AN APPROACH TO THE DESIGN OF CENTRIFUGAL MAGNETIC PEENING SYSTEM

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ABSTRACT

A new design for a portable centrifugal peening system was attempted. A magnet, which is mounted at the end of a rotating arm picks up steel shots and throws at required place by the use of commutator. A model was made and tested for the principle of working and it is found satisfactory. But, however, further improvements are necessary for actual use for peening purpose. The purpose of this investigation was to eliminate the conventional huge shot elevator and shot regulator. Magnetisation it self will pickup required quantity of shots and thus seperate shot elevator and regulator are not required.

KEYWORDS

Centrifugal peening system, Magnetic wheel and commutator.

INTRODUCTION

Shot peening is a process in which high velocity shots are allowed to impinge on the surface of metal parts with the intension of introducing residual compressive stress. The conception of peening equipment, material and shape of the peening media depends on the work piece to be peened. This will be determined by - (1) Cleanliness and structure of the surface (2) improvement of the mechanical behaviour (3) changing of geometries. Selection of proper peening media and equipment both are very important. [1].

Shots can be propelled over the workpiece either by pnumatic method or by centrifugal wheel. Weibel in 1935 recognised the value of shot peening treatment and since then considerable research has been done on shot peening and it's effect on fatigue, corrison fatigue and stress corrison cracking. Most of these publications gave very little emphasis on design of centrifugal peening equipment. Computer aided design of wheel was recently undertaken by Meguid and Klair at Crainfield. In these centrifugal system there has been given a huge shot elevator for shot elevation. [1].

In the present investigation it is proposed to remove this huge shot elevator by providing altogether a new design of centrifugal wheel. The proposed device is based on following principal and can avoid the need of the conventional shot elevator.

THEORY AND DESIGN

Under the influance of a magnetic field steel shots are attracted towards the magnetic pole. The lifted shots are carried by a rotating electro-magnet which when deenergised throws the shots radially outwards. The energization and de-energization of the electro-magnet has been accomplished by means of a commutator mounted on the same shaft. The desired position of shot release has been obtained by the adjustment of contact brushes.

The energy transferred to the shots during the process is due to the magnetic field. Which serves two puyrposes, first, it lifts the shots by a given distance from shot hopper and second, it holds them against the centrifugal and inertial forces.

Consider the case of aradial arm placed at X=0, y=b on the shaft of an electric motor. The arm has an electro-magnet fixed at it's end. Let r be the combined length of arm and the electro-magnet. When the arm has been placed vertically down the clearance between the pole face and the shots has been taken as s and at any other position the air gap has been taken as l_g. Then b=(r+s) meters.

The force exerted by a Horse-shoe type of electromagnet is given as:

$$F = 0.102\ (B^2 A)/\mu_0 \ \text{Kg} \qquad (1)$$

where B is the air gap flux density Wb/m^2.
A is the area of pole face, m^2
μ_0 is the permeability of free space, $4\pi \times 10^{-7}$ H/m.

Let the angular velocity of shaft be w rad/sec then the angular displacement after time t = w.t. radians.

Force exerted on shots at an angle (+wt) can be written as,

$$F = F_x + F_y$$

$$= |F \cos wt| + F \sin wt. \text{ for } \pi \geq wt \geq 2\pi \quad (2)$$

The modulus of F_x has been taken because the force remains attractive and acts towards centre for all values of w.t

If the iron parts are unsaturated, the ampere turns required for them is low as compared to that required by the air gap.

Let AT be the ampere turns required by the air gap. Then,

$$B = \frac{\mu_o \ AT}{l_g} \times \ wb/m^2 \quad (3)$$

From Eqn. (1) and Eqn. (3)

$$F = \frac{K}{l_g^{\ 2}} \quad Kg \quad (4)$$

$$\text{where, } lg = (r+s)/\text{-}\sin wt - r. \quad (5)$$

$$K = (\mu_o . AT)^2 \qquad \text{for } \pi \geq wt \geq 2\pi$$

The dynamic equation of motion for shots of mass m accelerated upwards under magnetic force can be written as,

$$M \frac{d^2x}{dt2} = F_x \quad \text{and} \quad m \frac{d^2y}{dt2} = F_y - mg \quad (6)$$

From eqns. (2), (4) and (6),

$$\ddot{x} - |\{(k/m) \cos wt\}|/l_g^{\ 2} = 0$$

$$\ddot{y} - \{(K/m) \sin wt\}/ l_g^{\ 2} + g = 0 \quad (7)$$

where g is acceleration due to gravity.

The condition that the shots reach the pole face can be given as:,

$$y - lg = 0 \quad (8)$$

Solution to Eqn.(7) has been obtained with initial conditions that at t=to, x=0, y=0, $\dot{x}$=0 and $\dot{y}$=0, till the condition given by Eqn.(8) is satisfied.

Let,

α be the angle subtended by ends of pole piece at the centre of the motor shaft,

τ = the time required by the shots to reach pole face, and lp denote the length of pole piece.

$$\text{Then } lp = r.\alpha \quad (9)$$

The angular velocity w = r. /τ rad/sec.

therefore,

$$\mathcal{L} = w.\tau/r. \qquad \text{radians} \qquad (10)$$

Solving Eqns.(9) and (10) the length of pole piece required have been obtained.

In this system a given quantity of shots have been thrown at the work piece and after striking the shots flow back and collect in the hopper due to gravity. Thus a shot elevator is not required.

ADVANTAGES

Following are the advantages of this system over the conventional peening systems.

The system is cheap, portable, wear is minimised due to less relative movement of shots, elimination of conveyor, size of shots can be different, economical due to low maintainance, less moving parts therefore reliable, easyness in assembly, using a number of radial arms different sizes of shots can be thrown at the work piece in each revolution thus programmed peening is possible, easyness in the control of the angle of attack by changing brush position, less quantity of shots required since recycling is not due to bucket conveyor, comparatively low noise, extended shot life, easily modified to enhance performance, no pnumatic control required feed control is possible by electrical methods, shots other than spherical may be used, non-magnetic dust separation, close process control due to electro-mechanical methods.

The one of the most serious limitation of this system is that, it can not handle non-magnetic media.

Fig.1-4 will show, the details of magnet, rotating arm and schematic of conventional and proposed peening system.

REFERENCE

1. Meguid and Klair, "Computer aided design of centrifugal peening equipment using solid modelling", Second International Conference on Impact treatment processes, 1986, pp 144-160.

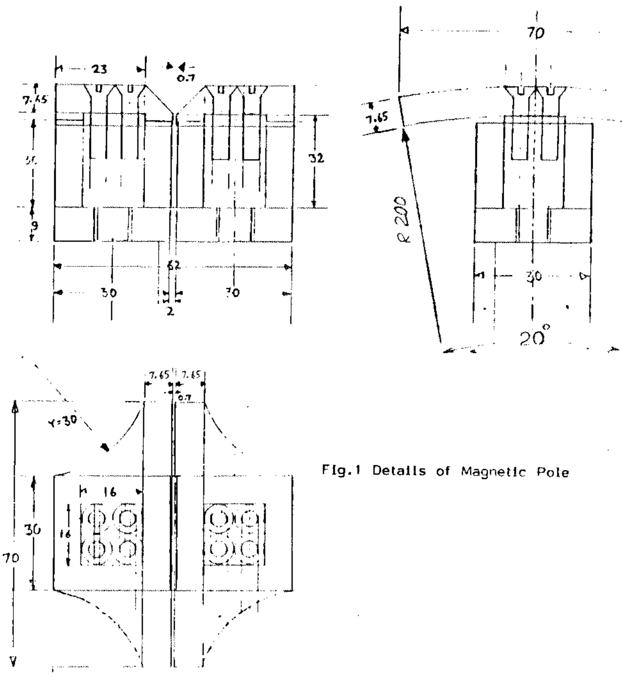

Fig.1 Details of Magnetic Pole

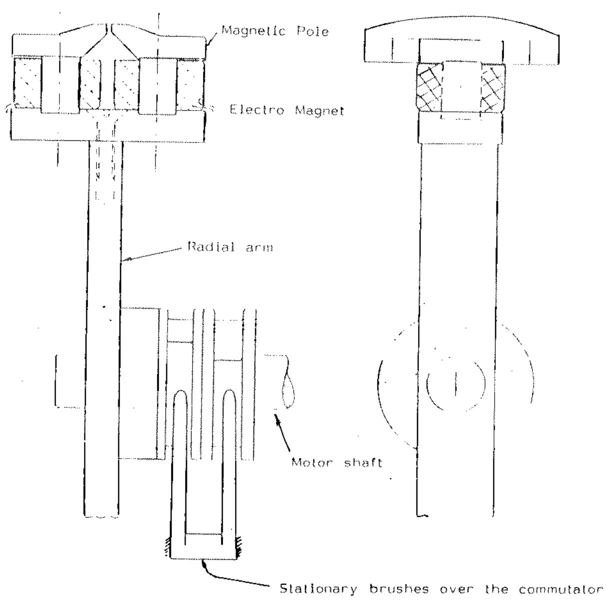

Fig.2 Radial arm assembly showing electro-magnet fixed at its end, Magnetic pole and commutator.

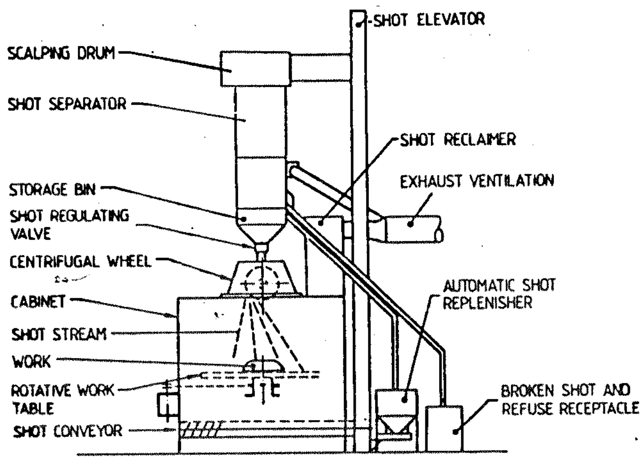

Fig.3 Conventional centrifugal peening system.

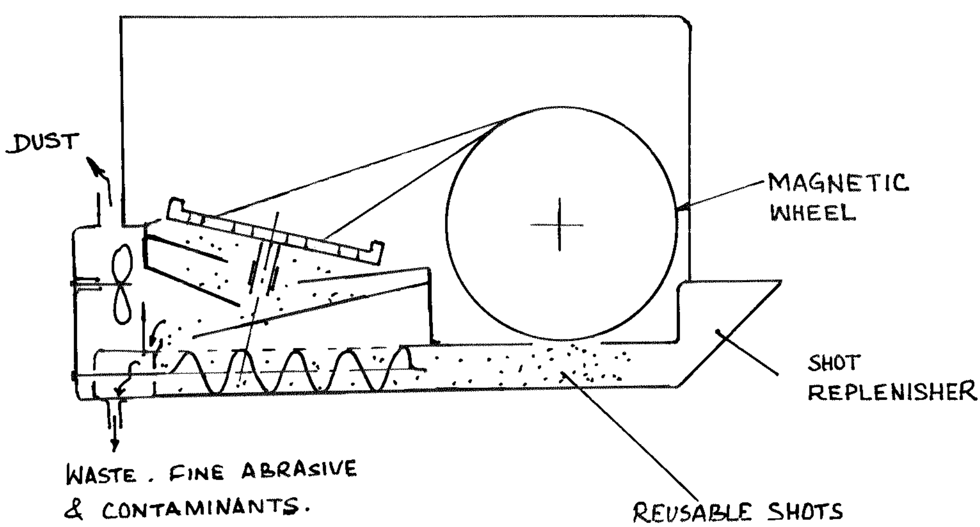

Fig.4 Proposed magnetic peening system eliminating huge shot elevator.