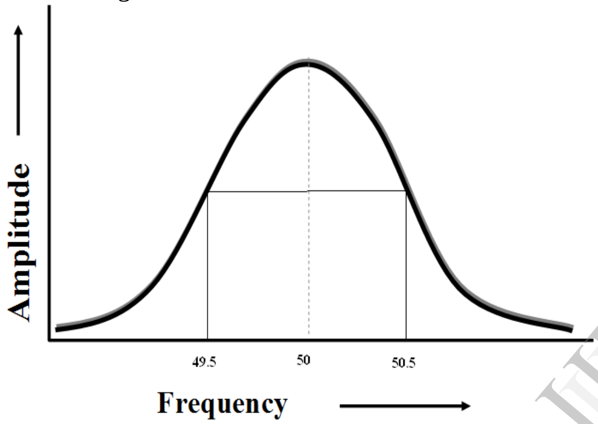

Figure 2: Variation of amplitude of vibrations with frequency.

III. MATERIAL PROPERTIES OF REED.

A. Fatigue strength

Because of the alternating cycle of input reed tends to vibrate this vibrations leads to cyclic tension and compression on either side of the reed [12,13]. This vibration may be responsible for the crack formation in the reed and may result into failure of reed after particular time if the material selected does not possess high fatigue strength. In brief the fatigue strength is responsible for life of the instrument [14].

B. Corrosion resistance

Corrosion depletes the material which changes the thickness of the reed, any change in dimension than the designed one will change the fundamental frequency. Though corrosion takes a long time to affect the fundamental frequency but the aesthetics get harmed very soon.

C. Machinability

The material selected for reed should obtain the size and shape of reed easily without burr and should be able to bend easily. Chemical etching is the suitable process of manufacturing reed because in punching the material is separated by 50% of cutting and 50% of shearing. In laser cutting burr formation is more as well as it disturbs the straightness of reed. It is important to remember that processing operations will almost always affect the material properties so that processability considerations are closely related to functional requirements.

D. Magnetic property

The material should ferrous in order to respond to the magnetic force generated by the electromagnet.

IV. OBSERVATION

Approximately 0.60%–0.99% carbon content in steel is used for the application of springs and high-strength wires [15]. The manufacturers of this instrument in India are using spring steel with annealing so that it can bend easily but the properties of the material get hampered in this case and this requires more time and efforts to calibration. The feedback from the manufacture Rishabh instruments PVT LTD regarding the production of this instrument shows that the production rate is about 5 meter per day even if the calibration process is fully atomized. Bending the material with annealing also increases the efforts in calibration of the instrument as the weight is to be placed on the reed to set the reed to a particular fundamental frequency. Approximately half an hour is required to calibrate 13 reeds. If the material is used without annealing then the theoretical calculations can coincide with the practical results as the material properties do not change. The question arises is only about bending of material at 90^0. Because of spring back of the material it is difficult to achieve 90^0 bend. During this case study various things about 90^o bending of such thin material is discussed with the press tool manufactures and made few sample. The conclusion from the trial shows that, by providing minimum radius of 1 mm it is possible to bend the material without annealing and at perfect 90^0. During bending the inner radius is under compression while the outer radius is under tension and due to elasticity property it tends to go back to its original shape this is known as spring back.

Following are the Factors affecting spring back in sheet metal bending [16].

A. The greater the yield strength of the material, the greater the spring back will be.

B. The thinner the raw material, the greater the spring back.

C. The larger the bend radius the greater the spring back.

D. Raw material manufacturing specification different from batch to batch.

First two factors are unavoidable because of the material selected is thin and strong. Thickness of material is around 0.15 mm to 0.2 mm; this is necessary to match with the functioning and aesthetics. As per the discussion with the press tool manufacturers allowable bend radius is 1mm to 2mm because the material with high carbon content can break for radius under 1 mm.

Factor 4 which mentioned above can be eliminated by maintaining a dead stock of same material from the same manufacturer by sacrificing all rules of inventory. The amplitude of vibration in the instrument is reached from +/- 1 to 2mm to +/-4 to 5mm due to selected material so that the user can easily identify the readings.

First trial for bending is made on C90 material but after failure of this material in the bending tool, chemical composition is determined which showed high carbon and high manganese content in the material. Presence of high carbon and high manganese content makes material brittle. In second trial C90 is replaced by another grade of spring steel C94 and tried to bend the material at right angle and found suitable for bending as the amount of manganese is less than C90 material and hence the material is not too brittle to bend at 90^0. The laboratory reports for material C90 and C94 are shown in annexure A and B respectively.

V. CONCLUSION

Reed is the heart of the vibrating reed type instrument. The materials which are currently used by the various manufacturers for reed requires more time and effort for calibration as well as the amplitude of vibration is very low about +/- 1 to 2 mm which is not suitable for reading the value as window size is 10 mm. If the spring steel is used without annealing it gives higher amplitude of vibration as well as it posse's important properties like corrosion resistance. The best suitable material for the reeds of the vibrating reed frequency meter is C94. The bending is easy and without failure for the reed of C94 material. This is because of appropriate content of manganese with high carbon content. Sufficient chromium provide corrosion resistance. Sulphur and phosphorus content is low as machinability is not of prime importance. Sufficient amount of silicon is present in the material which improves resilience of material for spring application and makes the material defect free. Fatigue strength is mainly improved by cold rolling and tempering process (maximum temperature for tempering 450 ^{0}c). After changing the material the amplitude of vibration achieved is +/- 4 to 5 mm.

VI. FUTURE SCOPE

Theory and discussion with press tool manufactures shows that, it is possible to bend the thin and hard material at 90^0 by providing minimum radius at the bend. This step is sufficient to bridge the gap between theoretical and practical results as the properties of the material remain constant. Remaining success of the objective is depends on calculation of fundamental frequency and variable parameters for it. By avoiding calibration not only the efforts of calibration will be saved but also the production rate will increase drastically.

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VII. ANNEXURE

Annexure A

YOUR SAMPLE REFERENCE : 13 Reeds - Single Piece

RESULTS OF CHEMICAL ANALYSIS : BY WET / INSTRUMENTAL METHODS IS - 228 - 1997

Our / Your Reference	C %	Mn %	Si %	S %	P %	Ni %	Cr %	Mo %		HARDNESS IS-1501-2002
G / 608	0.90	0.58	0.20	0.018	0.020	Nil	0.20	Nil	--	593 HV-5 (55 HRc)

Remark : Chemically above material conforms to En - 44 / En - 42 J Carbon Steel specification

Annexure B

YOUR SAMPLE REFERENCE : 40 x 150 x 0.15 mm thk. Sheet

RESULTS OF CHEMICAL ANALYSIS : BY WET / INSTRUMENTAL METHODS IS - 228 - 1997

Our / Your Reference	C %	Mn %	Si %	S %	P %	Ni %	Cr %	Mo %		HARDNESS IS-1501-2002
G/640	0.94	0.34	0.22	0.018	0.016	--	0.17	--	--	593 HV-5 (55 HRc)

Remark : Chemically above material conforms to En - 44 D specification