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On-Condition Maintenance for Medium Frequency Induction Furnace (Corless Type).

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ON-CONDITION MAINTENANCE FOR MEDIUM FREQUENCY INDUCTION FURNACE(CORLESS TYPE)

الصيانة المشروطة لفرن الحث والتردد المتوســــط وبدون قلـــــب

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الخلاصــة : ان مشكلة صيانة فرن الحث عادة ماتواجه العاملين بالمسابك الأمر الذى يجعلها من بين أهـــم المشاكل المطلوب بحثها وقد تم استخدام أسلوب الصيانة المشروطة لبطانة فرن الحث لتحديد الوقت المناســـب لتغير بطانة فرن الحث وذلك عن طريق القياس المستمر للمقاومة وبالتالى يفصل التيار الكهربى عن الفرن عندما تصل المقاومة الى القيمة المحسوبة مسبقا وبالتالى أمكن تجنب الانهيارات المفاجئة فى الفرن .

SUMMARY

In this investigation, the maintenance problem of induction furnaces which usually faces the foundry men has been examined, using on condition maintenance. This is for lining, and also to know when to take a decision to change the lining of furnace. This can be reached by continous measuring of furnace resistivity. In other words, the power should be stopped when the resistivity of the furnace reaches a certain predetermined value, other wise failure of the lining occurs and even explosion is liable to take place.

1. INTRODUCTION

Electric furnaces are used mainly for heating and melting of metallic material in general.

Electric furnaces can be divided by the method of conversion of electric energy to heat into the following groups :-
Resistance furnaces, induction furnaces, electric arc furnaces, electrolytic-heating furnaces, electron-heating furnaces, laser furnaces and plasma furnaces (1,2).

Induction heating has found very wide application in melting ferrous and non-ferrous metals, case harding of parts and heating of blanks before ferging and stamping (3,4).

Induction furnaces are devided into two types : 1) Channel-type furnace in which an inductor with a closed magnetic circuit, core, is placed inside a narrow concentric annular channel laid of refractory material. The channel is filled with molten metal to form a closed electrically conductiving. ii) Crucible-type furnace, without core, in which the metal being heated, fills a ceramic crucible placed inside a multiturn cylinderical inductor. In the crucible type furnace when lumps of metal are charged into the crucible and the coil is energized an electric current is induced in the metal which rapidly heats and melt the charge. The electromagnetic waves falling from the coil onto the surface of metal cause electrodynamic forces which exert a pressure on the molten metal and make the latter to circulate (5,6).

Maintenance is an important problem in this field, and it must be achieved with studies to avoid any stopages or damages in the furnace. Here applicable studies have been made to use the "on condition maintenance for medium frequency induction furnaces, coreless type".

2. PROBLEMS ARISINC DURING THE MELTING PROCESSES.

Different problems may face the foundary men using induction furnaces. These problems may be due to metallurgical, mechanical, or even electrical causes.

Preventive maintenance may not be sufficient to solve all these problems. Melting oftenly takes place at high themperatures requiring high frquencies and very efficient water cooling circuits. One of these problems is the refractory lining. The selection of the suitable refractories still cannot elimenate all the lining problems, therefore, many other precautions and measures should be taken in consideration such as :

a. The lining should be as thin as possible. a thin lining would prevent closing of magnetic flux through the charge which might increase the melting time and the consumption of refractories.

b. Lining should have a low thermal conductivity coefficient, except for rare cases. Thermal conductivity coefficient depends on the nature and porosity of a material and on the temperature since conductivity of refractories increases with temperature. The low conductivity of lining will hinder short circuiting with temperature. The low conductivity of lining will hinder short circuiting.

c. It should have high referactoriness.

d. It should withstand the eroding action of slage.

e. It's mechanical strength shold posses a higher value in order to withstand impact of falling charge places and mechanical wear in furnace. The load pressure onto lining in operating furnaces may be from 30 to 80 N/cm^2.

f. The lining is usually subjected to very severe condition its thin walls are subjected to high thermal stresses owing to large temperature differences, the inner surface of the crucible may have a temperature of 1600°C, while the temperature of the outer surface which contacts the water-cooled coil is only 200 to 300°C. Sharp volume charges are the main cause of cracking of lining inturn failure.

g. The lining should posses a sufficiently high thermal shock resistance.

3. THE OPERATION OF A MEDIUM INDUCTION FURNACE

It was noticed during melting different metal that the lining life depends largely on the chemical composition of the molten metal. In the case of steel containing high manganese, nickel titanium and aluminum contents melting should carried out in furnaces. If a high-manganese steel is smelted in acid lining deteriorates quickly due to the formation of the low melting point manganese silicates. While in the case of aluminum and titanium they reduce silicon from the lining ans pass it to steel or cast iron, and consequently, the thickness of lining is reduced. Life of lining becomes longer in furnaces operating continously, i.e., by reducing thermal stresses. If however, intermittent operation is necessary, then the furnace should be cooled down and heated up as slowly as possible. This can be achieved by sealing the furnace top during cooling and retarding the heat-up slightly on the subsequent heating.

The build-up slag at the dead region (middle of crucible) is very harmfull and decreases the lining life, because it resists the magnetic field and prevents the expansion and contraction of the lining in this region.

Long periods of holding molten metal of full capacity should also be avoided since this can result in premature wear and reduces the lining life.

The shape and the size of the crucible has considerable influence on the life of the lining, the taper may extent to different height and the amount of taper my vary resulting in different lifes of the crucible, see fig.1 while straight cylindrical types, see fig.2, are rarely used. Also, larger crucibles have shorter lifes than smaller ones, they are more subject to spalling and cracking. In a relatively short time of service the thickness of the lining changes. Furthermore not only does the thickness change, but also the inside shape is subject to alteration during the life time of one lining. Furnace may change the original shapes showen in figs. 1 and 2 to that shown in fig.3.

4. MAINTENANCE OF CRUCIBLE

Many studies (7,8) have been made on the maintenance of the lining and it's life, where maintenance can be either preventive or on conditional, the first one depends on the time as a base of maintenance and the second one depends on the permenant monitoring as a base of maintenance.

Permenant monitoring is a necessary and important point to prevent any danger, it indicates the condition of the furnace and the degree of it's deterioration.

As soon as the metal penetrates the lining it will reach the coil (1500 volt), an alarm can stop the furnace automatically and circuit breaker take a position of "trip" and the furnace stops. But if the tubed coil failed by molten metal the water mixes with molten metal and explosion took place due to contact with the electric coil (1500 volt).

5. EXPERIMENTAL WORK

The experiments of the present work have been carried out on a coreless type induction furnace in the foundry plant of Misr Company for Textile El-Mehalla El-Kobra.

The foundry is used to melt different metals and the experiments were carried out for periods reached to 252 operating hours at 90% power (540 KW/hr.) and 20% power (120 KW/hr.).

The individual reading of the resistivity were taken at periods of 6 to 8 operating hours, which cover the shift period in the foundry. The experiments were continued till the failure point of the refractory lining.

6. RESULTS AND DISCUSSION OF RESULT DATA

Statistical analysis of resistivity at power 20% (120 KW/hr.) has been carried out to obtain the upper limit of the resistivity(R).

$$\text{Average resistivity } (\bar{R}) = \frac{\sum R}{N} = 1.32 \text{ ohm.}$$

$$\text{Standard Deviations} = \sqrt{\frac{\sum (R-\bar{R})^2}{N-1}} = 0.191 \text{ ohm}$$

It was found that the average resistivity is 1.32 ohm with a standard deviation of 0.191 ohm. The data are plotted in fig.(4) between the resistivity and the operating time in hours.

It is evident from the plot that variation of resistivity between 9 and 130 operating hours is small, and a jump occurs in the resistivity at 148 working hours and continue till the end of the process, i.e. till the failure of the lining at 162 working hours.

The resistivity at the failure point is about 1.75 ohm. Accordingly care should be taken withrespect to the furnace when the resistivity reaches 1.62 ohm.

From the statistical analysis an equation in the form of: Maximum Resistivity = Average Resistivity + 2.2 x S ohm, where S is the standard deviation.

With respect to the case of operating conditions at power 90% (540 KW/hr.) for 180,243 and 207 working hours for different melting operations.

It was found that the resistivity tends to increase steadily with time, and reaches a value ranging between 2.6 and 2.62 ohm at which failure occurs see figs. 5,6 and 7. At this point irrespective of the operating time, a decision has to be taken for relining before any failure that may occur to avoid the damage and the danger that may proceed. This is for the safety of the system and the working personnel.

7. CONCLUSION

1. Preventive maintenance only is not sufficient to be used in conduction furnaces.
2. The resistivity of the coil tends to increase with operating time.
3. When the average resistivity of the coil reaches 1.6 ohm and 2.6 ohm for power 20% and power 90% respectively the lining should be replaced, irrespective of the operating time of the furnace.

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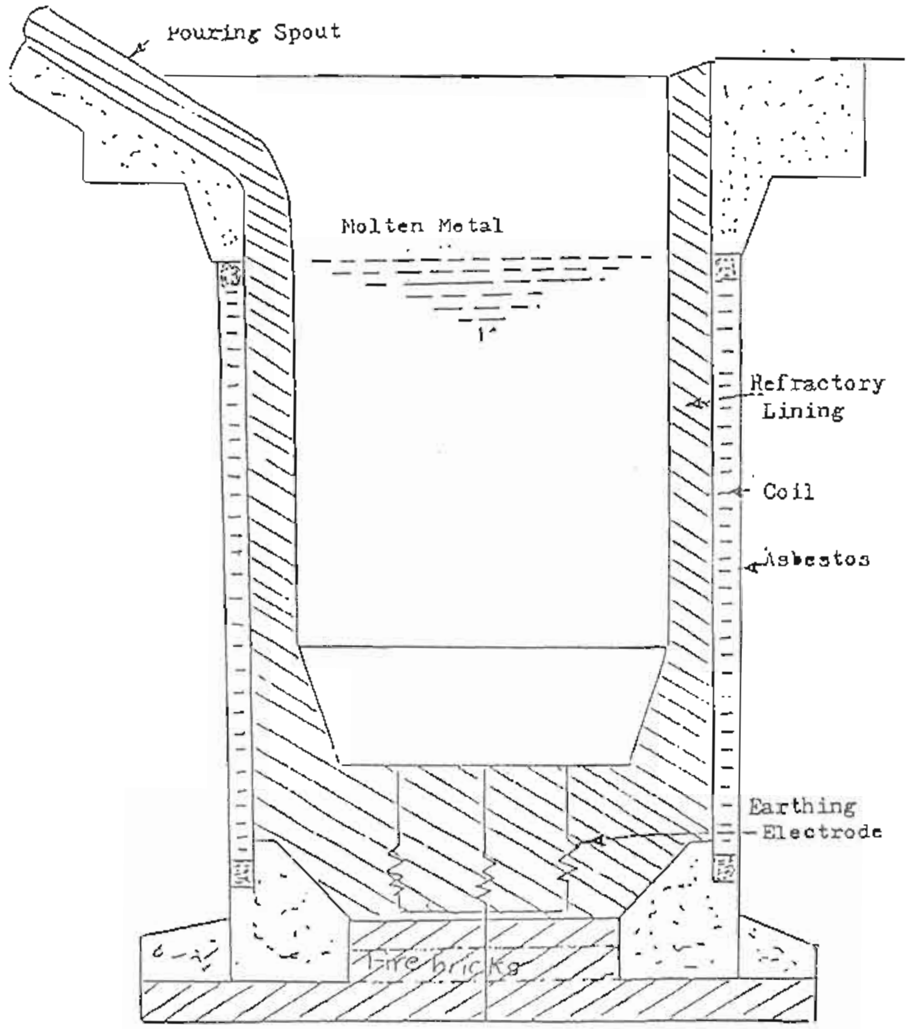

Figure (1) Induction Furnace

Magnetic Field and Electrodynamic Forces Acting in the Crucible of an Induction Furnace

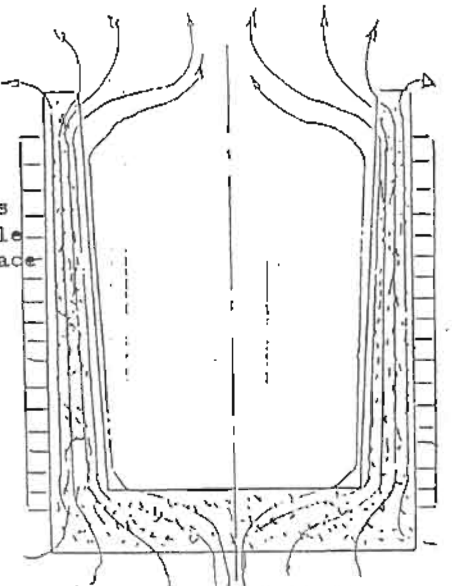

Figure (2) Induction Furnaces

Electrodynamic Circulation of Metal in the Crucible of an Induction Furnace

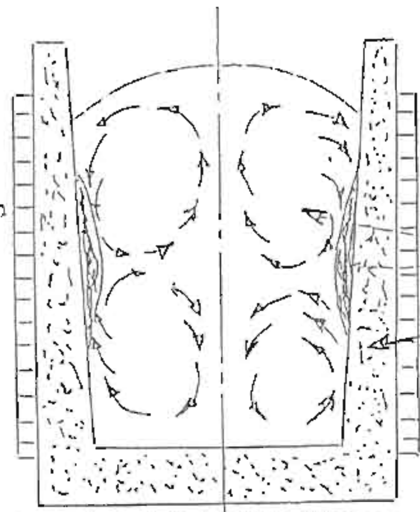

Figure (3) Induction Furnace

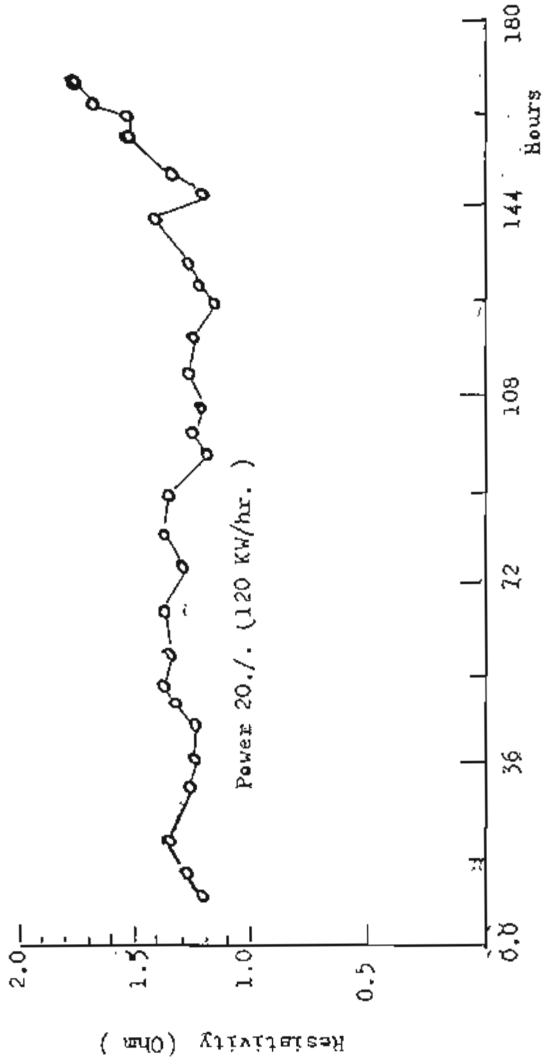

Figure (4) Resistivity Versus Operating Time

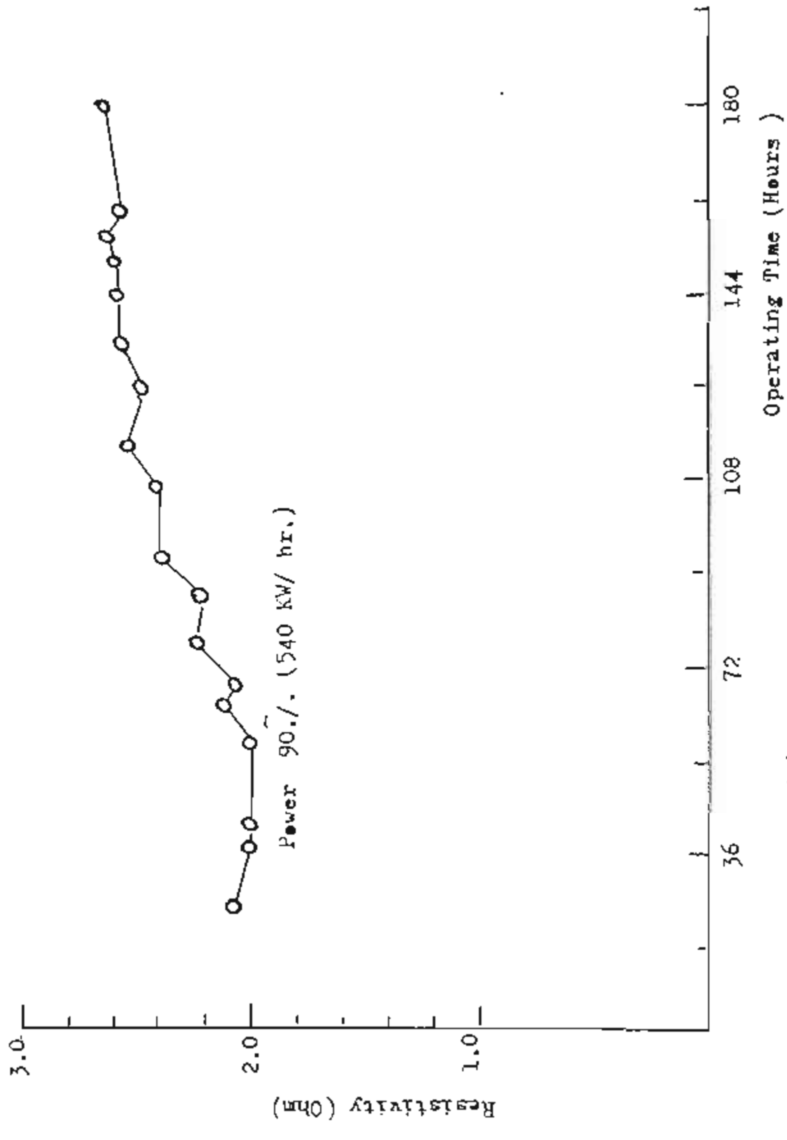

Figure (5)Resistivity Versus Operating Time

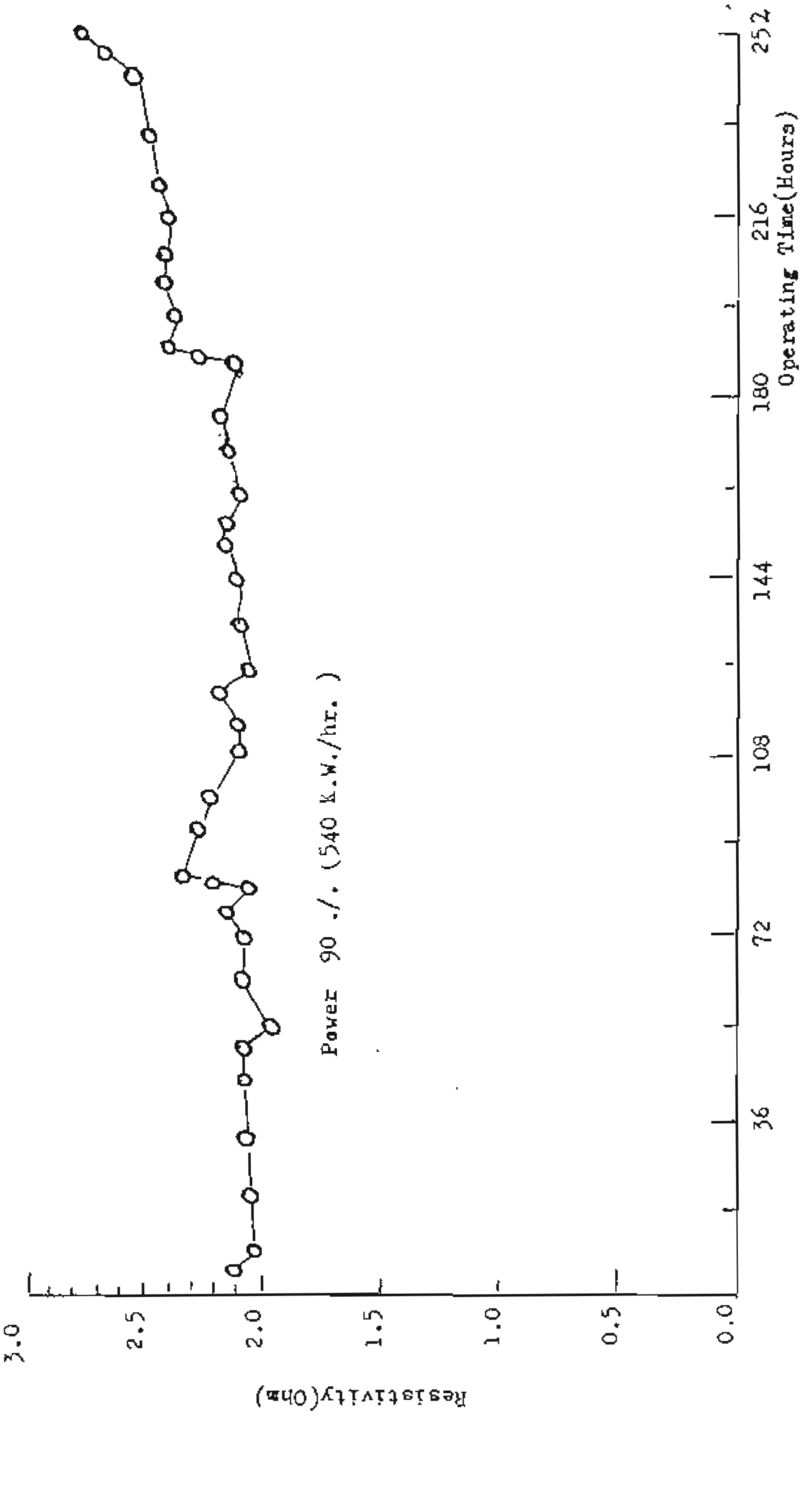

Figure (6) Resistivity Versus Operating Time

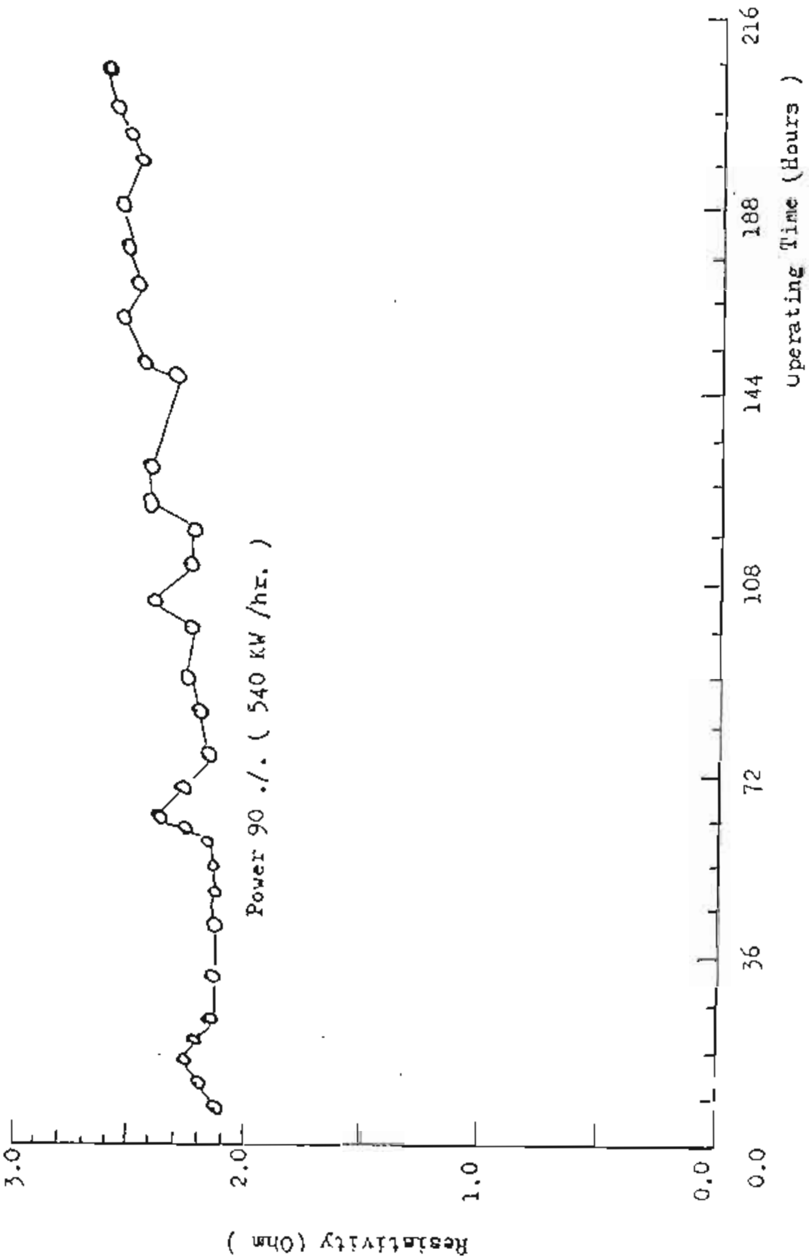

Figure (7) Resistivity Versus Operating Time