RUBBING ACTION OF RECOPROCATING NEGATIVE RAKE TOOL EDGES

By

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Summary

A grinding grit may be simulated with a two dimensional cutting edge heading different rake and clearance angles at its two opposite ends. Attention is confined, in this preliminary study to a force-chip phenomenal study of reciprocating at zero nominal depth of machining.

Tools of negative rake angles were made to move over thin free machining brass plates in the dry cutting conditions. Tests were continued without any reconditioning of the machined surfaces. Forces and chip thicknesses variations were revealed for several cutting and return strokes carried out at the same nominal conditions.

Appendix 1 gives the design, construction and calibration of a new two force dynamometer elaborated by the authors during their present research in the laboratories of Faculty of Engineering and Technology, Menoufia University.

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INTRODUCTION

For the horizontal plane grinding operations, the abrasive grits transverse and reciprocate over the workpiece surface. Needless to say, that such action involves the use of abrasive grains with varying rake and clearance angles.

In an effort to simulate that condition, two dimensional single point tools were made to reciprocate over workpieces fixed, in turn, on the vice of a milling machine employed as a planer. That cutting action, though performed at a low cutting speed, would shed some lights on that of grinding process. It remains to be seen whether the grinding action would involve material rebound after cutting or permanent recovery as the case found for cutting with those negative tools (1),(2).

EXPERIMENTAL DETAILS

Free machining brass specimens of dimensions (9.8x25x140mm) were fixed on the vice of a rigid milling machine used as a planer. The chemical composition of these plates are (60:65% Cu, 30:35% Zn and 3:4% Pb).

High speed steel orthogonal tools of cross section 20x20 mm and 90 mm length were ground with various rake angles of -55°, -65° , -75° add a common clearance angle of 9°. These tools were traversed along the workpiece width. The plates were employed as received in the rolled condition.

The workpiece plates were moved underneath the tool in a reciprocatory fashion. Both the horizontal and vertical forces were recorded by means of a specially designed dynamometer (Appendix 1). All the cutting tests were performed in the dry condition at low cutting speed of 800mm/min. All the actual cutting and return strokes were performed at nominal depths of cut equal to zero once the first preliminarly stroke was performed.

EXPERIMENTAL PROCEDURE

1 - Cutting stroke at the least nominal depth of cut of the machine (0,05 mm), were performed with the conventional rake face of the tool (i.e., with -55°, -65°, -75°), at cutting speed of 800 mm/min. That cut was performed to ensure that the tool edge would be touching all the workpiece surface for better tests.

2 - The direction of the motion of the milling table was to be reversed taking a nominal depth of cut zero, (i.e., without any re-adjustment of the table). In such a case the return stroke was to be performed by passing at the old clearance face of the tool which would represent the new rake face of an angle -81°.

3 - After these preliminary steps, records were made for both of the cutting stroke with nominal depth of cut of zero. The total number of round strokes after the preliminary, were four.

4 - Records were made for forces and chip thickness during cutting strokes, and for the forces only during the return stroke.

EXPERIMENTAL OBSERVATIONS

1 - No chips were elaborated for any of the return strokes with a rake angle of -81°.

2 - For the preliminary cutting strokes, chips were found to be discontinuous.

3 - For the actual cutting strokes, the chips were found to be severely curled and continuous.

4 - The quantity of chips were found to be smaller as the negative rake angle increase.

5 - For the same cutting tool, the chip thickness, was found to decay as the pass number increase.

6 - Surface brightness was found to increase with the increase of the negative rake angle.

RESULTS AND DISCUSSION

Fig. (1) shows the relationships between horizontal force (F_e) and the cutting stroke number (n_1) for various negative rake angles at a constant clearance angle of 9°. A decrease in the horizontal cutting force was noted with the increase of the pass number of cutting stroke, and for higher negative rake tools. This is logical, since the amount of chip removal is greater for a less negative rake angle tool and at a smaller cutting stroke number (n_1).

Fig. (2) shows the relationship between the thrust force component (F_t) and the cutting stroke (n_1) for different values of negative rake angles. Again a decrease in the value of the thrust force was noted as the cutting stroke number increase. However, the thrust force at a nominal zero depth of cut increase as the negative rake tool angle increase.

Fig. (3) shows the relationship between the chip thickness (t_c) and the cutting stroke number for various negative rake angles (-55°, -65°). A decrease in the chip thickness value was noted as the cutting stroke number increase and, with the increase of the negative rake angle.

It is worth mentioning that the cutting tool of a rake angle of -75° particularly did not elaborate any chip.

The existence of chip thickness at a zero nominal depth of cut in such a manner shown in Fig. (3), reveals the existence of decaying permanent recovery for the workpiece material as the cutting stroke increase (n_1).

However, as the negative rake tool angle increase more than -75° no chip elaborate at all. Instead, rubbing prevail and the material coming infront of the tool, would leave more or less at its rear, at the same height provided that the side flow is negligible.

Fig. (4) shows the relationship between the horizontal force and the return stroke number (n_2). It seems to be that the force value decrease generally as the return stroke number increase. In such a way that for initial return strokes the horizontal force increase as the negative rake angle decrease. On the other hand, the force value increase as the negative rake angle increase at higher return stroke number.

Fig. (5) shows the relationship between the thrust force component and the return stroke. General trends is that such forces decrease at higher return stroke number, and become higher as the negative rake angle increase.

CONCLUSIONS

1 - Permanent metal recovery decays with the stroke number increase and for lower negative rake tools.

2 - No chip evolve for negative rake angles more than -75° irrespective of the value of the clearance angle.

NOMENCLATURE

F_e - Horizontal force component per unit workpiece width.
F_t - Thrust force component per unit workpiece width.
t_c - Chip thickness.
n_1 - Cutting stroke number.
n_2 - Return stroke number.
t - Nominal depth of cut.
 - Tool rake angle.
C_1 - Clearance angle.

REFERENCES

1. M.Es. Abdel Moneim and R.F. Scrutton, Post machining plastic recovery and the law of abrasive wear, Wear, 24 (1973) 1.

2. A.M. Abdel Mahboud, Fundamental Study of Cutting with negative rake tools, M.Sc. dissertation, Fac. Eng. & Tech. Menoufia University, Dec. 1979.

Appendix 1

Dynamometer design, construction and calibration

Introduction

The biggest design problem in dynamometers is the compromise between a dynamometer having a high stiffness and one having a high sensitivity.

The principal on which all dynamometers are bases is one of measuring the deflections or strain produced in the dynamometer structure from the action of the resultant cutting force.

In a review of metal cutting dynamometers, Repair (A_1) suggested two parameters that are useful in assessment efficiency of various dynamometer design,

1 - These displacement ratio $r_d (r_d = x_1/x_2)$

where:

x_1 - displacement measured by gauge or transducer.
x_2 - tool displacement.

Such ratio (r_d) should be as large as possible in order to obtain the maximum output from the dynamometer.

In an efficient design, the tool displacement (x_2) should be as small so that the geometry of the cutting process is maintained; also the dynamometer structure should have a high natural frequency so that the possibility of vibrations is kept minimal.

Design Theory

The simplest type of a two component dynamometer is the cantilever dynamometer which is suitable for the employed machine in the current research.

Tool holder is supported at the end of a cantilever. Vertical and horizontal deflections of the cantilever are determined by strain gauge.

Dynamometer construction

Fig. (A1) shows the dynamometer construction. The horizontal component is measured by the strain gauge (1) which is connected in a full bridge as shown in Fig. (A2). The vertical component was measured by using a strain gauge (2) which is supported above the tool which is connected in a half bridge as shown in Fig. (A2).

Dynamometer Calibration

The universal testing machine was utilized to calibrate the horizontal force component; That was achieved by applying machine loads above the tool end. Records on the dynamometer chart would, hence represent the corresponding loads. As for the calibration curve for the vertical force component; a dead-loading technique was called for. Fig. (A3) gives the obtained calibration charts for the horizontal and vertical force components.

References to Appendix 1

A1 A.C. RAPIER, Cutting Force Dynamomets, H.M. Stationery office, NEL Pla. Rep. 158, 1959.

Acknowledgement

The authors extend their regards to Eng. Mahmoud Shaban Hewidy, of Faculty of Engineering and Technology, Menoufia University, who contributed in the design and construction of the employed dynamometer.

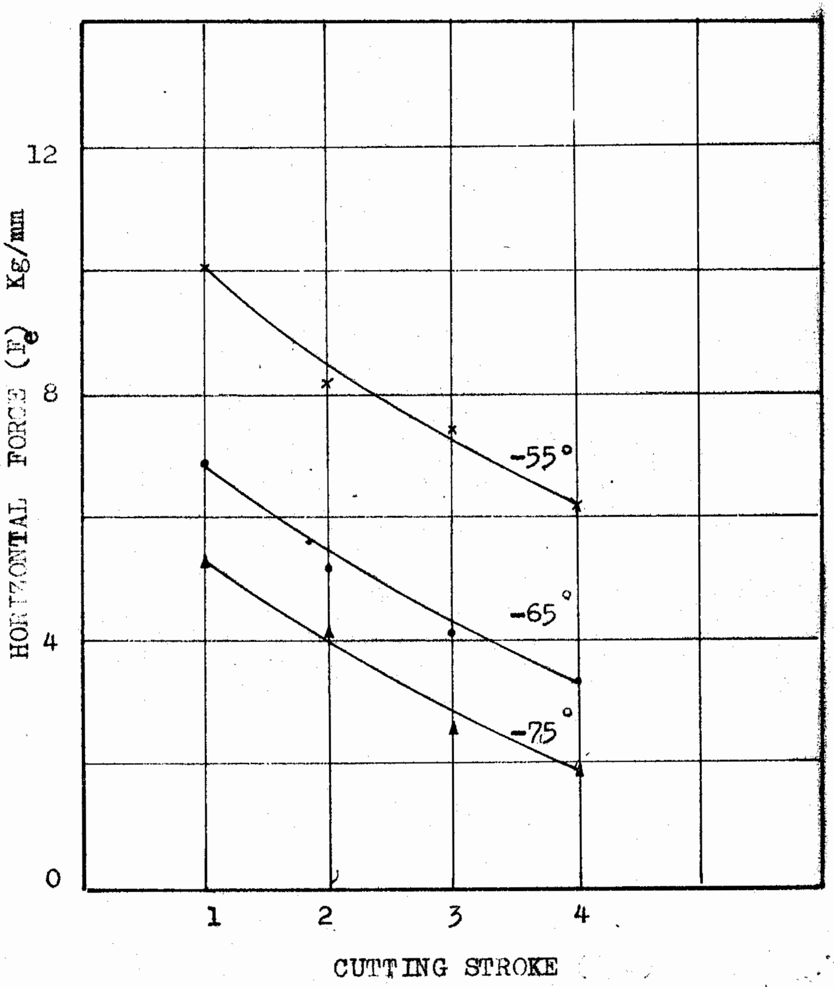


Fig.(1)

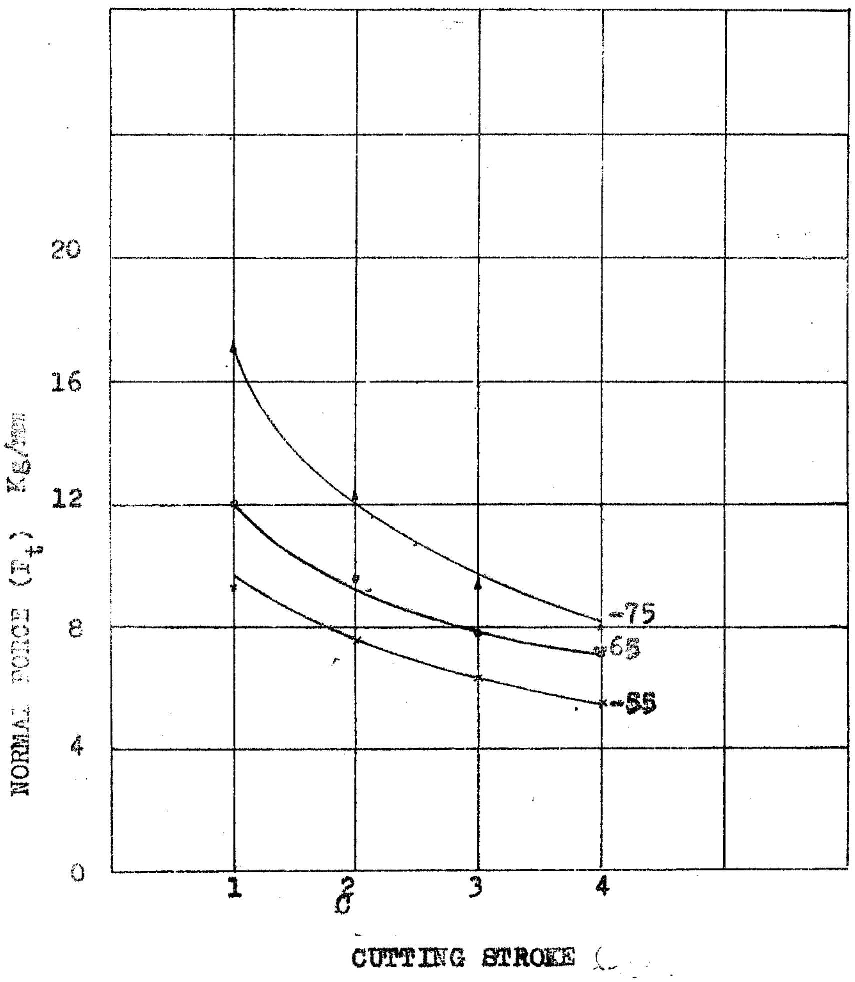
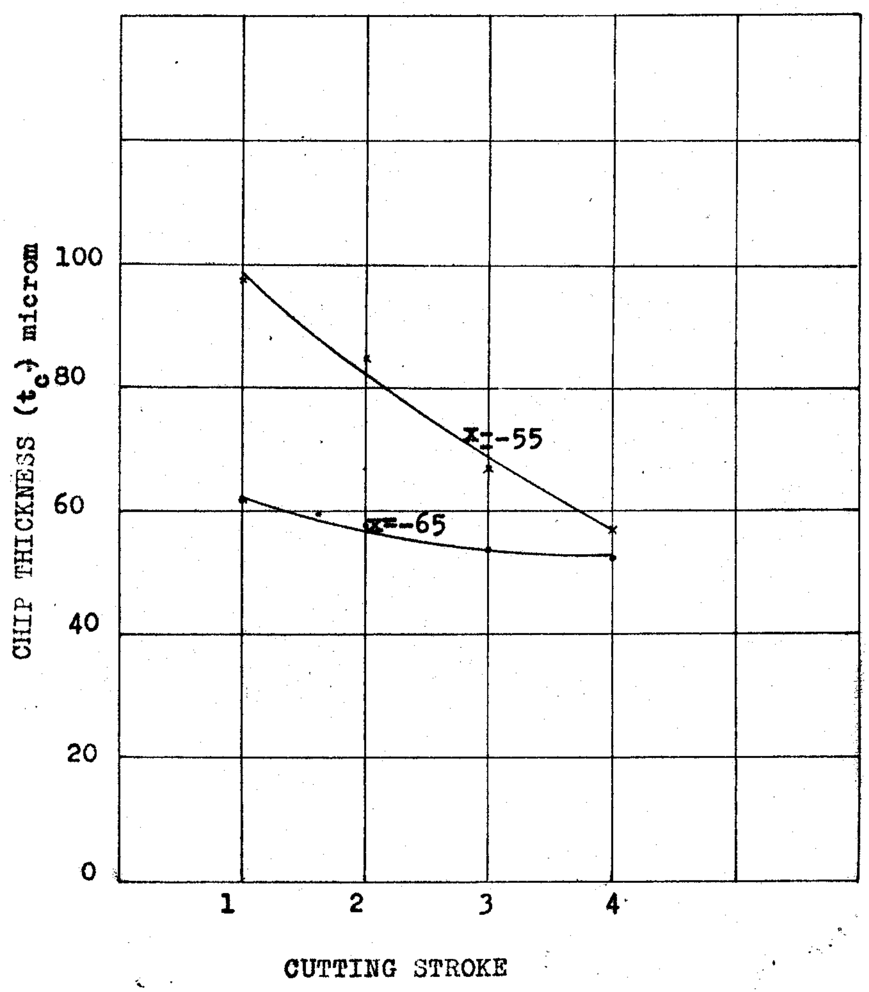


Fig . (2)



CHIP THICKNESS (t_c) microm
100
80
60
40
20
0
1
2
3
4
α=-55
α=-65
CUTTING STROKE

Fig (3)

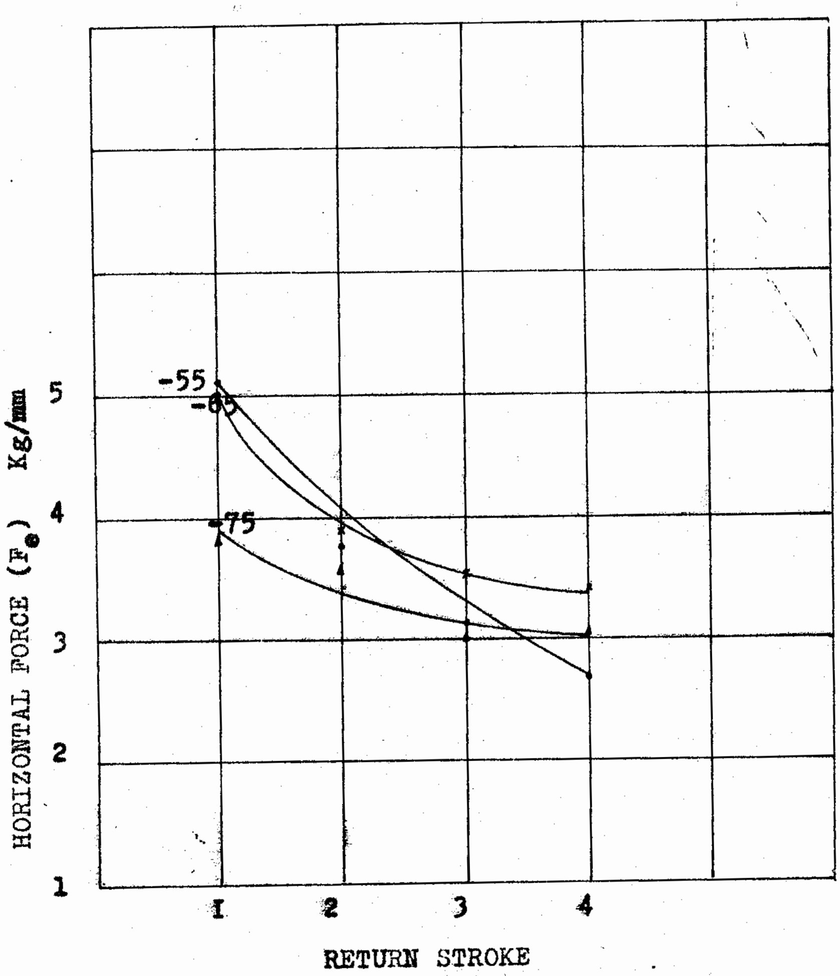


Fig. (4)

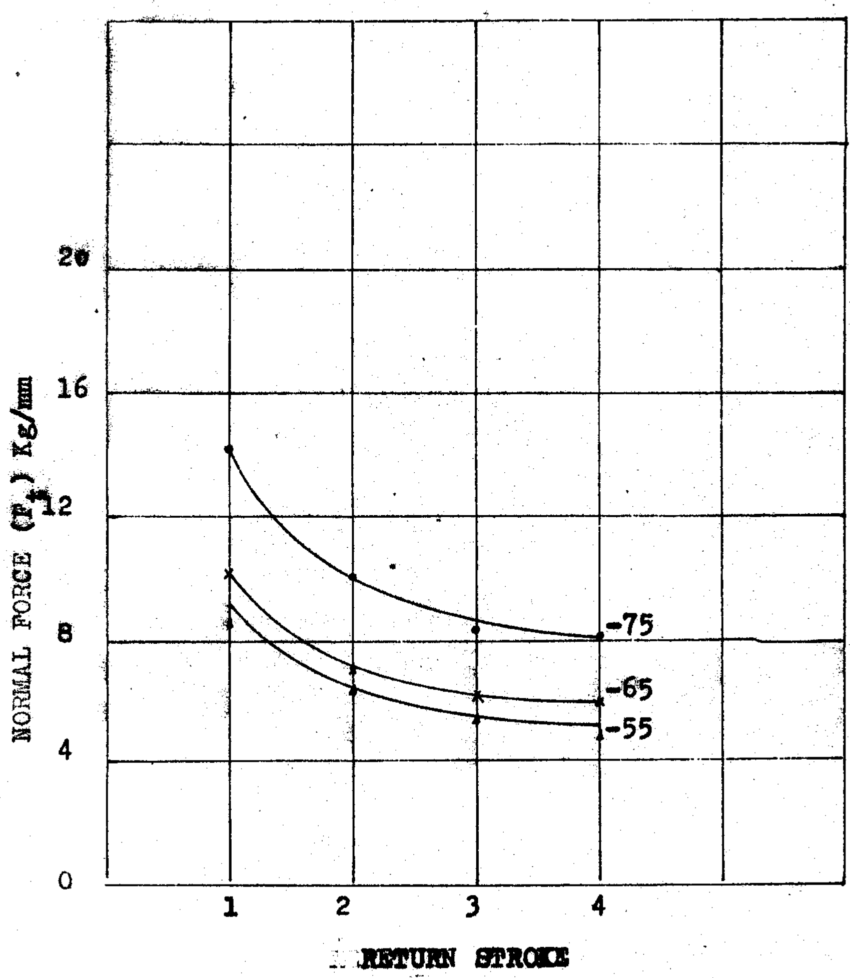
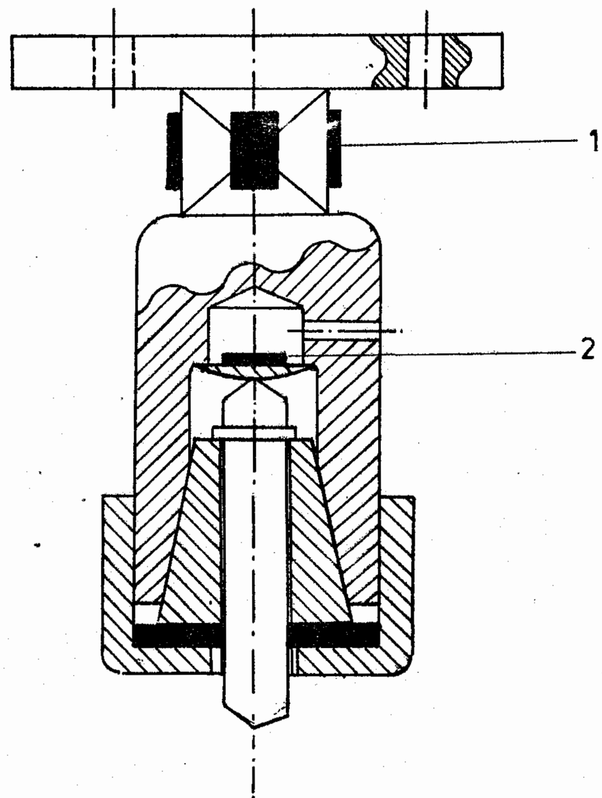
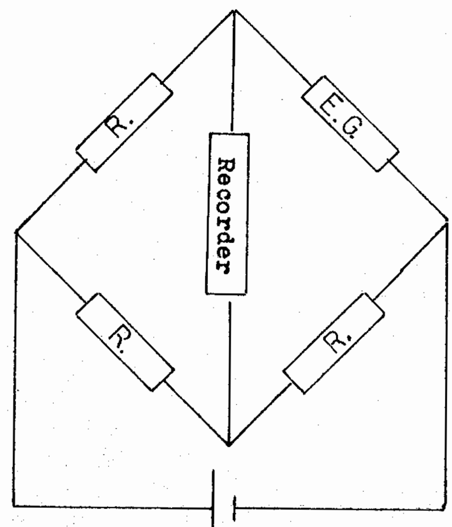


Fig (5)

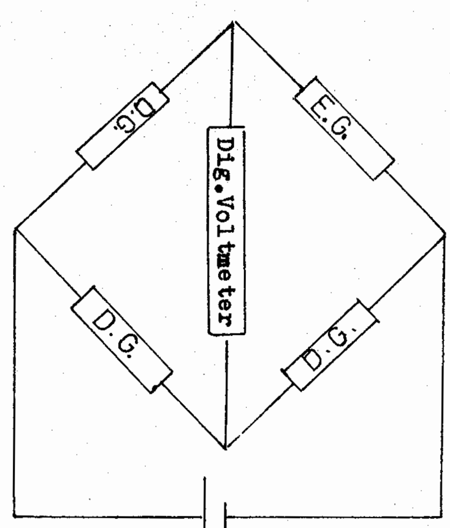


Special Strain Gauge Dynamometer

Fig. (A.1)

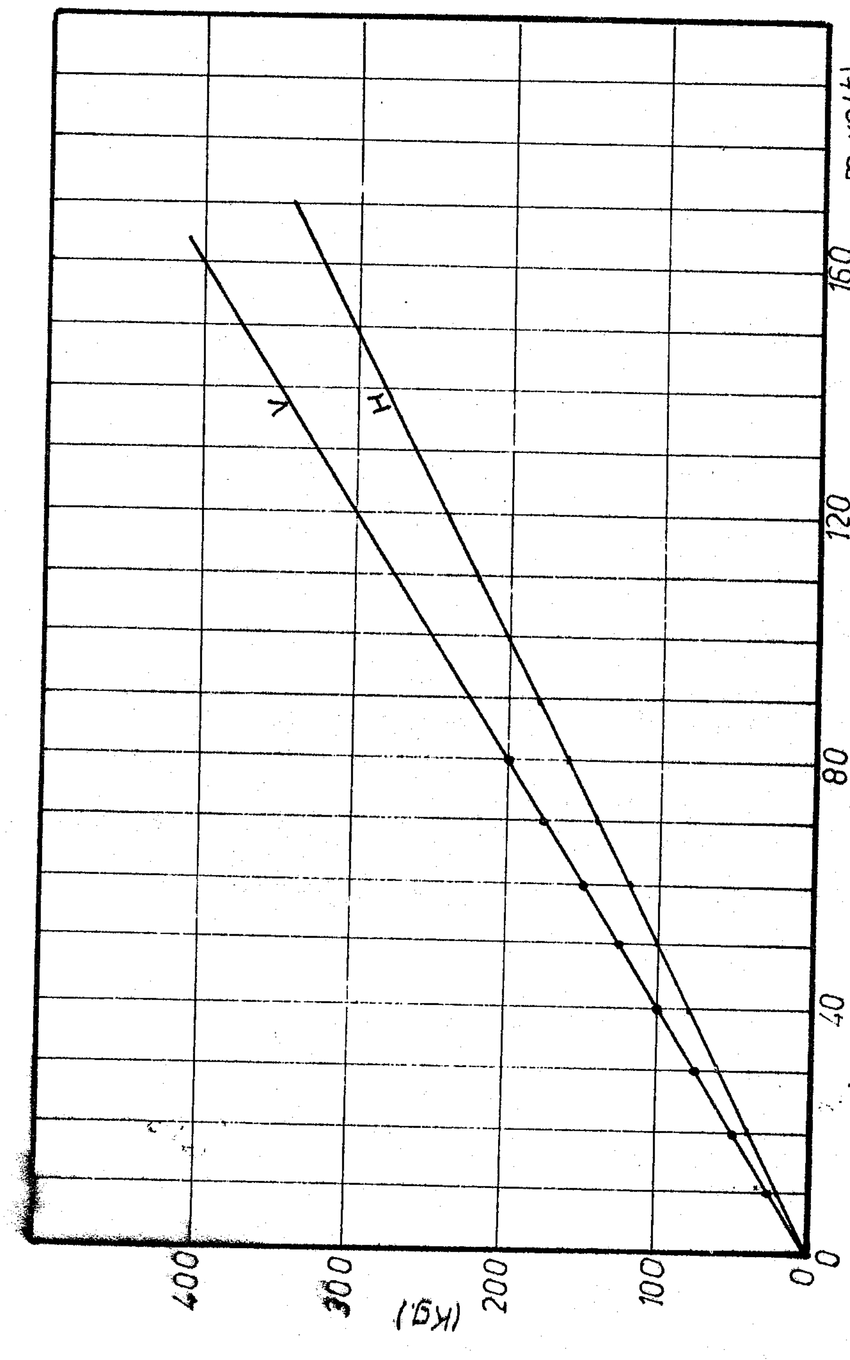


a- Half Bridge strain gauge for measuing F_t



b Full Bridge Strain Gauge For Measuring F_e

Fig. A-2



CALIBRATION CURVE

Fig.(A3)

القطع الترددى بالأقلام ذات زوايا الجرف السالبة

أ ٠د ٠ عبد الهادى عبد البارى ناصر   د ٠ منصور السيد عبد المنعم
م ٠ عادل محمود عبد المعبود جمعة

من المعروف أن عمليات التجليخ يمكن تمثيلها كعمليات قطع بزوايا جرف سالبة أو موجبة أو صفر – وفى هذه الدراسة المبدئية أعتبرت كزوايا جرف سالبة – وأجريت التجارب عن طريق القطع الترددى بالأقلام ذات زوايا جرف سالبة بين (–٥٥° ، –٦٥° ، –٧٥°) وزاوية خلوص (٩°) – على عينات من النحاس الأصفر بسرعة قطع ٨٠٠ م / دقيقة – عند عمق قطع Naminal مساويا الصفر (عملية احتكاك) وقد تم تصميم ومعايرة ديناموميتر لقياس قوى القطع يمكن تركيبه على الفريزة الأفقية لتعمل فى ظروف التجارب وقد أظهرت التجارب مايلى :

١ – عدم تكون رايش عند زوايا جرف (–٨١°) ٠
٢ – تكون رايش مستمر وملفوف فى زوايا الجرف ذات القيم السالبة العالية ٠
٣ – تقل كمية ظهور الرايش بزيادة زاوية الجرف عند عمق قطع مساويا الصفر مما يؤكد وجود ظاهرة Permanent Recovery فى النحاس الأصفر ٠