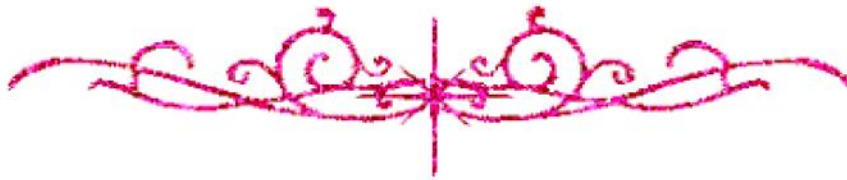


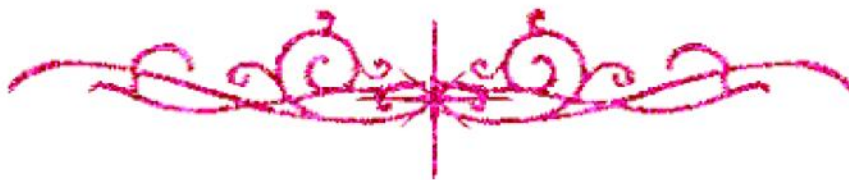
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# شبكة المعلومات الجامعية التوثيق الالكتروني والميكرو فيلم



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# جامعة عين شمس

## التوثيق الإلكتروني والميكروفيلم

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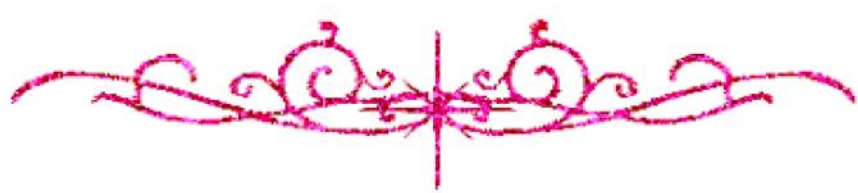
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بالرسالة صفحات

لم ترد بالأصل



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AN INVESTIGATION INTO  
THE MECHANICAL PROPERTIES OF METALLIC POWDER COMPACTS

A Thesis

*Submitted to the Faculty of Engineering & Technology  
Minia University, Egypt, for the partial fulfillment of  
requirements of the M. Sc. Degree  
in Mechanical Engineering (Production & Design Section)*

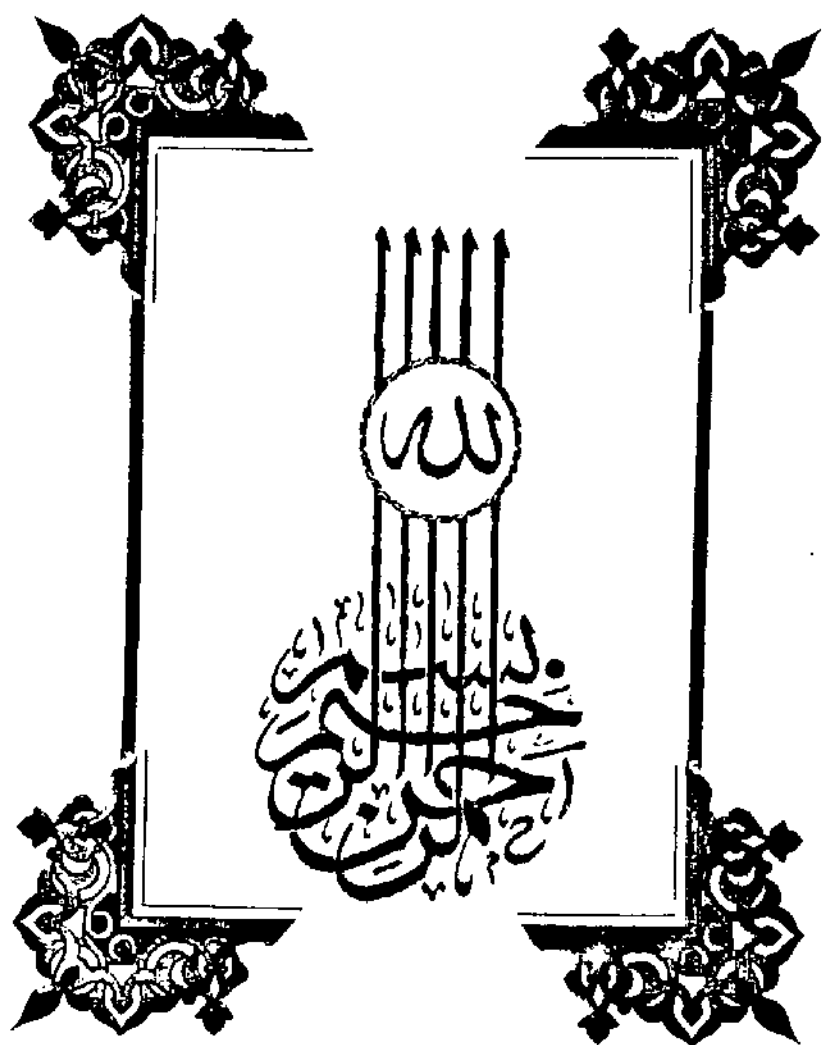
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TO MY DEAR PARENTS, WIFE, BROTHERS AND SISTERS

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# AN INVESTIGATION INTO THE MECHANICAL PROPERTIES OF METALLIC POWDER COMPACTS

## SUMMARY OF THE THESIS

In this work, an investigation of mechanical properties of powder metallurgy (PM) compacts was carried out. As it is well known, deformation and fracture of PM compacts in forming are quite different than these for solid parts. This is due to the presence of pores in the PM compacts, which gives relative density (compact density/theoretical density) less than 100%. The effect of relative density on the behaviour of PM compacts in upsetting was studied.

Two theories characterizing PM compact behaviour during deformation were reviewed :the first developed by Kuhn and Downey (1973) and the second by Hwang and Kobayashi (1990). To characterize the deformation of PM compacts, a simple workability index ( $\beta_p$ ) is proposed in this study considering the effect of both apparent effective stress of powder material and the hydrostatic (mean) stress components of the powder material proposed index is the same as the stress workability index ( $\beta$ ) proposed by Vujovic and Shabaik (1986): more negative value of the index means the addition of a hydrostatic compressive stress to the stress state which leads to a delay fracture; while more positive value of the index means the addition of a hydrostatic

tensile stress to the stress state which leads to speed fracture. When the two theories were applied to the working hypothesis, the Kuhn and Downey theory failed to verify that the effective stress of PM compact having 100% relative density to be the same as that for solid material at the ideal condition ( $\mu = 0$ , and  $\beta = -1$ ). So, It was suggested that the use of Whang and Kobayashi theory would give more realistic results.

An experimental program was planned and an experimental set up was designed and constructed to carry out the experiments. Compaction in both cold and hot working regimes was carried out to produce PM compacts from Aluminum and Copper powders. Properties of the compacts were measured. Effect of the compaction condition on compact properties was also checked. Then free upsetting of the compacts was preformed between two flat dies and height reduction to fracture were determined.

Hwang and Kobayashi (1990) theory was applied to the experimentally obtained results and constants were calculated. Then workability index ( $\beta_p$ ) values were predicted. The results showed a very good agreement with the hypothetical principle and the effect of relative density could be detected with the aid of this parameter. A recommendation of the use of this index for characterizing compsite materials was made.

## NOTATIONS

|                 |                                              |                   |                                               |
|-----------------|----------------------------------------------|-------------------|-----------------------------------------------|
| $C, n$          | material constants                           | $\beta_p$         | workability index                             |
| $D_f$           | final specimen diameter                      |                   | for porous material                           |
| $f$             | yield function                               | $\epsilon_{eff}$  | effective strain                              |
| $H_0$           | initial specimen height                      | $\epsilon_r$      | radial strain                                 |
| $H_f$           | final specimen height                        |                   | component                                     |
| $I_2$           | second invariant of stress deviator          | $\epsilon_z$      | axial strain                                  |
|                 |                                              |                   | component                                     |
| $J_1$           | first invariant of stress tensor             | $\epsilon_\theta$ | hoop strain component                         |
| $J_2$           | second invariant of stress tensor            | $\nu$             | plastic poisson ratio                         |
| $p$             | function of relative density & particle size | $\sigma_b$        | yield stress of base material                 |
| $P_{cr}$        | critical pressure at density of 100%         | $\sigma_{eff}$    | effective stress                              |
| $R$             | relative density                             | $\sigma_m$        | hydrostatic stress                            |
| $R_c$           | near-tap density                             |                   | component                                     |
| $\alpha$        | function of relative density                 | $\sigma_a$        | apparent effective stress of a powder compact |
| $\beta$         | workability index for pore-free materials    | $\sigma_r$        | radial stress                                 |
|                 |                                              |                   | component                                     |
| $\sigma_t$      | green strength                               | $\sigma_z$        | axial stress                                  |
| $\sigma_\theta$ | hoop stress component                        |                   | component                                     |
| $\epsilon_f$    | strain at fracture                           | $P_{D1}$          | compaction pressure                           |