

A transcendental approach to changing metal powder characteristics

It's not often that *Metal Powder Report* departs from the path of hard facts into the somewhat 'mushier' area of metaphysics, but opportunities crop up. While recognising that science has its fair share of charlatans, one such opportunity was presented by a paper submitted by an Indian researcher in which he details work aimed at probing the effects on powder samples where changes were apparently generated by thought. Some will laugh, others will cry, but perhaps among our readers there are those who might be able to help elucidate further the phenomena described...

Atoms condense to form metallic solids due to two primary forces. When the condensing atoms possess 's' and 'p' electrons as well as vacant electron positions in their outer most shell, these form metallic bonds. The outer atomic shells overlap causing electrons to delocalise and hold the now remaining positive atomic/ionic cores in fixed arrangement. This would mean that the electrons continuously move as if they are a cloud or gas among positively charged atoms. Thus the metallic bond is flexible and gives metals the characteristic malleability, ductility, thermal conductivity and electrical conductivity.

When the outer shells of the condensing atoms possess uncoupled (single electrons), these form covalent bonds by coupling with the electrons of opposite spin in the outer shells of the neighbouring

atoms. Thus the covalent bonds are strong giving rise to high strength, high hardness, brittleness, high melting/ decomposition temperature, electrical insulation and low reactivity.

The transition elements exhibit mixed metallic and covalent bonding combining the best properties of pure metals and pure covalent ceramics. The overlap of 's' and 'p' electrons form metallic bonds while the lone 'd' or 'f' electrons form covalent bonds.

Apart from atoms and molecules the next smallest materials available are powders. These could be single crystalline or polycrystalline the particle size of which is in the micrometric or nano metric range (<100nm) [1 and 2]. Particles exhibit fine microstructures and can contain such a high density of defects (point defects, dislocations, sub (crystallite) boundaries, grain boundaries, inter phase boundaries, etc.) that

the spacing between neighboring defects in nano powders can approach the inter atomic distance [3]. As the grain size becomes smaller and smaller, a larger and larger fraction of atoms resides on the single crystal grain boundaries (at a 6nm grain size, nearly half the atoms reside on the grain boundaries), thus the behaviour of nano-sized powders is often dominated by events at the grain boundaries [4].

Due to the extremely small size of the grains and a large fraction of the atoms located at the grain boundaries, these materials have properties like higher strength/hardness, enhanced diffusivity, improved ductility/toughness, reduced elastic modulus, increased specific heat, higher electrical resistivity, higher thermal expansion coefficient, lower thermal conductivity, and superior magnetic properties much improved over those exhibited by conventional grain

Table 1. Variation in particle size of treated powders.

POWDER/ TREATMENT	AVERAGE PARTICLE SIZE	PARTICLE SIZE IN MICROMETRES					
		Titanium	Chromium	Iron	Cobalt	Copper	Zinc flake
Control	d50	36.8	28	77.1	58.6	89.3	34.7
Treated 1	d50	33.3	25.4	84.1	44.5	89.7	24.3
Treated 2	d50	32.1	25.6	74	48	14.4	27
Treated 3	d50	32.3	26.6	73.9	42.6	14.6	28.3
Treated 4	d50	33.4	29.1	84.4	50.1	16.4	28.7
control	d99	131	100.4	163.8	146.6	193.6	133.5
Treated 1	d99	74.8	82.4	169.4	145.7	224.9	711.4
Treated 2	d99	72.7	59.4	149.8	172.6	85.8	73.8
Treated 3	d99	74	86.2	157	146.1	87.1	73.9
Treated 4	d99	88.6	101.8	213.3	141.2	80	74.3
Percent change in particle size							
Treated 1	d50	-9.5	-9.3	9.1	-24.1	89.7	24.3
Treated 2	d50	-12.8	-8.6	-4.0	-18.1	14.4	27
Treated 3	d50	-12.2	-5.0	-4.2	-27.3	14.6	28.3
Treated 4	d50	-9.2	3.9	9.5	-14.5	16.4	28.7
Treated 1	d99	-42.9	-17.9	3.4	-0.6	16.2	432.9
Treated 2	d99	-44.5	-40.8	-8.5	17.7	-55.7	-44.7
Treated 3	d99	-43.5	-14.1	-4.2	-0.3	-55.0	-44.6
Treated 4	d99	-32.4	1.4	30.2	-3.7	-58.7	-44.3

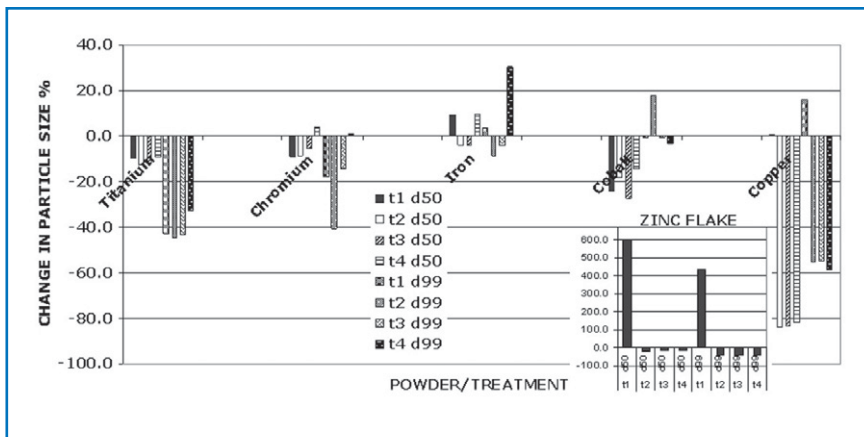


Figure 1. Percent change in particle size of treated powders.

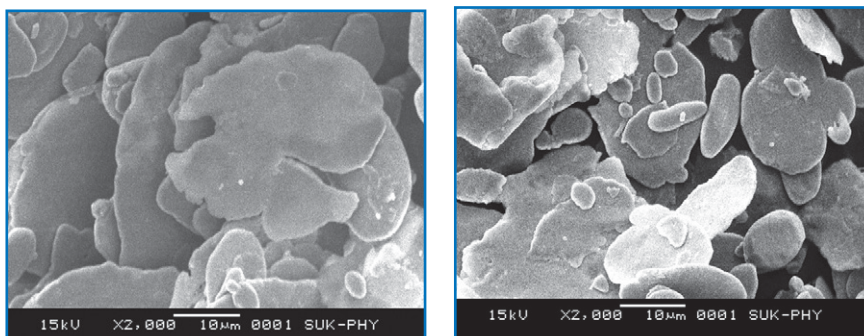


Figure 2. SEM pictures of Control (A) and Treated (B) zinc flakes.

sized (>10µm) polycrystalline materials [1].

Both micrometre and nanometre sized powders are produced by methods like mechanical milling [5], inert gas condensation, spray conversion process, chemical processes [6], and electro deposition [1], etc. Often mechanical milling is used for synthesis of fine and nano-sized powders in bulk quantities using simple equipment and at room temperature [2]. During this process, the metal powder particles are subjected to severe mechanical deformation from collisions with the milling tools. Consequently, plastic deformation at high strain rates (103–104 s⁻¹) occurs within the particles and the average grain size can be reduced to a few nanometers after extended milling [7][8]. Plastic deformation generally occurs by slip and twinning at low and moderate strain rates, while at high strain rates it occurs by the formation of shear bands, consisting of dense networks of dislocations. The plastic strain in the material increases due to increasing dislocation density in the early stages of ball milling. At a threshold dislocation density, even at moderately elevated tem-

Table 2. ANALYSIS OF X-RAY DIFFRACTION RESULTS ON FIRST SERIES OF TRANSITION METAL POWDERS- (Alpha Aesar powders- AA, SD fine chemicals- SD).

METALPOWDER/ CHARACTERISTIC		Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
CRYSTAL STRUCTURE	TYPE OF SAMPLE	H AA	C AA	C AA	C AA	C .SD	C AA	C AA	C AA	H AA
LATTICE PARAMETER 'a' X 10 ⁻⁸ cm	JCPDS STANDARD	2.951	3.030	2.884	6.314	2.866	3.545	3.524	3.615	2.665
	CONTROL	2.952	3.030	2.885	6.308	2.862	3.536	3.522	3.617	2.671
	TREATED T ₁	2.951	3.032	2.889	6.304	2.870	3.543	3.520	3.620	2.670
	TREATED T ₂	2.950		2.881		2.863	3.540	3.520	3.615	2.662
	TREATED T ₃	2.951		2.881	6.305		3.540	3.523	3.616	2.666
	TREATED T ₄	2.955		2.882	6.305		3.543	3.525	3.615	2.671
% CHANGE IN 'a'	TREATED T ₁	-0.047	0.06	0.156	-0.058	0.301	0.196	-0.06	-0.055	0.103
	TREATED T ₂	-0.067		-0.127		0.049	0.128	-0.04	-0.044	-0.056
	TREATED T ₃	-0.037		-0.139	-0.051		0.110	0.04	0.04	-0.006
	TREATED T ₄	0.093		-0.086	-0.050		0.195	0.09	0.093	-0.041
VOLUME OF UNIT CELL x 10 ⁻²⁴ cm	CONTROL	35.3	27.8	24.0	250.98	23.4	44.2	43.7	4.73	30.6
	TREATED T ₁	35.3	27.9	24.1	250.54	23.6	44.5	43.6	4.74	30.5
	TREATED T ₂	35.3		23.9		23.5	44.4	43.6	4.72	30.4
	TREATED T ₃	35.3		23.9	250.59		44.3	43.7	4.73	30.5
	TREATED T ₄	35.4		23.9	250.60		44.5	43.8	4.72	30.6
% CHANGE IN VOLUME OF UNIT CELL	TREATED T ₁	-0.093	0.18	0.469	-0.174	0.905	0.590	-0.17	-0.165	0.309
	TREATED T ₂	-0.134		-0.381		0.146	0.386	-0.13	-0.133	-0.167
	TREATED T ₃	-0.073		-0.416	-0.152		0.330	0.12	0.119	-0.019
	TREATED T ₄	0.186		-0.259	-0.150		0.585	0.28	0.279	-0.123
CRYSTALLITE SIZE 'G' x 10 ⁻⁹ m	CONTROL	146	110.9	63.8	148.2	40.7	49.7	89.4	55.6	108.79
	TREATED T ₁	146	88.7	111.7	111.2	21.3	40.6	111.8	111.2	72.52
	TREATED T ₂	109.5		149		34.43	49.7	89.4	89	87.1
	TREATED T ₃	146		40.6	111.2		29.8	111.8	89	108.83
	TREATED T ₄	62.6		111.7	111.2		63.8	111.8	111.3	108.79
[% CHANGE IN 'G']	TREATED T ₁	0.01	-20	75.1	-25	-47.7	-18.2	25	100	-33.34
	TREATED T ₂	-25		133.5		-15.37	-0.06	0.01	60	-19.94
	TREATED T ₃	0.01		-36.3	-25		-40.1	25	60	0.03
	TREATED T ₄	-57		75.1	-25		28.5	25	100.1	0

peratures, the material relaxes into sub grains separated by low-angle boundaries, leading to a decrease of atomic level strain. During subsequent milling the process of high deformation/sub grain formation is repeated resulting in the sub grains becoming finer and finer, and the relative orientation of the sub grains with respect to each other ultimately becoming completely random. Once the sub grains reach a critical level of refinement, further refinement becomes virtually impossible since the stresses

required for dislocation movement are enormously high due to the Hall-Petch strengthening. Thus nano sized powders with a minimum grain size are produced [2]. Titanium powders of about 2 μ particle size when subjected to high energy attrition milling in an argon atmosphere after 15 hours of milling yielded an average particle size of 35 nm has been obtained [9]. Thus it is now possible to produce large quantities of ultra fine and nano powders by high energy milling.

In the present investigation we report the use of an unknown and subtle energy (through thought intervention) on various transition metal powders obtained from reputed suppliers. The effect of this energy on particle size and crystallite size and the possible causes for the observed changes are discussed.

Metal powders belonging to first series of transition metals were selected for the investigation. One portion of these was kept as a control/standard sample while the other portions were exposed to Mr

Trivedi's (See box) thought intervention/physical touch referred to as-treated samples.

Both the control and treated samples were analysed by X-ray diffraction using powder Phillips, Holland PW 1710 XRD system. A copper anode with nickel filter was used. The wavelength of the radiation was 1.54056 Å (10-10 m or 10-8 cm).

Average particle size and size distribution were determined by Sympatec HeloS-BF laser particle size analyser with a detection range of 0.1 to 875 µm (micrometres). From the particle size distribution, d50 the average particle size and d99 (maximum particle size below which 99% of particles are present) for the control (untreated or as received powders) were taken as standard and were compared with the results obtained on four separately treated powders.

Results

Average particle size d50 and d99 the particle sizes below which 99 percent of the particles are present are given in [Table 1](#) for various powders. The particle sizes in treated powders in general decreased, although some powders showed increase in size. The percent change in particle size of various treated powders with respect to control powders is computed using the formula

$$\text{Change in average particle size d50 (\%)} = 100 \times (d50t - d50c) / d50c$$

In a similar manner the change in particle size d99 (%) is computed. These values are given in [table 1](#) and are plotted in [Figure 1](#).

Both titanium and chromium powders showed a decrease in d50 and d99. Evidently the larger particles might have fractured at the inter particle boundaries there by reducing the d99 size. Thus the decrease in the latter was much more than that observed in d50. Some samples of iron and cobalt powders showed slight increase in particle size suggesting that the particles would have elongated, work hardened and eventually fractured to smaller particles. This could be due to the higher ductility of these metals as compared to titanium and chromium. The maximum decrease in size was observed in copper and zinc powders. The later showed an initial increase in size possibly due to plastic deformation and a latter decrease due to fracture at the

weaker interfaces as shown in Figure 2 by SEM pictures. Either way the results indicate that Mr Trivedi's energy had acted as if the powders have been subjected to high energy milling.

What must be happening to cause these significant changes in particle size? In order to find a probable cause the powders were examined by x ray diffraction.

The data was obtained in the form of 2θ Vs Intensity chart as well as a detailed table containing $2\theta^0$, d value Å, peak width $2\theta^0$, peak intensity counts, relative Intensity %, etc. The 'd' values are compared with standard JCPDS data base and the Miller Indices h, k and l for various $2\theta^0$ values are noted. The data are then analysed using PowderX software to obtain lattice parameters and unit cell volume.

Then the crystallite size is calculated using the formula,

$$\text{Crystallite size} = k \cdot \lambda / b \cos \theta$$

Where, λ is the wavelength of x-radiation used (1.54056×10^{-10} m) and k is the equipment constant with a value 0.94. The obtained crystallite size will be in nano meters or 10^{-9} m. Crystallite size in metals can correspond to sub grain size when the grain size is equivalent to single crystal size. It is also possible that some part of the observed x ray peak width could be due to the instrument broadening (already corrected) while the other part could be due to the strain in the crystal lattice. The change between various powders is assessed by using relative parameters as follows;

The percentage change in lattice parameter is the ratio of difference in the values between control and treated samples to the value of control sample expressed as per cent. Typically for the parameter 'a' this is equal to $100 \times (\Delta a/a_c)$ where $\Delta a = (a_t - a_c)/a_c$. This is also known as strain, and, when multiplied with the elastic modulus gives the force applied on the atoms. When the force is compressive the change is negative while a positive value indicates a stretching or tensile force. In a similar manner the percent change in unit cell volume and crystallite sizes are computed.

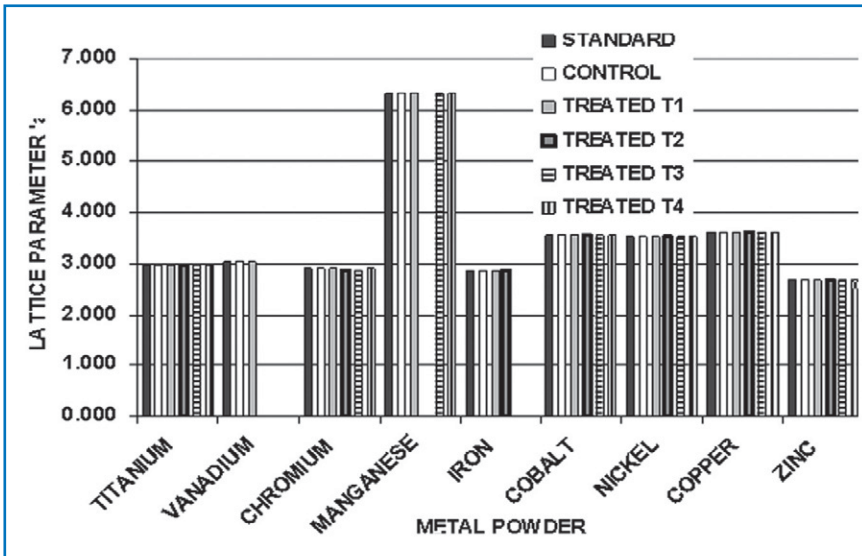


Figure 3. Comparison of lattice parameter 'a' of Control and treated powders with standard JCPDS data. The exactness of the present experimental data is indicated by the similarity in variation and magnitude of the lattice parameter 'a'.

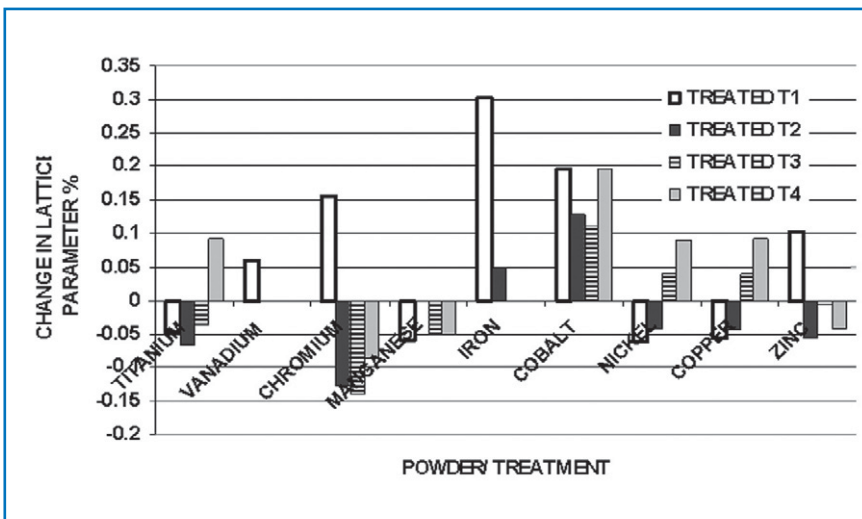


Figure 4. Percent change in lattice parameter 'a' between Control and treated sample.

Table 3. Effective nuclear charge and arrangement of electrons.									
ELEMENT	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
ARRANGEMENT OF ELECTRONS IN OUTER SHELL OF THE ATOM	$3d^24s^2$	$3d^34s^2$	$3d^54s^1$	$3d^54s^2$	$3d^64s^2$	$3d^74s^2$	$3d^84s^2$	$3d^{10}4s^1$	$3d^{10}4s^2$
EFFECTIVE NUCLEAR CHARGE OF THE 3 'd' ORBITAL AND OUTER 4 's' ORBITAL	8.14 4.82	8.98 4.98	9.76 5.13	10.53 5.28	11.18 5.43	11.86 5.58	12.53 5.71	13.20 5.84	13.88 5.97

Table 4. ANALYSIS OF X-RAY DIFFRACTION RESULTS ON FIRST SERIES OF TRANSITION METAL POWDERS- Atomic parameters and density.

METALPOWDER/ CHARACTERISTIC		Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
% change in nuclear charge per unit volume of atom	CONTROL									
	TREATED T ₁	0.14	-0.18	0.47	0.17	-0.90	-0.59	0.17	-0.308	0.074
	TREATED T ₂	0.20		0.38		-0.15	-0.38	0.13	0.167	0.980
	TREATED T ₃	0.11		0.42	0.15		-0.33	-0.12	0.018	0.488
	TREATED T ₄	-0.28		0.26	0.15		-0.58	-0.28	0.122	0.000
% CHANGE IN ATOMIC WEIGHT (PERCENT CHANGE IN NUMBER OF NEUTRONS AND PROTONS)	TREATED T ₁	-0.17	0.18	0.47	-0.17	0.91	0.59	-0.08	0.31	-0.05
	TREATED T ₂	-0.21		-0.38		0.15	0.39	-0.05	-0.17	-0.65
	TREATED T ₃	-0.15		-0.42	-0.15		0.33	0.20	-0.02	-0.32
	TREATED T ₄	0.11		-0.26	-0.15		0.58	0.36	-0.12	0
% CHANGE IN DENSITY	TREATED T ₁	0.09	-0.18	-0.47	0.17	-0.90	-0.59	0.17	-0.31	0.05
	TREATED T ₂	0.13		0.38		-0.15	-0.38	0.13	0.17	0.65
	TREATED T ₃	0.07		0.42	0.15		-0.33	-0.12	0.02	0.33
	TREATED T ₄	-0.19		0.26	0.15		-0.58	-0.28	0.12	0.00

Figure 3 shows the comparison of lattice parameter 'a' of various control and treated transition metal powders with the values obtained from standard JCPDS (Joint Committee on Powder Diffraction Standards) data. It can be noticed that the 'a' values obtained in the present experiments closely match the standard values. In most powders the external energy used had changed the lattice parameter 'a' in the third decimal place and in some cases by second decimal place (from Table 2).

The percentage variation in lattice constant in various powders after treatment is shown in Figure 4. It can be noticed from Table 2 that the volume of the atom calculated using the parameter 'a' showed similar variation. The decrease in lattice constant of elements till manganese indicates that a compressive force has been applied; although one sample each in titanium, vanadium and chromium showed an increase in lattice constant. Iron and cobalt in general showed an increase thereby indicating the force to be tensile. The variation of lattice constant in nickel and copper is not significant, while that in zinc showed a considerable decrease. These changes are significant as $100 \times (\Delta a/a)$ represents percent linear strain and any value above 0.2% strain is considered to be above the elastic limit for metals. Further, the elastic strain is expected to be released once the

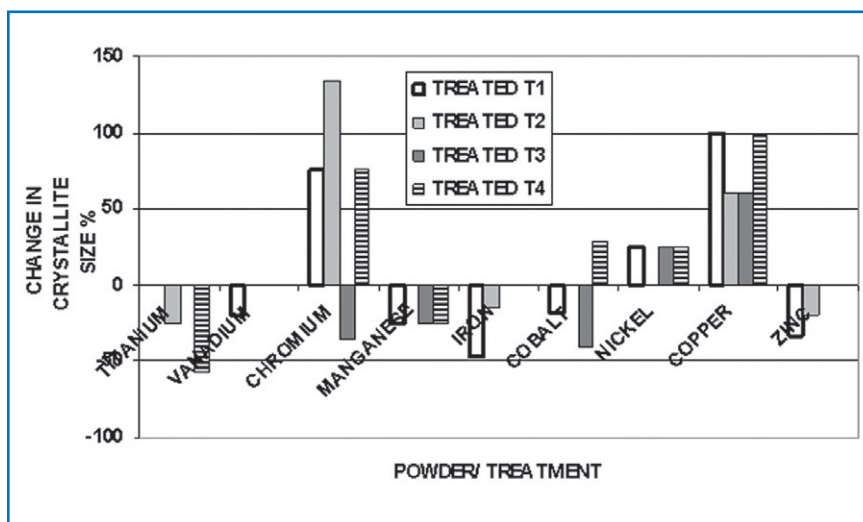


Figure 5. Percent change crystallite size between control and treated samples.

applied force is removed, which did not happen in the present experiments. Rather the strain was permanent indicating that it is plastic in nature and the lattice constant was permanently altered even though the crystal structure remained same.

The percent variation in crystallite size is shown in Figure 5. The crystallite size had changed substantially showing both increase as well as decrease, indicating heavy plastic deformation. The latter is not possible as the crystal structure remained the same. The existence of severe lattice strain is evidenced by the change in lattice parameters. It is possible that these internal

strains made dislocations to move on the slip planes and intersecting slip planes built in stress concentrations to such an extent causing the crystal to fracture at the sub boundaries. This is perhaps the explanation for decrease in crystallite size. On the other hand when the dislocations move unhindered, they might reorient the planes on either side of the crystallite boundaries resulting in an increased crystallite size.

The atomic size in a bound state is not constant and varies depending on the environment of nearest neighbours. Thus the lattice parameters are decided by the equilibrium inter atomic distance

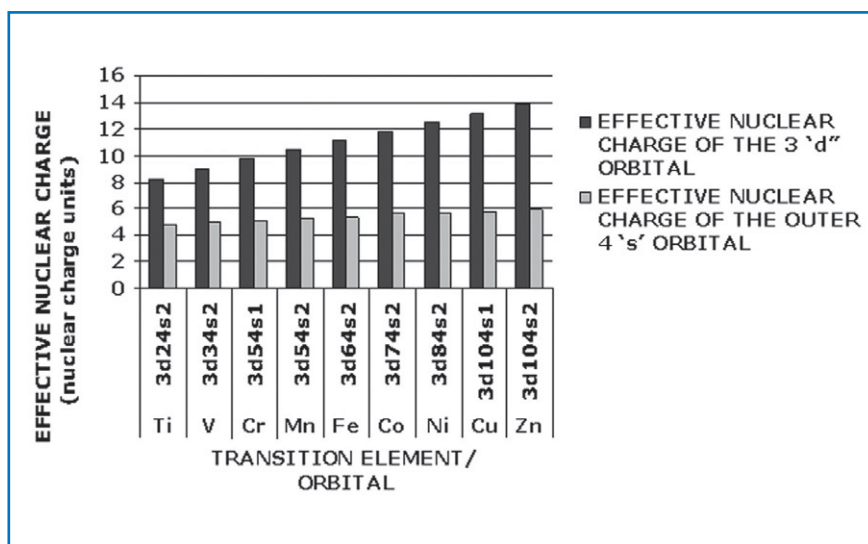


Figure 6. Effective nuclear charge of a free transition metal atom. As the electrons move farther from nucleus the effective charge of the latter decreases and eventually assumed to be near zero on the surface of the free atom.

where the attractive forces due to nuclear charges are balanced by the repulsive forces due to the orbiting electrons. The effective nuclear charge on the latter decreases with increasing distance from the nucleus as illustrated in Table 3 and Figure 6 gives the arrangement of electrons and effective nuclear charges [10] of outer orbitals in the free atoms of the transition metals. When atoms are subjected to an external compressive force the flexible electron cloud is likely to be pushed closer to the central nucleus, thereby decreasing the volume of the atom and increasing the effective nuclear charge. The reverse might happen when the external force is tensile. The atoms are likely to be pulled apart there by increasing the volume and decreasing the effective nuclear charge. Thus the density should increase during compression and decreases during tension. The reverse happens in the case of unit cell volume.

From Table 3 it is evident that the elements titanium to manganese contain lone 'd' electrons which form covalent linkages with electrons of opposite spins from neighbouring atoms. Thus the external force is likely to aid these bonds making them stronger decreasing lattice constant. From iron onwards, 'd' electrons start getting coupled making the bonds weaker and hence the applied force stretches the electron cloud increasing the lattice constant. With a decrease in volume of the unit cell the density increases. Since this implies increase in

bond strength the effective nuclear charge should increase. In order to verify these, the atomic parameters are computed from the x-ray data as follows.

The weight of atom is computed from the sum of all electrons, protons and neutrons.

Weight of atom = number of protons x weight of proton + number of neutrons x weight of neutron + number of electrons x weight of electron

Since the number of atoms per unit cell of the crystal is known, the weight of the unit cell is computed. The latter divided by the volume of the unit cell gave the theoretical density.

The weight of the atom when multiplied by Avogadro's number (6.023×10^{23}) gave the atomic weight (M) or the weight of a gram atom of the substance. The ratio difference in atomic weight between control and treated samples to the atomic weight of control sample is then expressed as percent change in atomic weight. Typically this is same as $100 \times (\Delta M/M_c)$ where $\Delta M = (M_t - M_c)/M_c$. This value also represents the percent change in sum of weights of protons and neutrons in the nucleus.

The percent change in positive charge per unit volume is computed as follows;

The atomic radius is obtained by dividing the lattice parameter 'a' with 2. $r = a/2$

Then the volume of the atom is obtained by assuming it to be spherical $V = 4 \cdot r^3/3$

The positive charge per unit volume of the atom due to protons is computed by multiplying the number of protons (p) in the atom with elementary charge 1.6×10^{-19} coulombs and then by dividing with the volume of the atom.

Positive charge per unit volume of atom = $Z^+ = 1.6 \times 10^{-19} \times p / V$ coulombs/ cm^3

The percentage change in positive charge per unit volume ΔZ between control and treated samples is then obtained as

$$\Delta Z \% = 100 (Z_t^+ - Z_c^+) / Z_c^+$$

The computed values of the atomic parameters together with their percent variation between control and treated samples are given in Table 4. When plotted as function of lattice parameter 'a', all the atomic parameters showed a linear relationship

$Y = B X$, where X = Percent change in lattice parameter 'a' and the values of B are as follows

Y= percent change in	B	Regression coefficient
atomic characteristic		
Percent change in atomic charge per unit volume	-3.002	-0.999
Percent change in atomic weight	2.693	0.979
Percent change in density	-2.706	-0.864

A decrease in lattice parameter 'a' and unit cell volume will increase the density. This in turn should decrease the size of the atom. The effective nuclear charge on the surface of the atom therefore increases as has been observed in the present experiments. The observed decrease in atomic weight and hence the sum of protons and neutrons in the nucleus with increase in

The Authors

THIS article is from Effect of unknown external energy on the structure and powder characteristics of transition metal powders

Mahendra Kumar Trivedi¹, Rama Mohan Tallapragada²

¹Founder and President, Society for Divine Life

²Formerly Professor, IIT Bombay and Visiting Professor at USC, Los Angeles and OSU, Stillwater, USA. Currently Scientific Advisor, Society for Divine Life, Mumbai.

density or decrease in lattice parameter is unusual.

The results raise certain unanswerable questions. As density represents weight per unit volume and as the number of atoms per unit cell are fixed by the crystal structure, a decrease in density corresponds to reduced number of protons and neutrons in the nucleus and hence to a reduced weight of the atom. But the decrease in density in the present experiments had resulted in a decreased charge per unit volume indicating a decrease in number of protons. The opposing dependence of the atomic weight and atomic charge on the lattice parameter is possible only if it is assumed that nuclear reactions involving

protons, neutrons with neutrinos resulting in electrons and positrons takes place [11]. In other words the external energy transmitted by Mr Trivedi could be in the form of neutrinos changing mass in to energy and vice versa.

The impact of Mr Trivedi's energy on inorganic materials cannot be explained by existing theories of physics or any other branch of science. The principal question raised is regarding the nature of the energy and interactions. For more than a decade now he has been treating seriously ill patients in whom an amazingly beneficial effect has been seen. There is insufficient reason for doubting the effects, especially in view


of the results of the present experiments (Transcendental Science link in www.divinelife.us). The observed interaction with materials at a distance then is more than a projection of metabolic or other biological energies, and has the ability to interact with some very basic essence of the sample, especially in larger organisms. It involves externalisation of energy, the availability of some basic quantity which provides information and direction as well as the use of a creative force. Mr Trivedi himself believes that he is contacting an external energy. These are points to ponder, even after discarding any subjective elements in the process.

Do the life Energy/consciousness/information signals presented here provide the missing link eluding connection between matter, energy and spirituality [12-15]? This is a subject for theoretical and quantum physicists to deliberate and conduct further studies. Mr Trivedi in such a case is willing to help by participating in collaborative controlled experiments.

The present paper is open ended in the sense that although the results are true the interpretation given is as per the current knowledge and there may be subjective elements. The authors hope and welcome the participation and opinions of the international scientific community so that the missing link between science and spirituality can be found in the coming years.

Conclusions

- Mr. Trivedi through his thought intervention/physical touch changed the atomic and crystal parameters of the transition metal powders.
- The treated powders exhibited increase as well decrease in volume of unit cell, effective nuclear charge per unit volume of the atom and the atomic weight.
- The changes in atomic parameters are significant enough to increase and decrease the crystallite as well as particle sizes.

We hypothesise that the changes caused by Mr Trivedi could be due to change in protons and neutrons in the nucleus caused by weak interactions. 

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