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Design and fabrication of compacting machine for nano products

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A B S T R A C T : Powder metallurgy is recognized today's as one of the most important near net shape fabrication technique for manufacturing several industrial products. The real advantage of PM is to cost effectively produce large volume, highly tolerance metal components & widely applied to produce mainly automotive parts such as bearings cap, cams, synchronization hub, sprocket and toothed components. There is little repetitive failure during production of Compaction (Forming) press tool found in manufacturing process. Each failure causes very high Economical cost to manufacturer in terms of production loss due to down time as well as commitments to the customer. The failure analysis of this compaction press tool was found most interesting. During these work modes of failures of tool was studied to conclude and recommend the solution.
Design of compaction press tool was the methodology used to analysis the problem. The parts will be modeled in Solid Works and the core components will be subjected to structural analysis in ANSYS. As a result of design and analysis, the dimensions are finalized with the tolerances and mating condition.. In this paper description of a punch and die pressing approach for powder materials will be presented where very high pulse pressures are applied for short duration on powders. Such a punch and die pressing offers the ability to form uniformly high density net shape parts with fine microstructures. This method can be applied to wide range of materials such as metals, ceramics, and composites. A broad range of powder particle size distribution, from coarse micron size to fine nano size powders, can be used in this process. Punch and Die Compaction process discussed in this paper.

Keywords: Nano product

1. Introduction

Powder metallurgy (PM) is the process of blending fine powdered materials, pressing them into a desired shape or form (compacting), and then heating the compressed material in a controlled atmosphere to bond the material. The powder metallurgy process generally consists of four basic steps: powder manufacture, powder blending and sintering.

A metal powder compaction tooling set consists of a die, Top punches, Bottom punches and a set of springs. The distribution of radial stress, tangential stress of die and buckling analysis of punches has been analyzed using Finite Element Analysis. The compacting cycle can be divided into three stages: 1) Filling the die, 2) Densifying the powder, and 3) Removing the compact from the die. Each of these stages is characterized by specific positions or movements of the individual tool members. And in each of these stages, specific technical problems occur. The nano crystalline materials exhibit many unique properties, which are different from those of the materials having typical grain size.

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Nomenclature

PM	Powder metallurgy
CCS	Cold Crushing Strength

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2. Problem identification

Nano crystalline materials have been synthesized and analyzed by using various techniques. Researchers didn't compact and analyze the mechanical properties such as hardness of Ti64 powder. In this we are focusing to synthesis and consolidate nano crystalline powders. In hot compaction method using induction heating method. Clean and fast being supplied to the heated work piece meets the considerably increased the requirements with regard to environmental protection. Induction heating provides a heat source which is very easily controllable and create heat up process. Heating equipment with a level of automation which allows to be integrated in a production line such as machine tools.

2.1 aim of the work

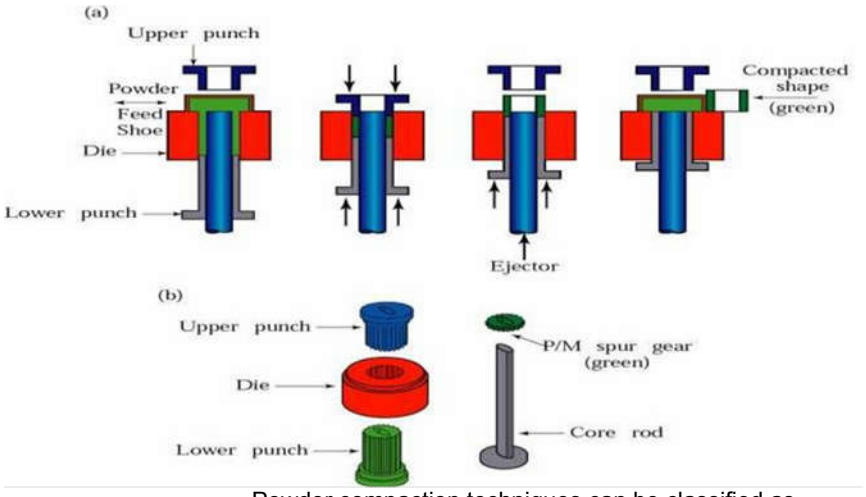
The first and foremost aim of the work is to formulate a small sized device to compact powdered materials using hot compaction technique. In this research we found the induction heating method is the best method to heat the materials without much damage.

3. Process description

The compaction cycle can be divided into three stages:

1. Filling the die
2. Densifying the powder
3. Removing the compact from the die

3.1 Powder compaction methods:



Powder compaction techniques can be classified as,

Methods without application of pressure–i) loose powder sintering in mould, ii) vibratory compaction, iii) slip casting, iv) slurry casting, v) injection molding

Methods with applied pressure–i) cold die compaction (single action pressing, double action pressing, floating die pressing), ii) isostatic pressing, iii) powder rolling, iv)powder extrusion, v) explosive compaction

Pressure compaction techniques

These techniques involve application of external pressure to compact the loose powder particles; Pressure applied can be unidirectional in nature.

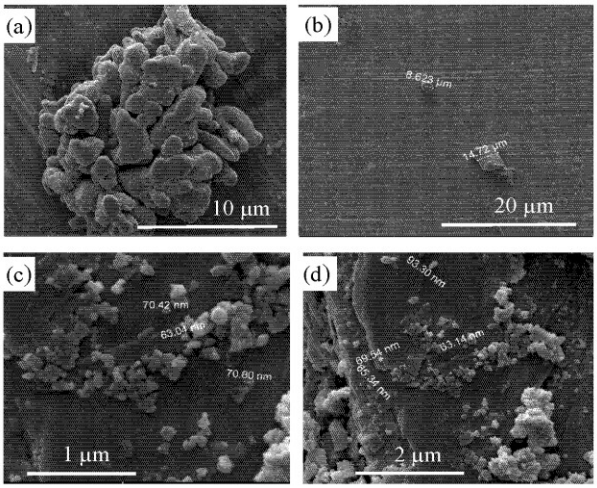
Die compaction: In this process, loose powder is shaped in a die using a mechanical or hydraulic press giving rise to densification. The mechanisms of densification depend on the material and structural characteristics of powder particles.

Unidirectional and bidirectional compaction involves same number of stages and are described in this figure. They are, i) charging the powder mix, ii) applying load using a punch (uni-) or double punch (bi-) to compact powders, iii) removal of load by retracting the punch, iv) ejection of green compact. The table gives compaction pressure ranges for metals and ceramics

3.2 Powder material:

In our project we use copper powder (Cu, >99.5%, 40-70 nm) to compaction process. Copper and copper alloy powders have been used in industrial applications for many years. Many applications for electronic and manufacturing industry require micro structural stability and high temperature resistance materials in addition to good mechanical properties, high electrical conductivity and corrosion resistance.

For such applications, the most promising metal is copper because of its high electrical and thermal conductivity. However due to its relatively high ductility, is necessary to increase its mechanical resistance being careful not to alter their electrical properties. it become conductive, two events must occur. First, the organic encapsulant that surrounds the nano-particle must be removed in a burn-off event. Second, the nano-particles must be raised to a temperature that allows for them to sinter or melt in a continuous film; this is referred to as the conduction temperature.



3.3 Production of copper powder:

Copper powder can be produced by a number of methods, the most important being atomization, electrolysis, hydrometallurgy and solid state reduction.

Atomization method:

Copper powder can be produced by a number of methods, the most important being atomization, electrolysis, hydrometallurgy and solid state reduction. Each method yields a powder having certain inherent

characteristics.

Typically, copper is melted and the liquid metal flows through an orifice where it is struck by a high velocity stream of gas or liquid, usually water, thus breaking the molten metal into particles which solidify rapidly. After atomization and annealing in a reducing atmosphere to decrease any surface oxide formed during atomization, the product is milled, classified and blended to achieve the particle size distribution required.

The purity of the product depends on that of the raw material since refining of the melt prior to atomization is generally not practiced. Purity is generally over 99%. The powder can be made either spherical or irregular in shape. Particle size and shape, apparent density flow and green strength are influenced not only by atomization variables but also by controlling oxidation during atomization, subsequent reduction during annealing, and by final processing.

4. Applications

Due to their special properties and also small dimensions, find important applications in optical, magnetic, thermal, electronic and sensor devices, catalysis, etc. Almost all properties of nano particles are due to their small sizes Applications for copper nano crystals include as an anti- microbial, anti-biotic and anti-fungal (fungicide) agent when incorporated in coatings, plastics, textiles, in copper diet supplements, in the interconnect for micro, integrated circuits, for its ability to absorb radioactive cesium, in super strong metals, alloys, in nano wire, nano fiber, in certain alloy and catalyst applications.

5. Compressing testing machine

This Compression Testing Machine is a hydraulic, electrically operated unit, designed for conducting compression tests on concrete specimens up to 20 cm. Diameter (or width and depth) and 30 cm, in height and also rocks and various other materials. Cold Crushing Strength (CCS) test is also possible in this Compression Testing Machine.

The Compression Testing Machine consists of a steel cross head and cast iron base with two pillars connecting the base and cross head by means of nuts. The hydraulic jack of this Electric Compression Tester is fixed to the base. The upper platen has got a self aligning action and is attached to a screw which passes through the cross head and can be raised or lowered for initial clearance adjustment. The lower platen rests on the jack ram and is positioned with the help of a centering pin.

Loading is accomplished by the upward movement with the help of a centering pin. Loading of Compression Testing Machine is accomplished by the upward movement of the motorized pumping unit is of plunger type and is connected to the jack by means of a steel connecting tube.

A maximum red pointer is provided to facilitate taking of the readings after failure of specimens. The pressure gauges of 20 cm diameter with isolating valves are fixed on the pumping unit at an angle for easy readability.

The Electric Compression Tester Machine is fitted with control which enables the rate of application of load to be varied. The Compression Testing Machine is equipped with facilities for hand operation as well.

The electrical pumping unit is fitted with three micro switches one for each pressure gauge and will switch off the Compression Testing Machine automatically as the load on the machine approaches its full capacity of the gauge in case the isolating valves are not operated. This will protect the pressure gauges and the whole unit so that in case of breakdown of power supply, the machine will stop and will not restart unless the starting switch is operated

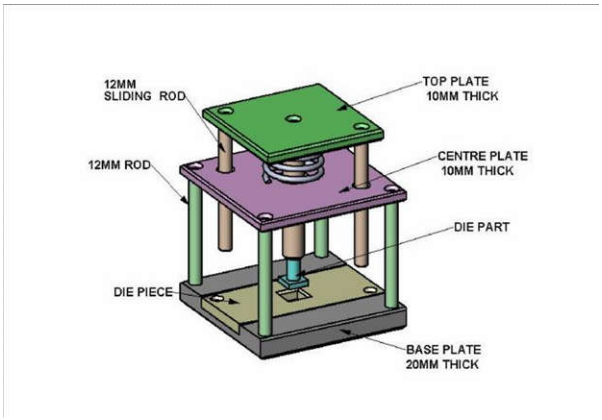
5.1 Salient features of Compression Testing Machine are:

- High Stability
- Self-aligning platen assembly

- Load Gauges are calibrated in KN against certified proving rings, traceable to NPL/NCCBM.
- Suitable for testing cubes and cylinders of various sizes.
- Using special platens, bricks can also be tested.
- Logged data printing facility through a parallel port interface available in digital and Micro controller used versions.
- Calibration process accreditated by NABL.
- Machines with CE mark also available, on special request.
- Operator's safety features like metal door with a Perspex window and overload tripping device are provided in all models.

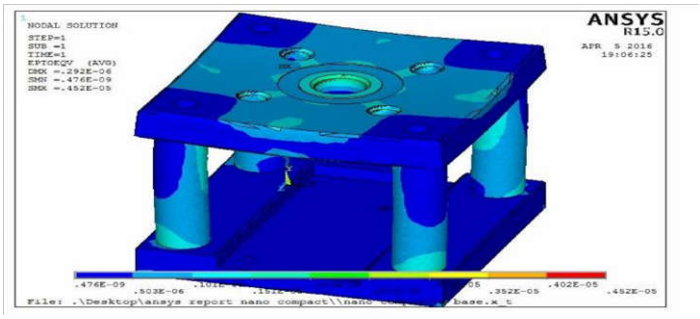
6. CAD model

Assembly:

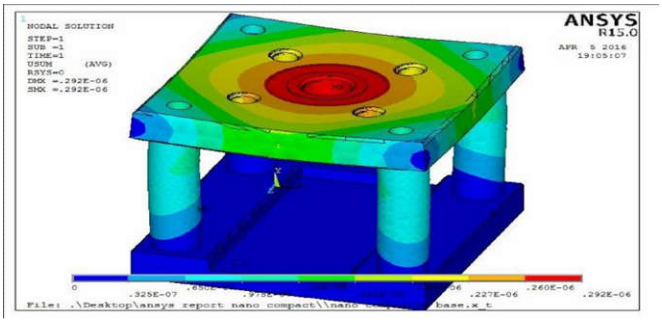


ANSYSREPORT
PUNCH:
Punch load deformation:

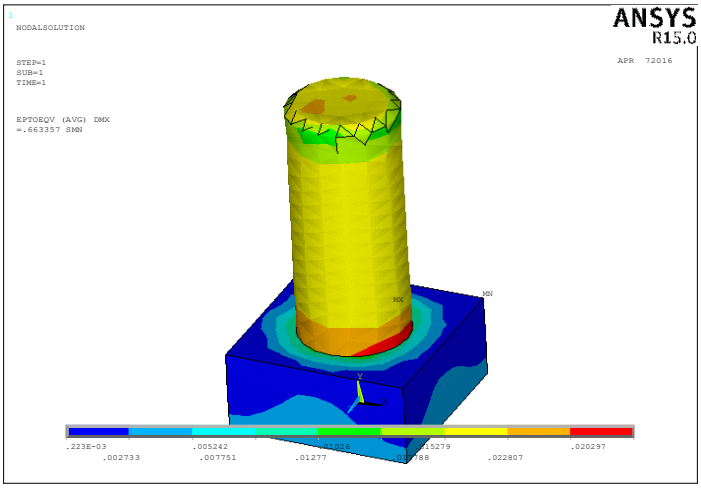
Base load strain:



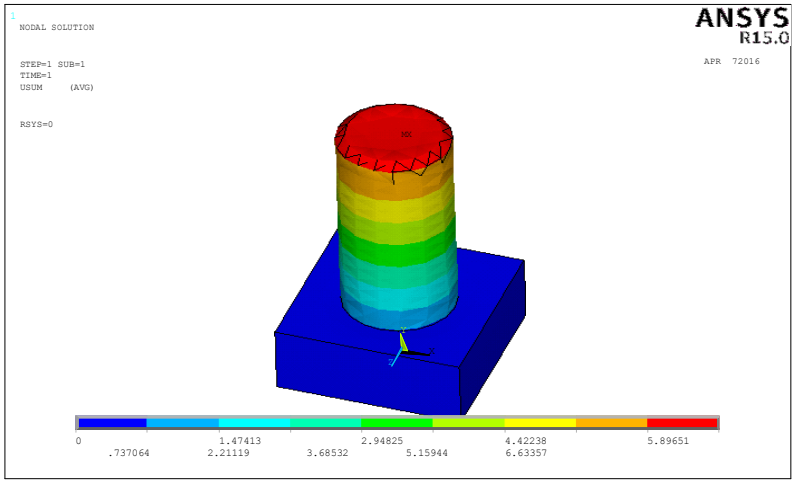
Base load deformation



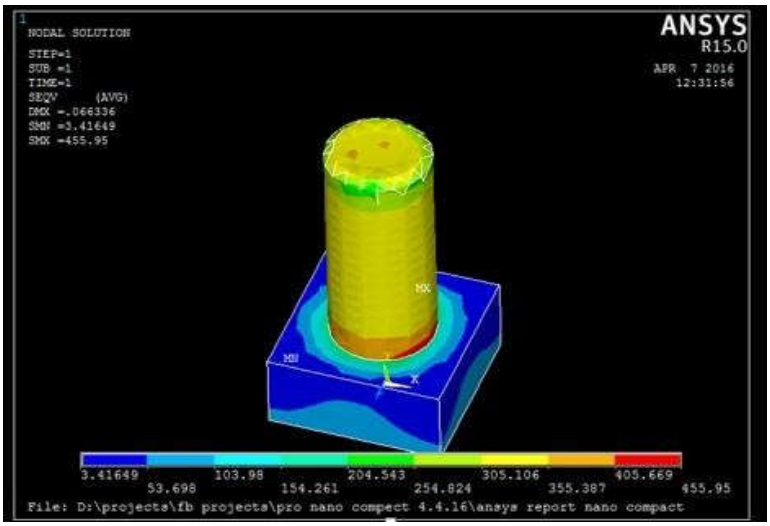
Base load stress:



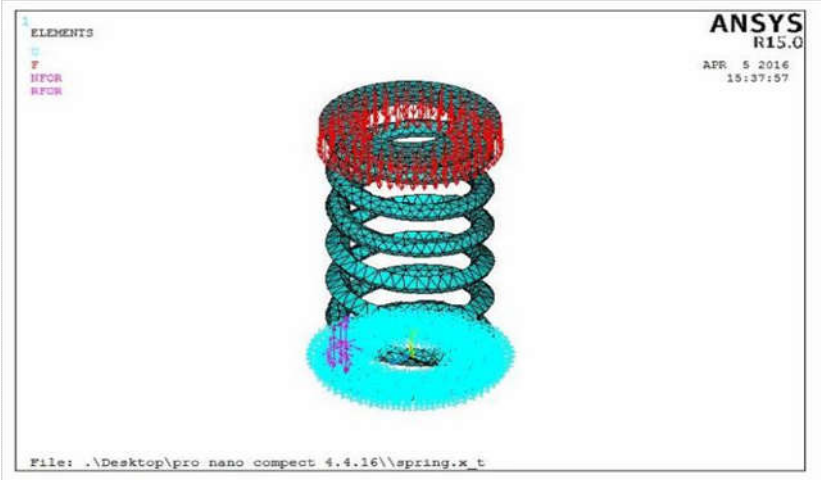
Punch strain displacement:



Punch stress deformation:



Spring boundary condition:

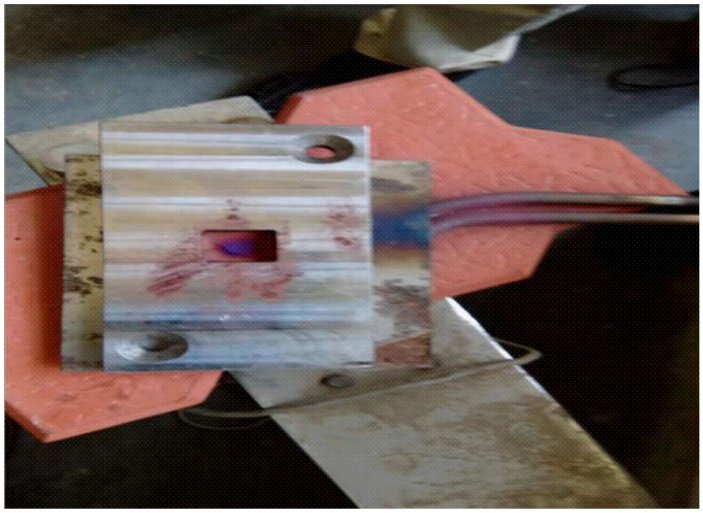


EXPERIMENTALSETUP:

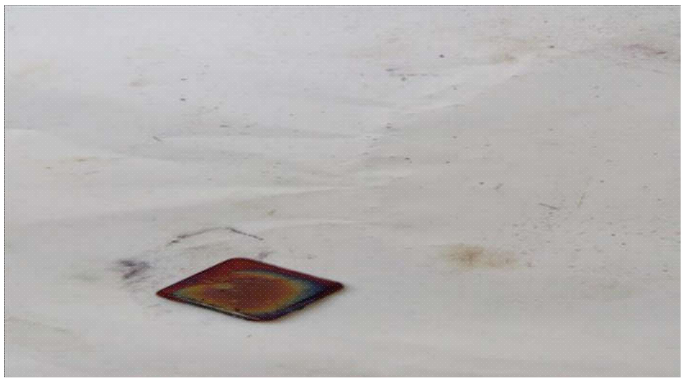
Compacting machine placed in CTM machine:

Machine setup

Die plate heating by heating coil:



RESULT: Final product:



Conclusion

The proposed project work attempts to design, analyze and fabricate a new device called Compacting machine which aims to lift the load capacity of Tons at different pressures.

The all new design is needed in the market and industry with the space constraints and dimensional constraints. Finite element analysis has to be carried out properly taking care of each and every step of implementation. I believe in my work and efforts that the design will be helpful for the industries.

The overall cost of the Compacting machine is much lesser than the other market resources. The testing machine is designed, analyzed and tested with utmost care of limits and tolerances of mating parts to achieve the target of load. The Punch and die compacting process holds potential for expanding P/M markets into full density and high performance products.

The process feasibility is demonstrated for various powders of ferrous, non-ferrous, ceramic and composites. The development of specific prototypes parts with steel powder for automotive industry, electric motor parts have been accomplished. Other product applications with different powder materials are being investigated.

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